



Identification of pipeline damage, assessment and mitigation

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This talk

Identification of damage

- In-line inspection (pigging)
- Above ground surveys

Damage types

National Grid's damage assessment procedure (T/PM/P/11)

Repair methods

Concluding remarks

Identification of damage during condition monitoring

In-line inspection (pigging)

- ◆ Selection of intelligent pigs

Above ground surveys

- ◆ Close Interval Potential Survey (CIPS)
- ◆ Pearson
- ◆ Direct Current Voltage Gradient (DCVG)
- ◆ Electromagnetic Current Attenuation
- ◆ Long range ultrasonics

In-line inspection (pigging)

Inspection should be carried out for new pipelines, immediately following commissioning (fingerprinting)

Inspection of the pipeline should be carried out periodically to ensure that the pipeline is not deteriorating

- ◆ Relevant legislation
- ◆ IGE/TD/1 allows risk-based approach to determine inspection intervals, otherwise recommends 10 year max interval
- ◆ Dry natural gas - inspection is predominantly to monitor for external corrosion, although provides other information
- ◆ Assess Fitness for Purpose

Selection of intelligent pigs

Feature detection and sizing capability

Feature location accuracy to minimise subsequent excavation

Purpose

- ◆ Geometry/deformation measurement – dents, wrinkles
- ◆ Metal loss detection – corrosion, gouges
- ◆ Crack detection – SCC, fatigue

Intelligent pigs for metal loss detection

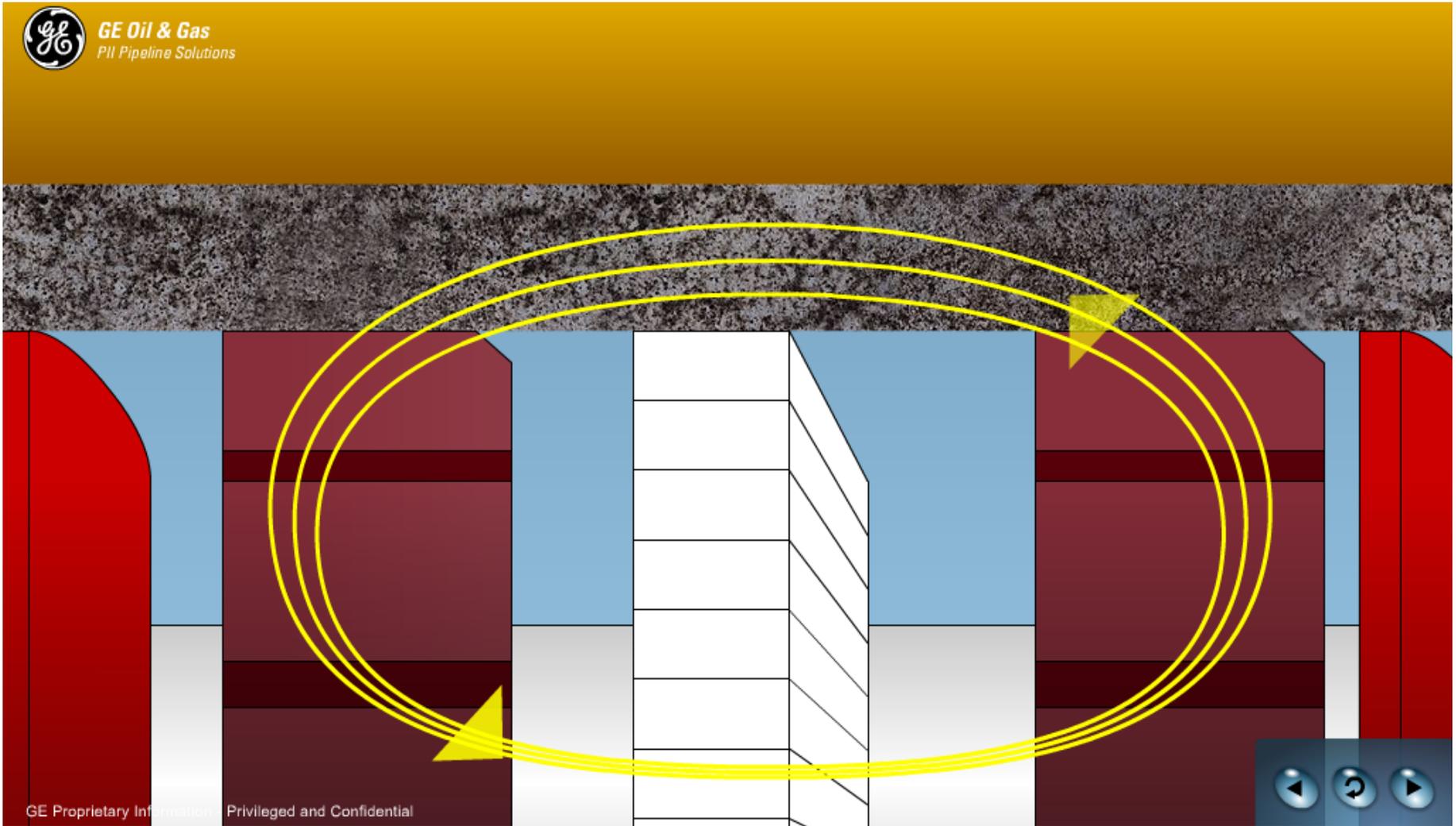
Magnetic Flux Leakage (MFL)

- ◆ Axial field MFL – most common type
- ◆ Transverse field MFL - for long, axial, narrow metal loss
- ◆ The selection of MFL tool should consider the type of corrosion expected in a particular pipeline.

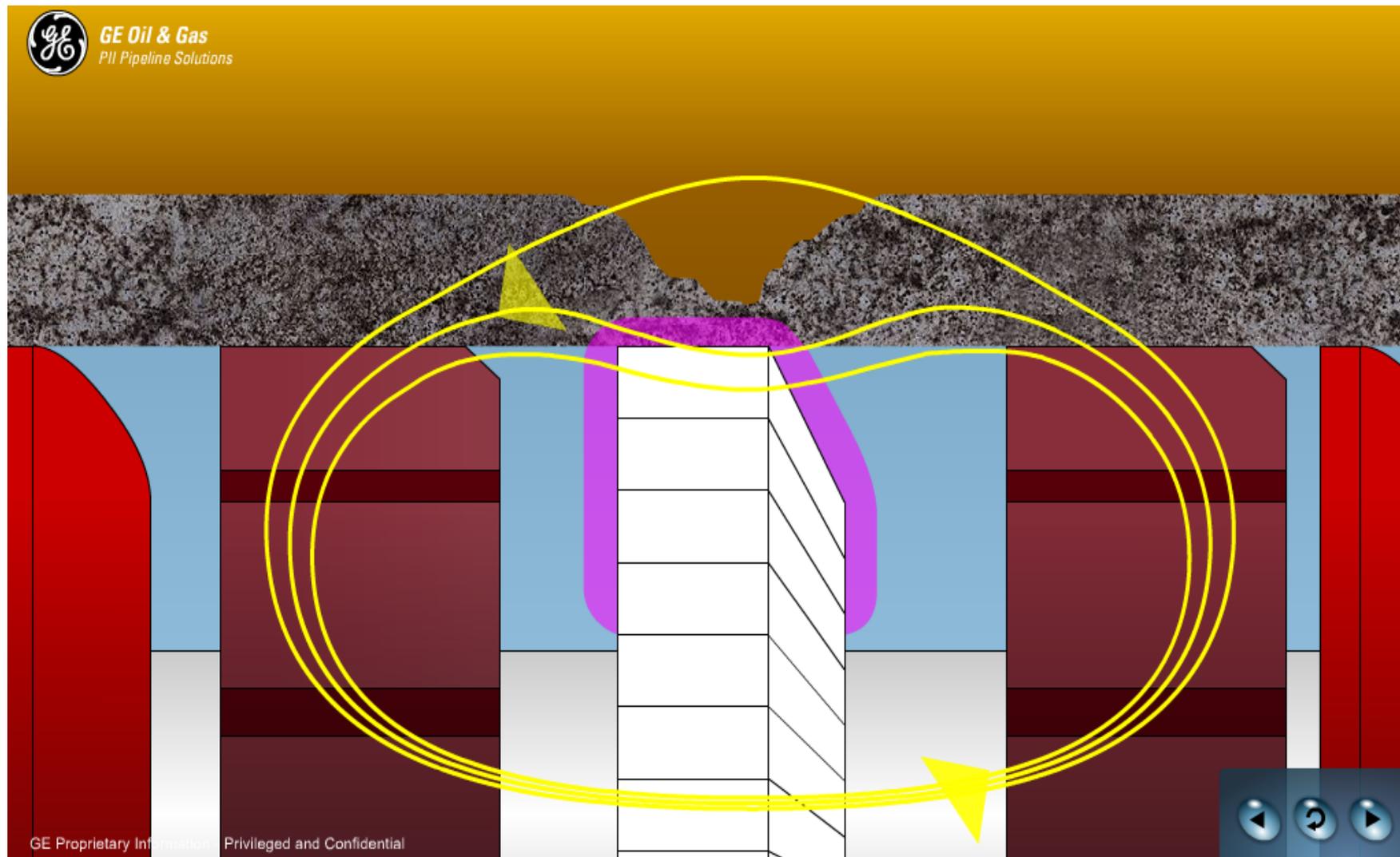
Ultrasonics

- ◆ Generally only run in liquid lines
- ◆ Gives an absolute measure of defect depth

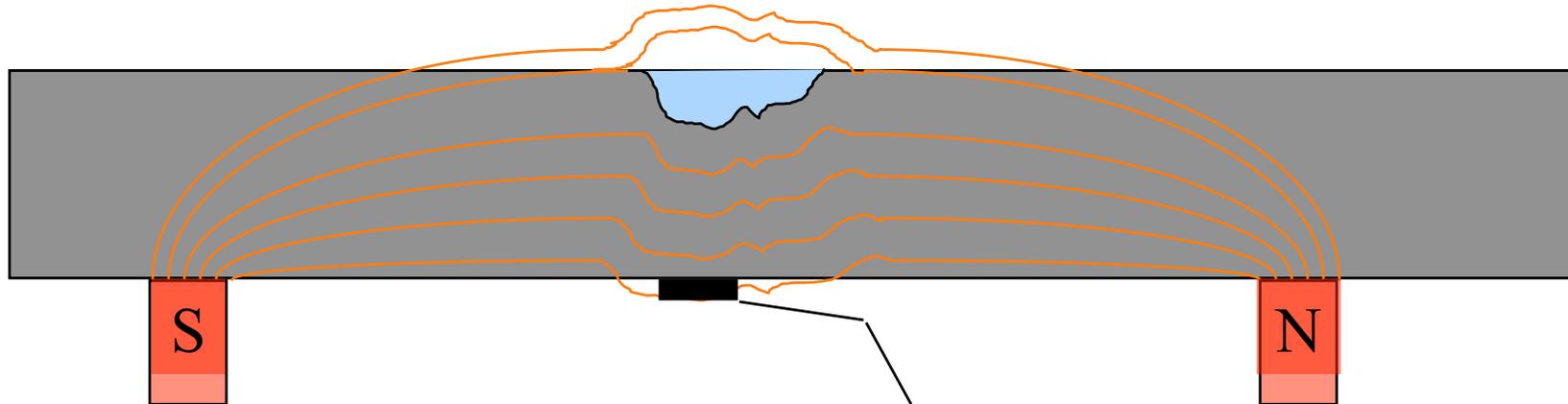
No corrosion present – flux unaffected



Corrosion present – flux affected

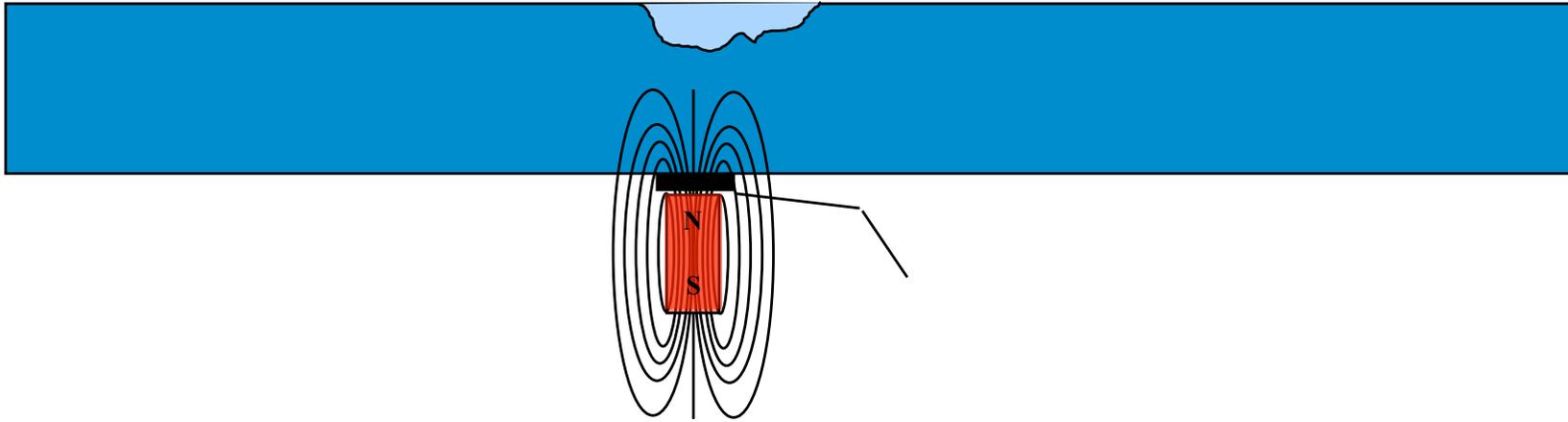


The Primary Sensor System – (Axial Field)



- High magnetic flux field imposed parallel to the pipe wall.
- Magnetic flux lines will be deflected:
 - if there is metal loss within the pipe wall.
 - if there is ferrous material near the pipe wall.
 - if the properties of the steel pipe wall change.
- The primary sensor detects any leakage of the magnetic flux.

The Secondary Sensor System



- Low magnetic flux field imposed perpendicular to the pipe wall.
- Magnetic flux lines will be deflected if there is metal loss on the internal surface of the pipe.
- The secondary sensor detects internal magnetic deflection.

MFL tools – axial field

The most widespread types of MFL ILI tool use magnets arranged so that the magnetic field direction is parallel to the pipe's axis. They are therefore termed *axial field* tools.

The MFL method will only produce a detectable response when a metal loss feature has some variation of depth perpendicular to the field's orientation. Thus, for an axial field device, detectable features must have some extent around the pipe's circumference.

A feature such as a flat-bottomed axial groove — even if it is wide enough to be detected — will only cause a signal to be generated from the depth variations at each end.

MFL tools – transverse field

***Transverse field* MFL tools are constructed so that the direction of magnetization in the pipe wall is around the circumference — that is, transverse to the axis.**

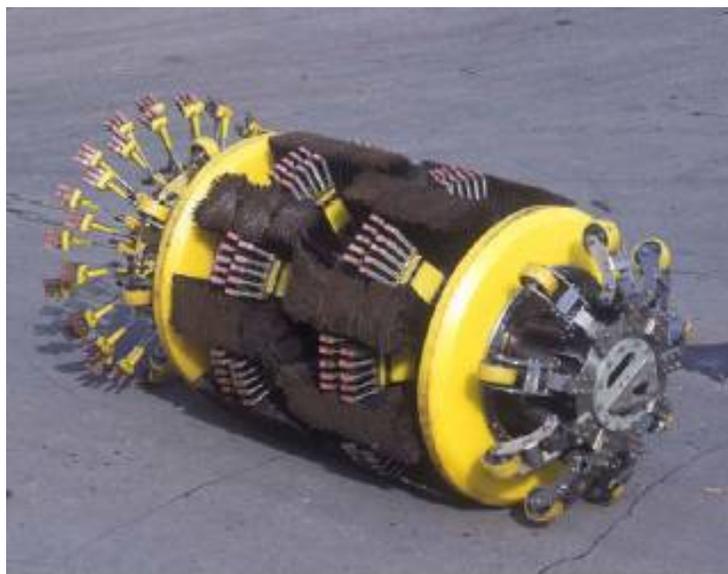
Narrow axial features therefore have their largest extent at right angles to this transverse field and can be clearly detected.

General and pitting corrosion will also be detected, although the sensitivity to pits will not necessarily be as good as for an axial field device.

MFL tools



Axial Field



Transverse Field

MFL Inspection Vehicle

Detects metal loss resulting from corrosion

Determines between internal or external corrosion

Accurately sizes area and location

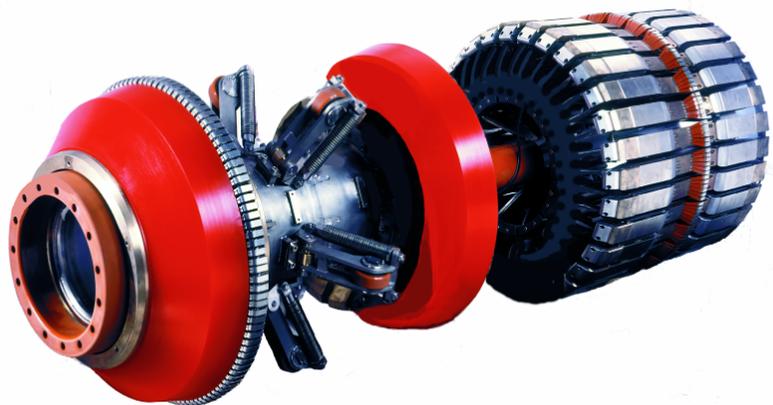
Identifies pipeline features such as welds, bends, valves, off takes, sleeves, shell repairs

Optimum velocity window (typically 1-4 m/s)

Minimum pressure required range for successful data collection (typically in excess of 10 bar)

High resolution MFL tools

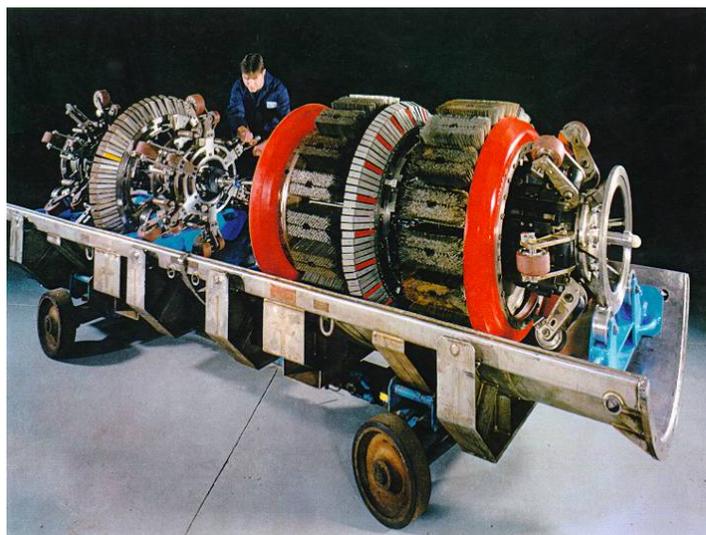
Baker Hughes CPIG



ROSEN CDP



GE- PII

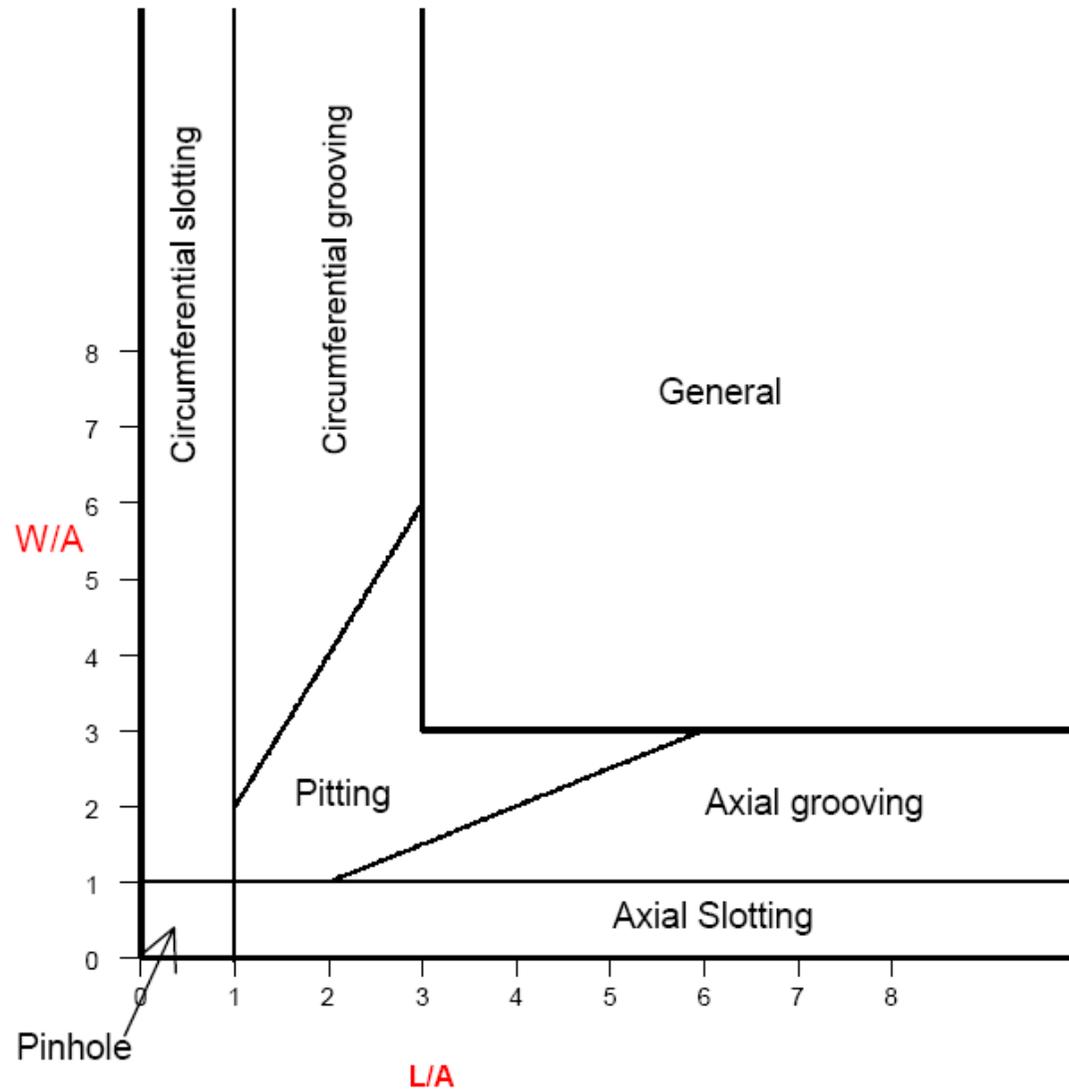


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Metal loss anomalies (POF)



Typical Reporting Specifications

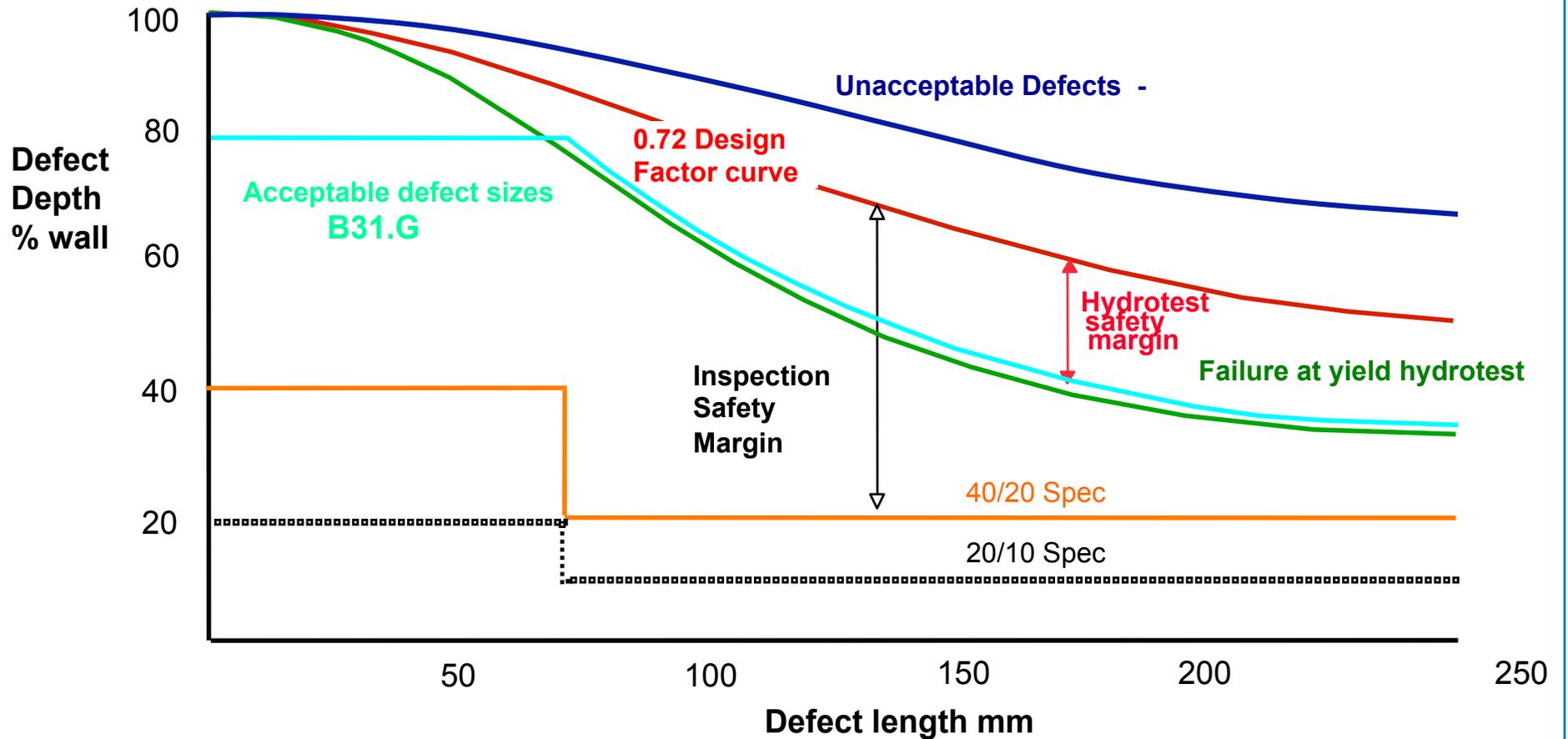
30/50 specification

- ◆ >30% wall thickness metal loss is required for General Corrosion
- ◆ >50% wall thickness metal loss is required for Pitting Corrosion

20/40 specification

- ◆ >20% wall thickness metal loss is required for General Corrosion
- ◆ >40% wall thickness metal loss is required for Pitting Corrosion

Safety margins for pipeline operation



Ref: GE-P11

MFL reporting

Tool operational data

Details of metal-loss features, size and orientation

Pipeline features - bends, valves, off-takes, girth welds

List of anomalies - girth weld anomalies, eccentric casings etc

Summary and statistical data

Fully assessed feature sheets

Defect assessment method

Typical feature sizing for general corrosion

Confident of sizing 90% of features 5% and above of wall thickness.

Depth sizing accuracy is typically +/- 10% of wall thickness in parent pipe

Example

- ◆ Feature depth is claimed to be 30% deep,
- ◆ Wall thickness is 15.88mm
- ◆ Feature depth is 4.77 +/- 1.59mm

Factors affecting MFL performance

Cleaning

Sensor damage

Magnetic properties of line pipe

Remnant magnetization

Wear to mechanical components, such as drive cups and suspension arms, due to length of run or aggressive in-pipe conditions.

Speed excursions

Wall thickness

High resolution geometry/deformation tools

Geometry tool: Configuration pig designed to record conditions, such as dents, wrinkles, ovalities, bend radius and angle



High resolution geometry results

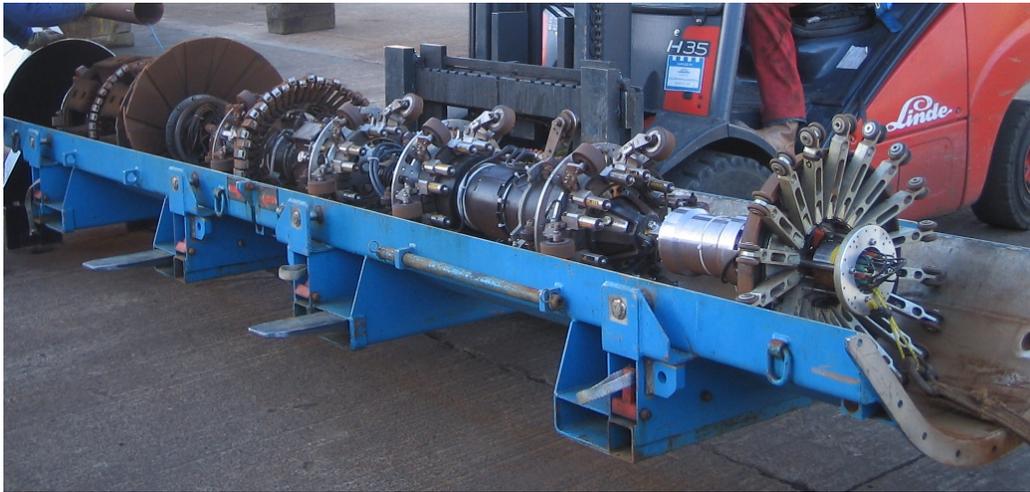
Data quality

Main pipeline features, such as valves, tees, bends etc

All bore reductions and geometric deformations, such as dents, wrinkles, buckles, partially closed valves, debris in pipeline etc

Profile of all dents, wrinkles, buckles and other bore changes

MFL developments – combination tools



ROSEN MFL, geometry and mapping

GE-PII MFL and geometry



Baker Hughes 10" combo tool



Assessment of results

Results to be reported in a suitable form to enable location and significance to be readily determined and to provide comparison with previous inspection results.

Results of inspection should be examined as soon as possible and appropriate remedial work initiated to ensure the continued fitness for purpose of the pipeline.

Inspection report template

- ◆ Metal loss features due to corrosion
- ◆ Metal loss features with appearance of a gouge
- ◆ Smooth dents
- ◆ Smooth dents with metal loss
- ◆ Kinked dents
- ◆ Girth weld anomalies
- ◆ Mill and construction defects
- ◆ Ferrous metal objects near to the pipeline
- ◆ Eccentric casings
- ◆ Pipeline repairs
- ◆ Pipeline anomalies
- ◆ Metal loss, dents, gouges coincident with welds and their heat affected zones.
- ◆ Speed restrictions and degraded data



Guidance on assessing the inspection results

General guidance

- ◆ Types of features or damage that are reported by the inspection tool and the types of damage identified in the damage assessment procedure,
- ◆ Range of technical skills required to review inspection report,
- ◆ Review previous reports and other available data,
- ◆ Tracking, audit and close out of actions from the inspection.

Specific guidance on each of the topics in the inspection report

- ◆ Metal loss features due to corrosion,
- ◆ Metal loss features with appearance of a gouge,
- ◆ etc.

In-line inspection - safety

Nitrogen purging to ensure safe atmospheres

Loading/unloading of pigs

Opening of pig trap doors

Ensure either side of pig is fully depressurised

Non-routine operations, with detailed written procedures giving valve operating sequences

Pig cleaning and disposal of any waste (NORM dust)



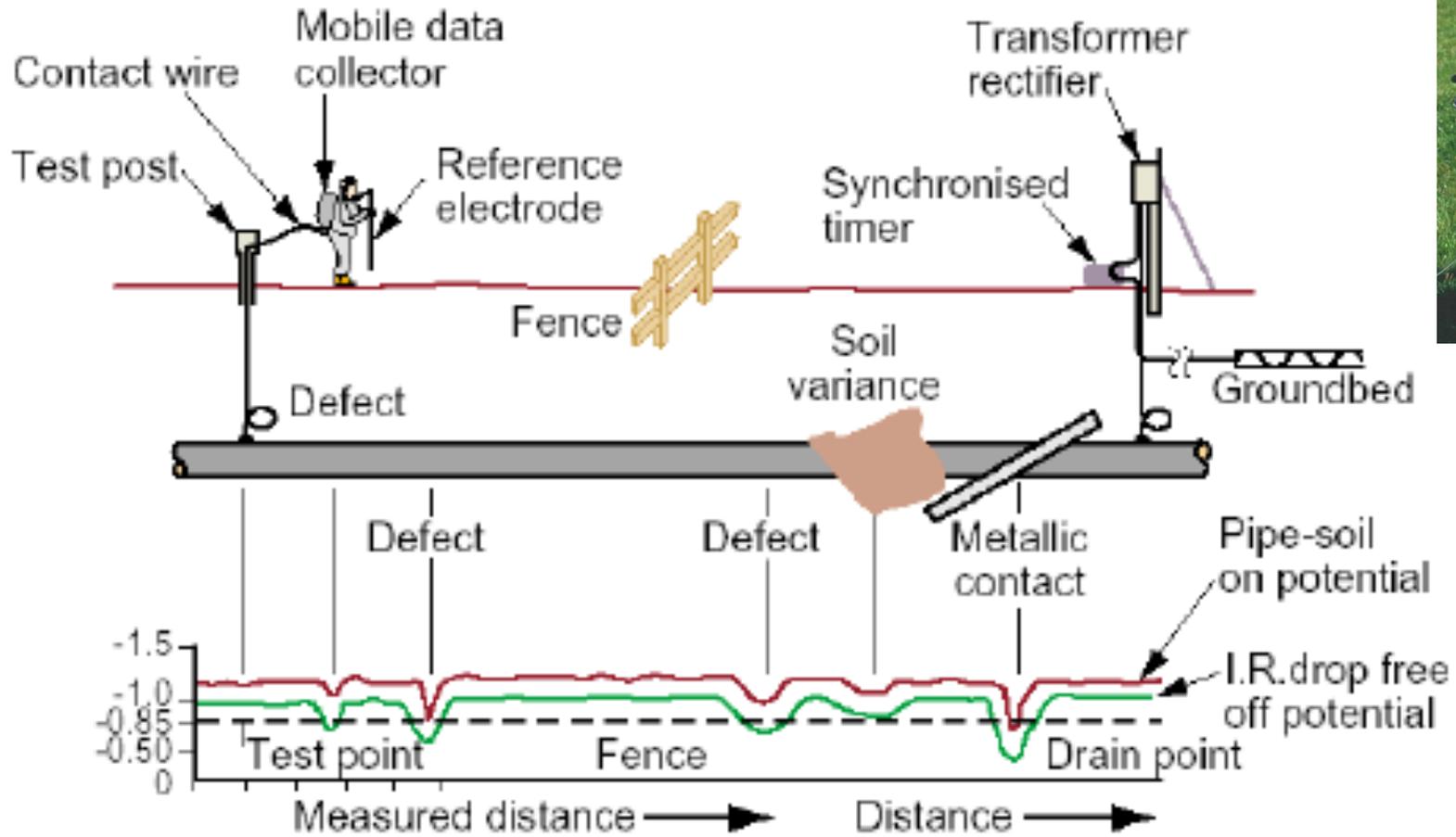
Above ground surveys for un-piggable pipelines

Above ground surveys are used for monitoring the condition of non-piggable pipelines.

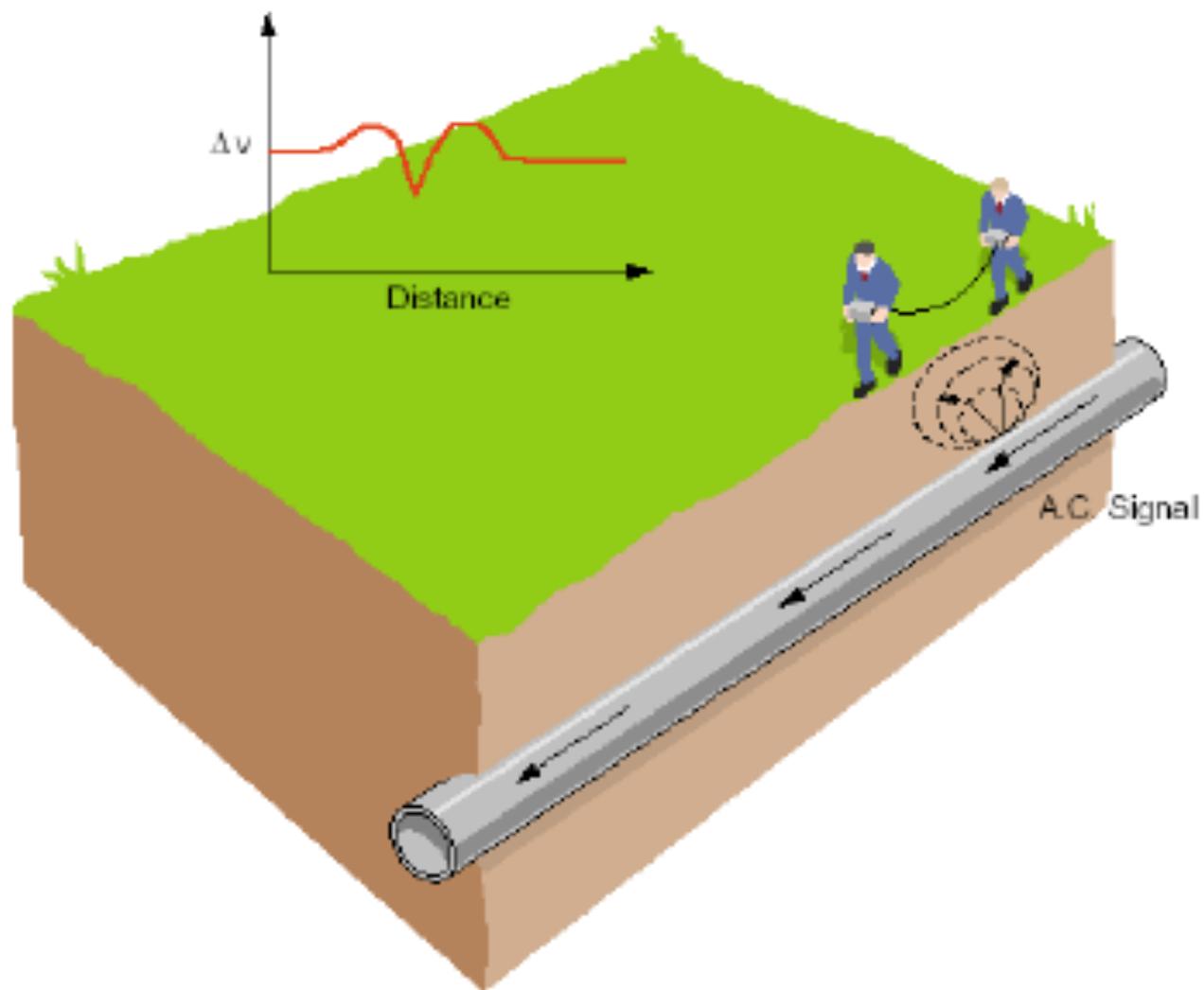
Traditionally survey techniques used have been:

- ◆ Close Interval Potential Survey (CIPS) to assess the effective of the Cathodic Protection (CP) system
- ◆ Pearson survey to assess the coating condition

CIPS



Pearson



CIPS and Pearson limitations

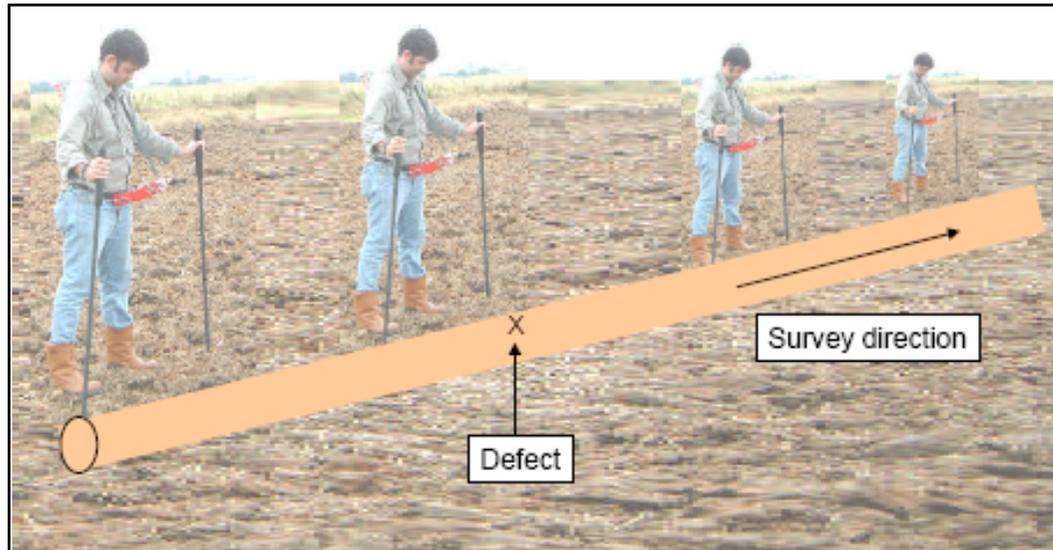
The CIPS and Pearson survey methods are not ideally suited for areas, such as street works, road or rail crossings, areas of electrical interference etc.

In such circumstances, supplementary survey techniques need to be employed to help assess whether the pipeline is likely to be affected by corrosion.

The supplementary survey techniques presently available are:

- ◆ Direct current voltage gradient (DCVG)
- ◆ Electromagnetic current attenuation (ECA)
- ◆ Long range ultrasonic testing (LRUT)

Direct Current Voltage Gradient (DCVG)



Can be used as alternative to Pearson

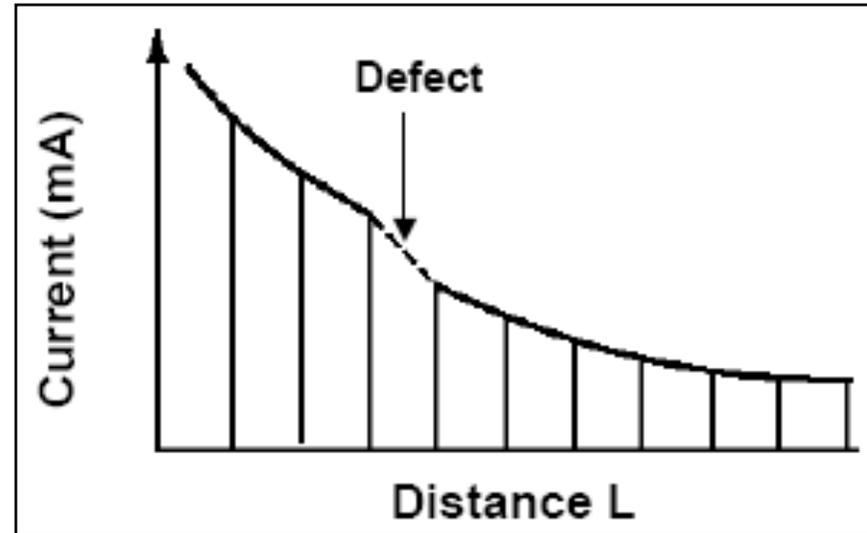
Can provide information on the relative sizes of coating defects

Minimally affected by AC and DC interference

More sensitive than Pearson

Has potential to locate coating damage under hard services

Electromagnetic Current Attenuation



Useful technique to give a general indication of pipeline coating, especially in built up areas, as it can be successfully carried out over hard surfaces, such as tarmac or concrete, and does not involve the use of trailing cables.

Locates coating defects on buried pipelines.

Locates inadvertent metal to metal contact with other pipelines/structures.

Large area coating damage is often located by current attenuation techniques but smaller damage is generally missed

Long Range Ultrasonics



Threshold for detection typically 10% of cross sectional area

Dimension of corrosion cannot be directly determined

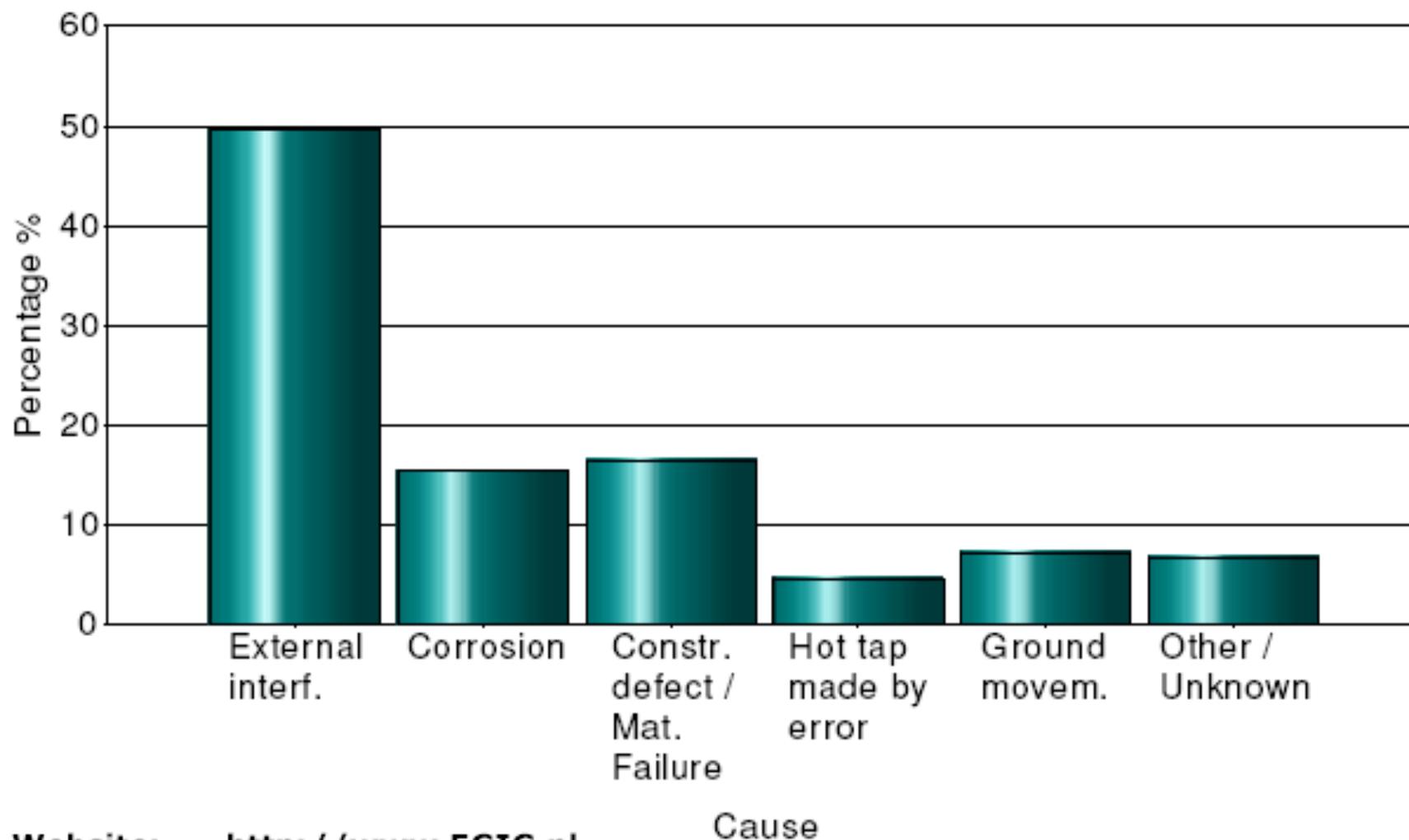
Affected by coating types and thickness, adjacent pipe features

Damage types

European Gas pipeline Incident data Group (EGIG)

- ◆ Database of pipelines and incidents, 3.15 million km.yr. exposure
- ◆ Natural gas transmission pipelines
- ◆ Unintentional gas releases
- ◆ Maximum Operating Pressure greater than 15 bar
- ◆ Located outside the fences of installations

EGIG loss of gas causes: 1970 - 2007



Website: <http://www.EGIG.nl>

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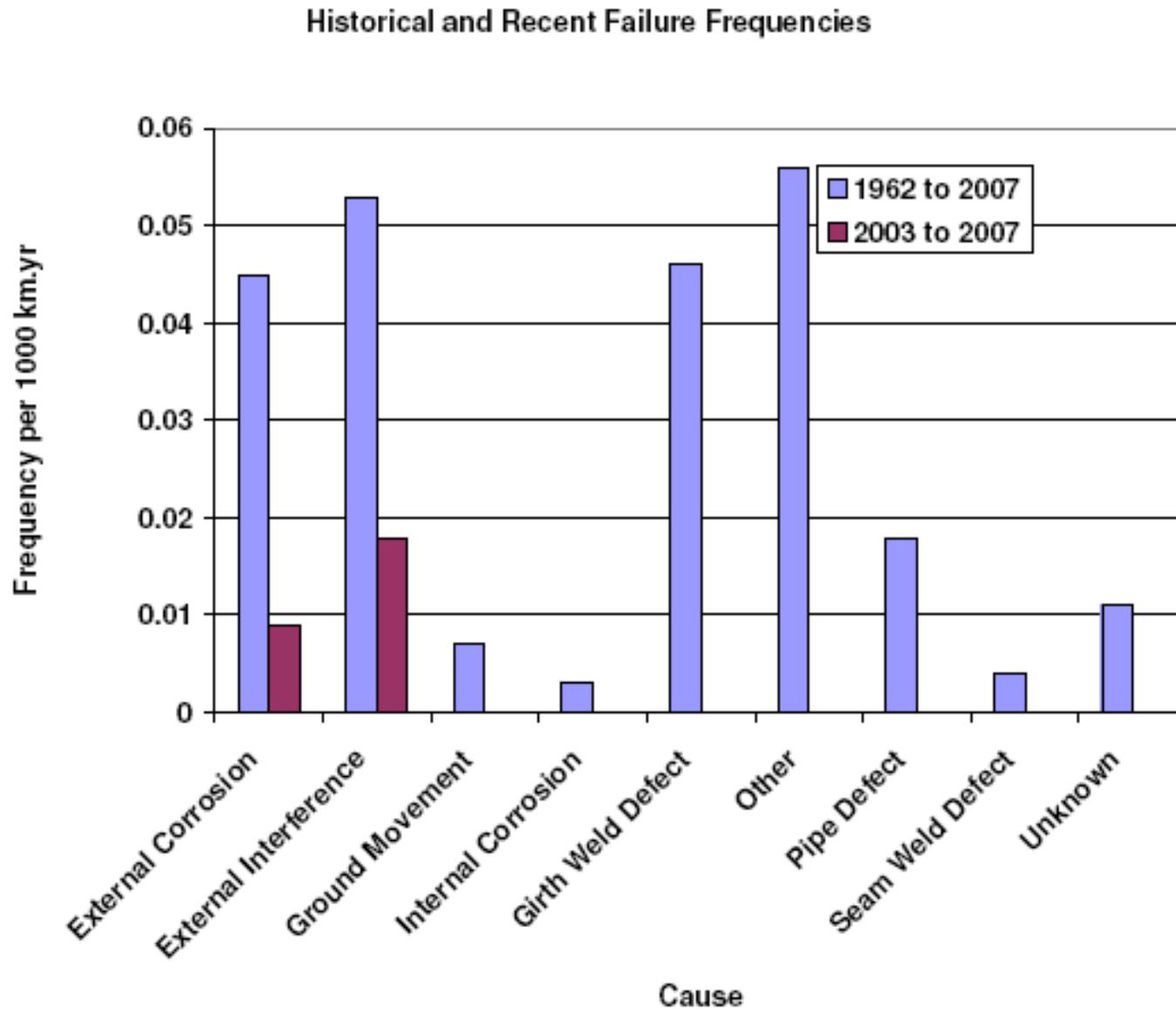
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EGIG – main damage types

Main causes

- ◆ External interference 50%
- ◆ Construction defects/material failures 16%
- ◆ Corrosion 15%

UKOPA loss of product causes: 1962 to 2007



National Grid damage assessment procedure

T/PM/P/11 - Inspection, Assessment And Repair Of Damaged (Non-Leaking) Steel Pipelines Above 150 mm Nominal Diameter And Designed To Operate At Pressures Greater Than 2 bar

Screening level assessment

T/PM/P/11

Inspection

**Damage categories (superficial, moderate, severe, extreme)
depending on severity of damage for different stress levels**

Safe working practices – pressure reductions

Repair methods

Damage types

Gouge

General corrosion

Pitting corrosion

Smooth dent

Kinked dents

Dent and gouge

Spalling or cracks

Arc strikes

Stress corrosion cracking

Also includes damage near/on welds



Damage categories - 1

Superficial Damage

- ◆ Damage does not significantly affect the integrity of the pipeline. Generally no action is required although if already excavated the defect should be inspected and if necessary repaired. Gouges classified as Superficial do require action.

Moderate Damage

- ◆ Again the integrity of the pipeline is not significantly affected. However, cracking may be present and so must be excavated, inspected and if necessary repaired.

Damage categories - 2

Severe Damage

- ◆ Defect constitutes significant damage which could fail as a leak

Extreme Damage

- ◆ Defect constitutes significant damage which could fail as a rupture

Severe and Extreme damage must be repaired by a shell type repair or a cut-out and replace

T/PM/P/11 – superficial corrosion limits

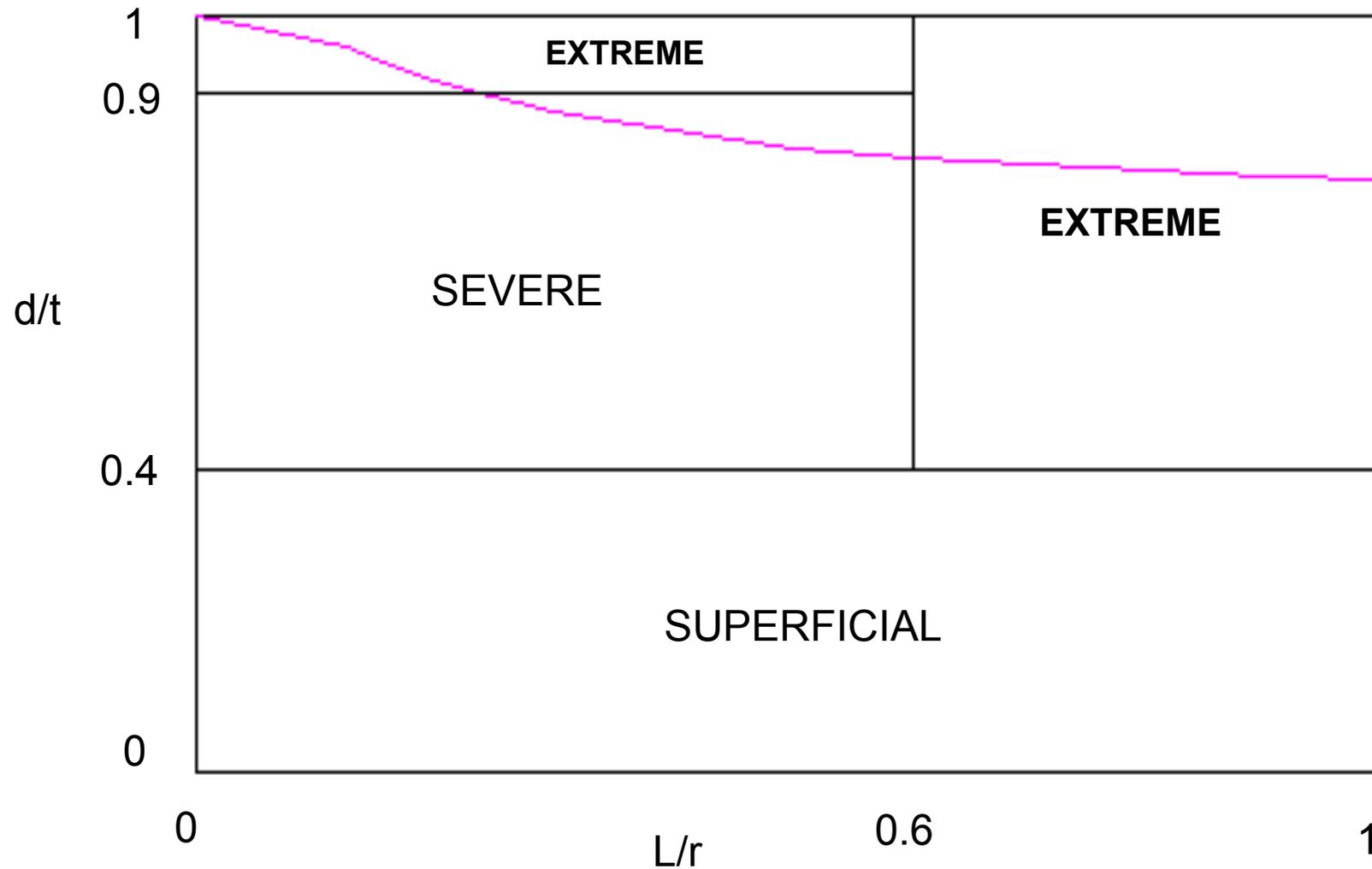
Up to 30% SMYS

- ◆ General corrosion: depth less than or equal to 40% wall thickness
- ◆ Pitting corrosion: depth less than or equal to 60% wall thickness

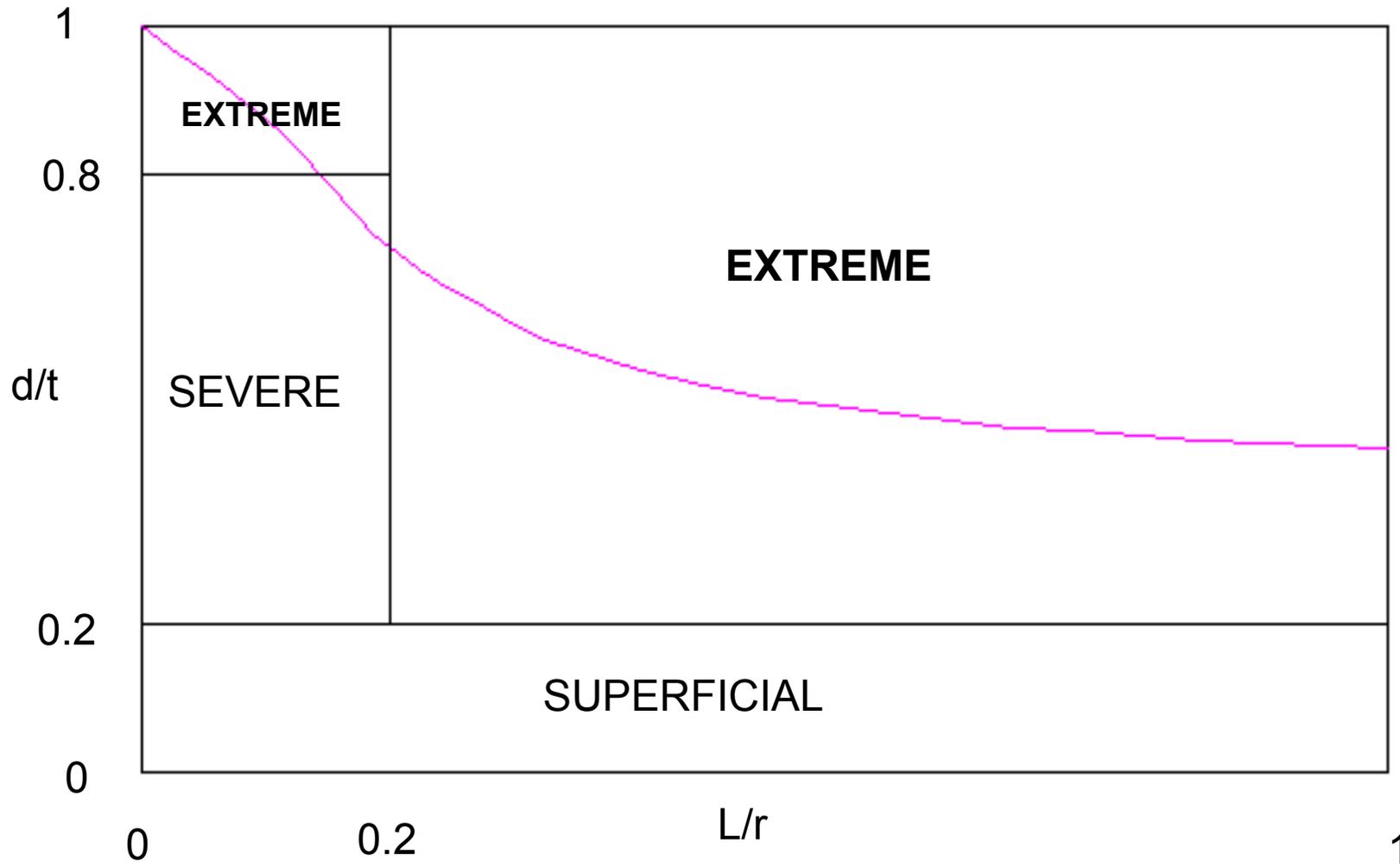
Up to 72% SMYS

- ◆ General corrosion: depth less than or equal to 20% wall thickness
- ◆ Pitting corrosion: depth less than or equal to 50% wall thickness

General corrosion limits at 30% SMYS



General corrosion limits at 72% SMYS



T/PM/P/11

Simple to apply

Conservative

Acceptable limits are unambiguous and uncomplicated

Safe

Expert level assessment

If simplified approach is not acceptable, an expert level assessment is possible

- ◆ Uses more accurate, less conservative, defect assessment
- ◆ Pipeline Defect Assessment Manual (PDAM)
- ◆ Advanced assessment methods, finite element methods, detailed defect assessment, testing
- ◆ Specialist skills required

Repair methods in T/PM/P/11

TABLE 10 - Appropriate repair methods for damage categories

a) Permanent repair methods

	Superficial Damage	Moderate Damage	Severe Damage	Extreme Damage
Dressing	✓ (see Note 1)	✓ (see Note 1)	-	-
Epoxy shells	-	-	✓	✓
Snug-fitting shells, undrilled	-	-	✓	-
Snug-fitting shells, drilled	-	-	-	✓
Stand-off shells, undrilled	-	-	✓	-
Stand-off shells, drilled	-	-	-	✓
Hot tap fittings undrilled	-	-	✓	-
Hot tap fittings drilled	-	-	-	✓
Replacement pipe pup	-	-	-	✓

b) Temporary repair methods

	Superficial Damage	Moderate Damage	Severe Damage	Extreme Damage
Leak clamp	-	-	✓	✓

Repair techniques

Permanent

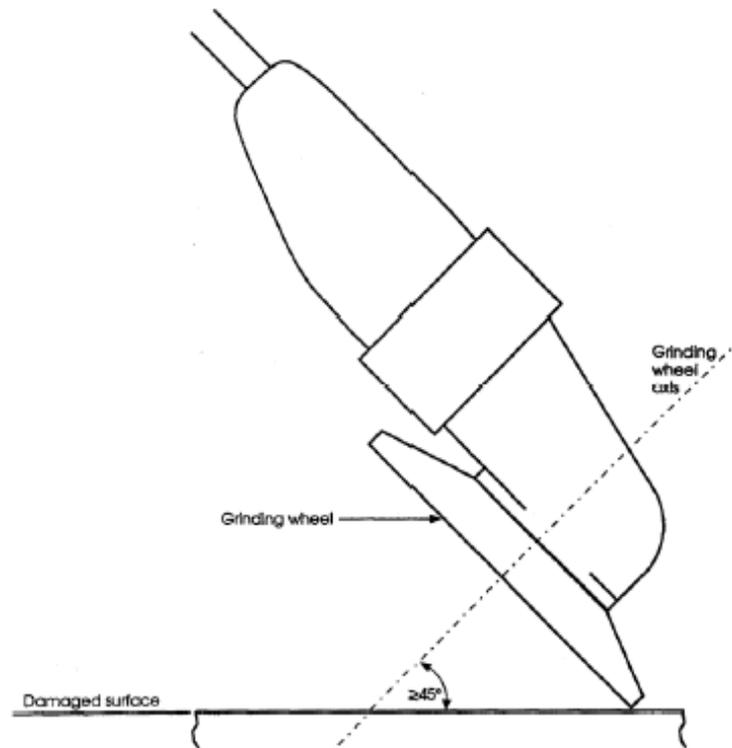
- ◆ Dressing
- ◆ Epoxy filled sleeve
- ◆ Close fitting shells
- ◆ Snug fitting shells
- ◆ Hot tap fitting
- ◆ Composite sleeve

Temporary

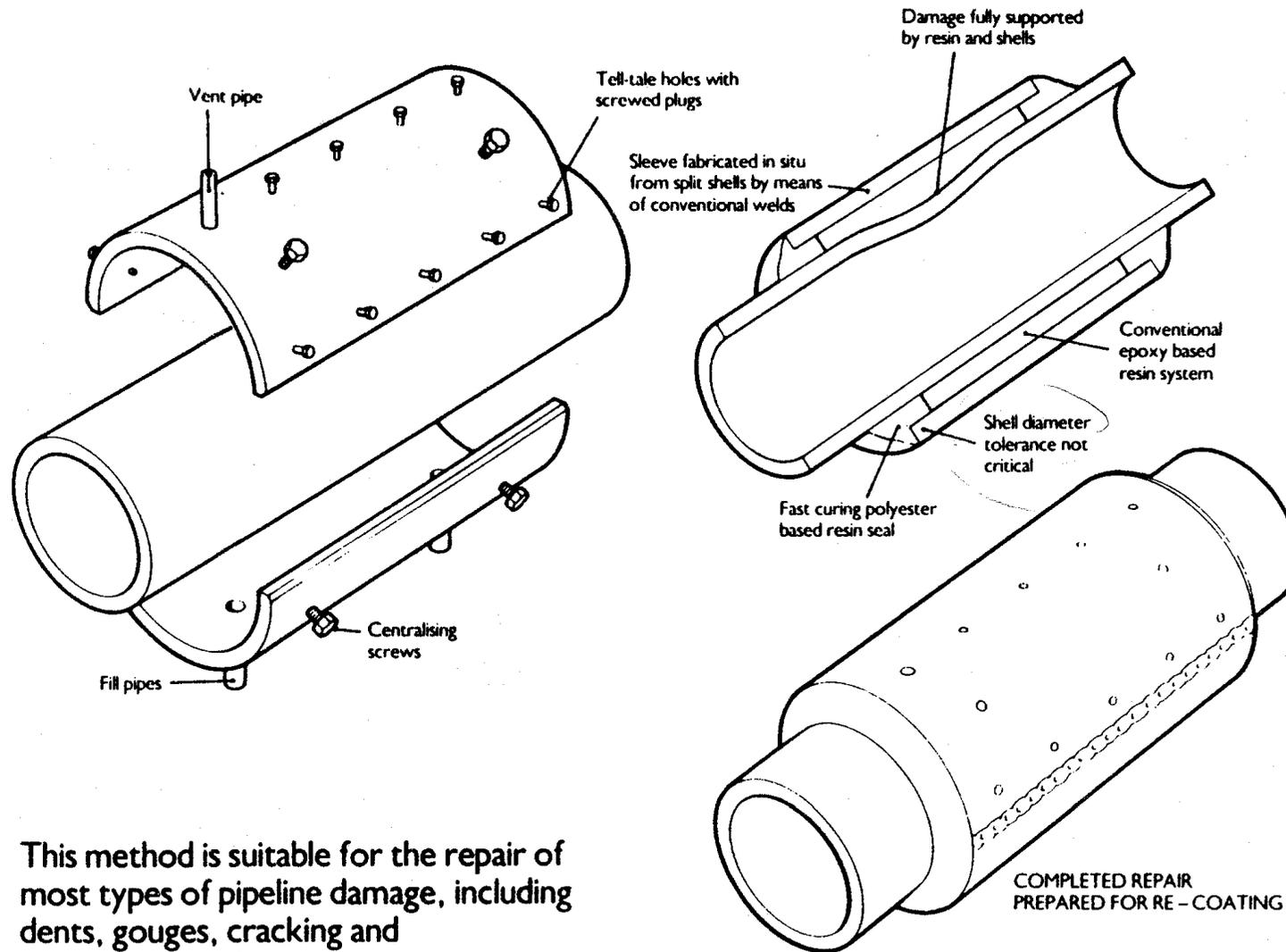
- ◆ Leak clamp

Dressing

Dressing removes stress concentration at a defect or an imperfection.

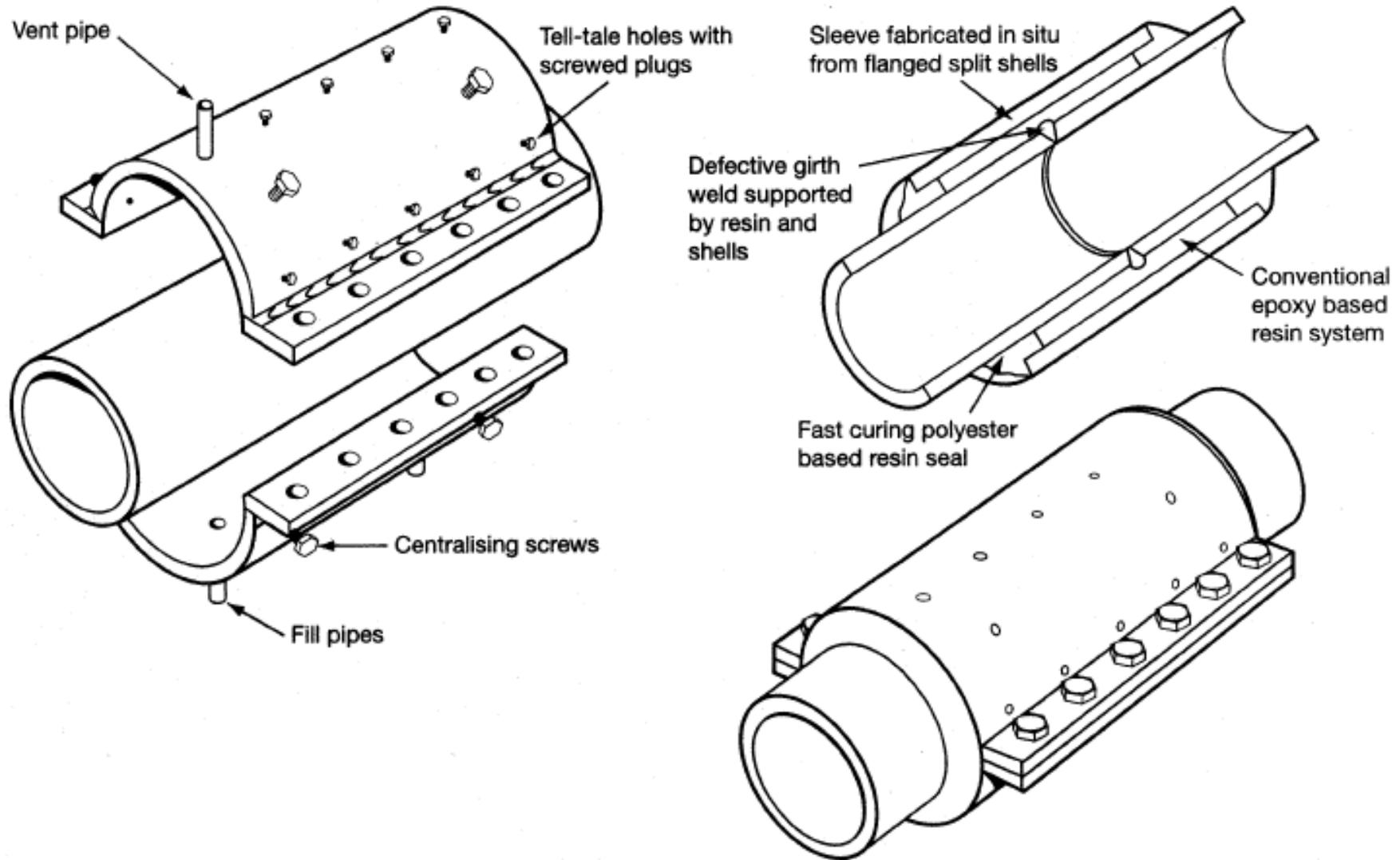


Epoxy filled sleeve – welded version

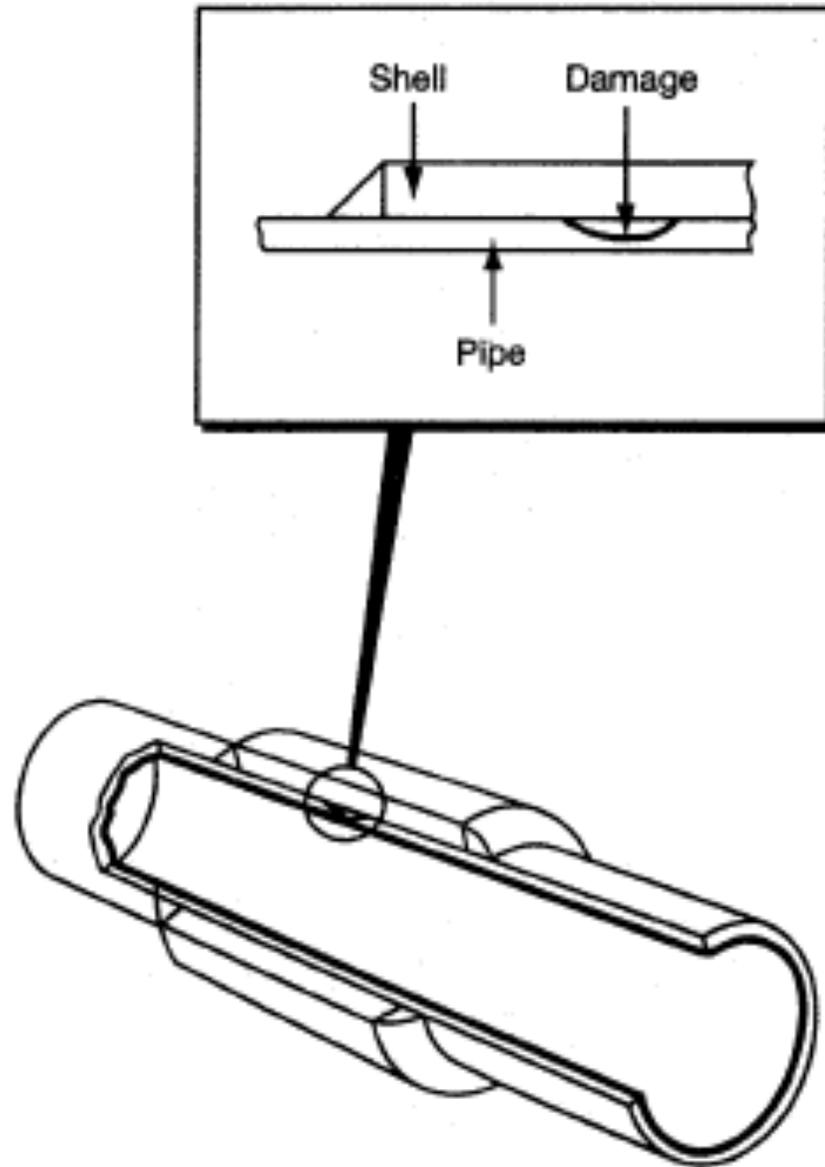


This method is suitable for the repair of most types of pipeline damage, including dents, gouges, cracking and combinations of these.

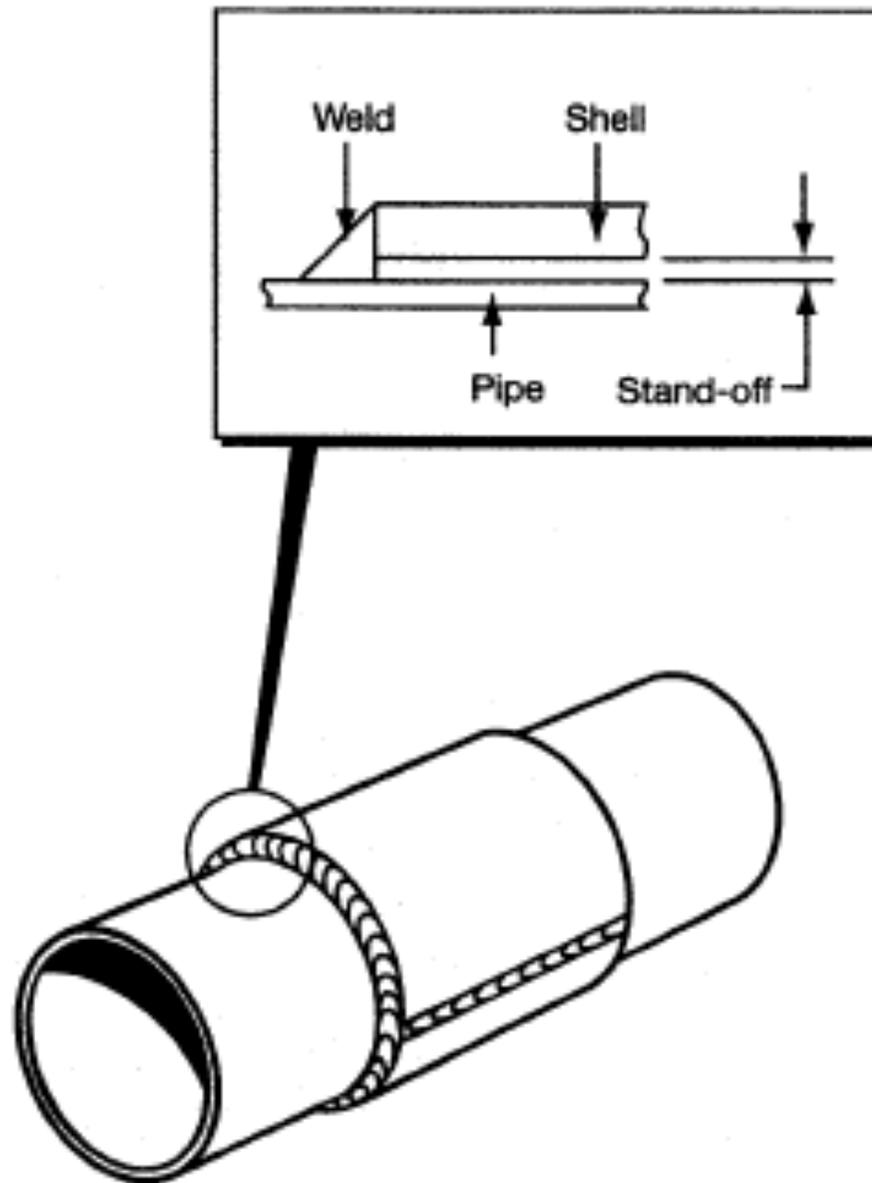
Epoxy filled sleeve – flanged version



Snug fitting welded shell



Stand-off welded shell



Hot tap

A hot tap can be used to remove a coupon of material containing the defect.

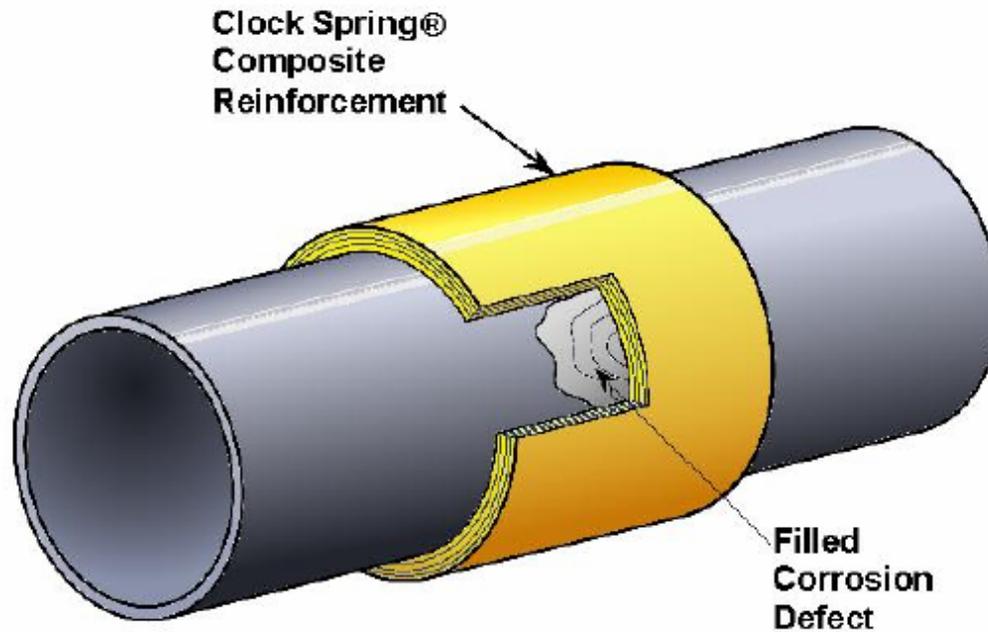
Hot tap is welded to the pipeline and is left permanently attached to the pipeline.



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Composite repairs



Clock Spring

WrapMaster

TDW Black Diamond

Leak clamps - Plidco



Concluding remarks

Piggable pipelines

- ◆ High resolution MFL widely used to detect metal loss
- ◆ Increasing use of high resolution geometry/deformation tools

Un-piggable pipelines

- ◆ Traditional above ground surveys (CIPS, Pearson) have limitations
- ◆ Supplementary techniques can extend coverage

Main causes of damage

- ◆ External interference most likely cause of loss of gas incidents
- ◆ Construction defects/material failures and corrosion

Repair techniques

- ◆ Epoxy filled sleeve – versatile and widely used