1st 2012

IGU WOC3 and

WOC3

Study Group Meeting

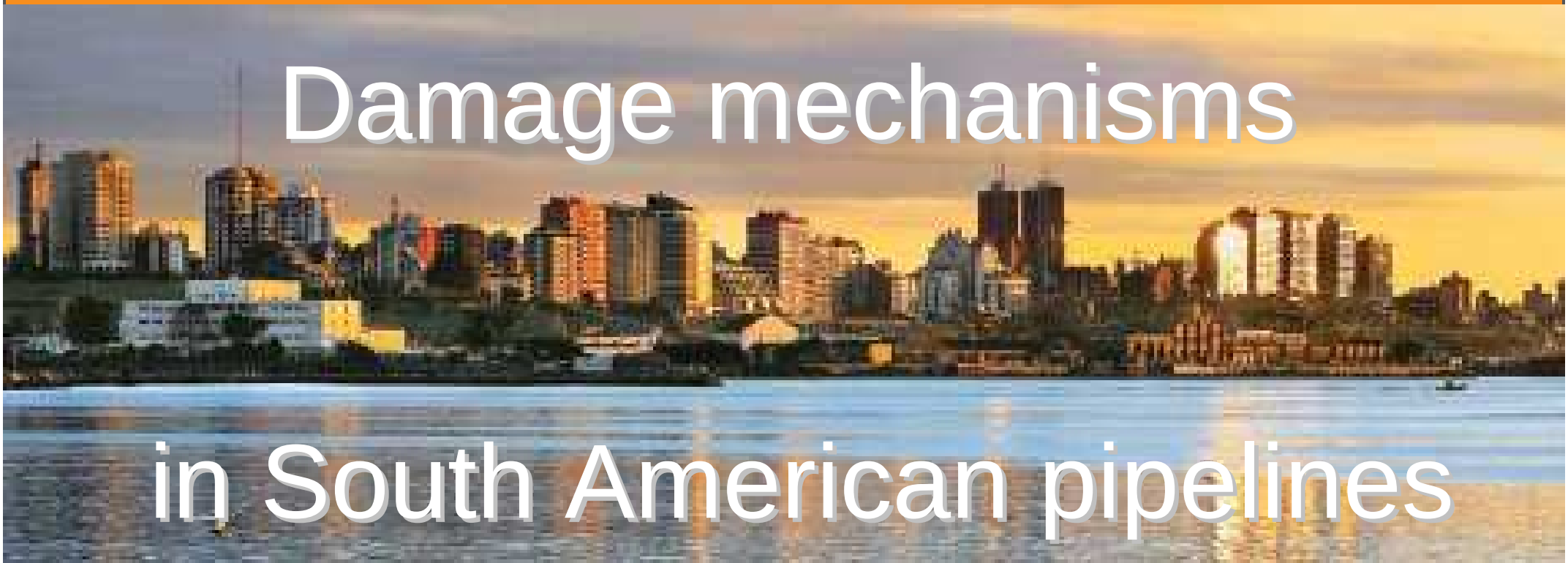
Asset Integrity Management

www.giemdp.com.ar

October 24th - 26th, 2012

Mar del Plata

Buenos Aires, Argentina



Damage mechanisms

in South American pipelines

Damage mechanisms

in South American pipelines

GIE experiences

José Luis Otegui, Ph.D

Damage mechanisms in South American pipelines

A.- Argentina: Old Pipelines in stable ground:

1. SCC
2. ERW and old repairs
3. Fatigue and other mechanisms
4. Materials identification: ABI

B.- Peru- Ecuador - Colombia: new pipelines in unstable soil

1. Pipe – soil interaction models
2. Instrumentation and monitoring
3. Urban soil

C. – Chile: new LNG facilities

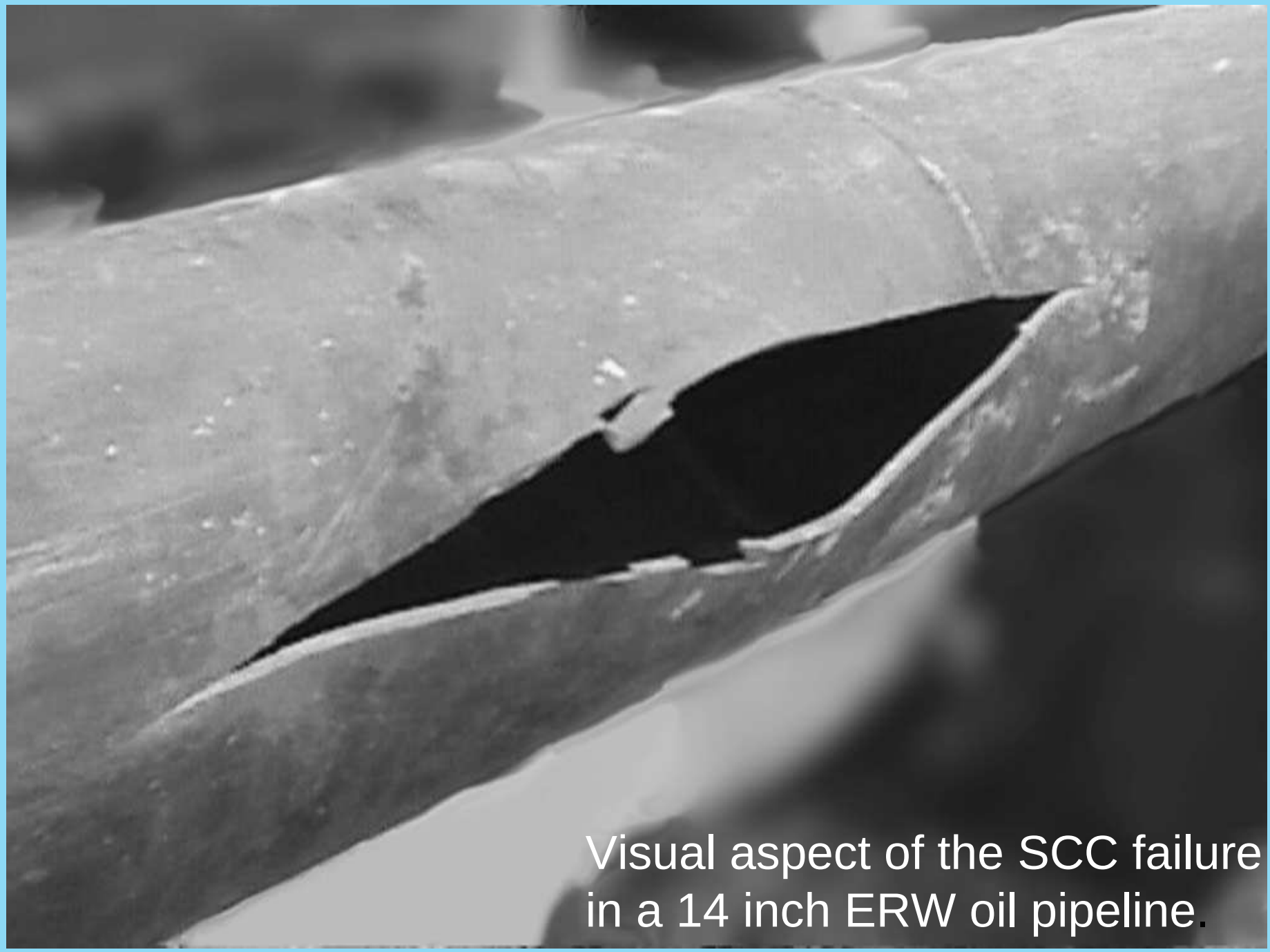
Repairs in cryogenic equipment

Failures by SCC in buried pipelines

Engineering Failure Analysis 9 (2002) 495–509

Until the 1990´s there had been no record of stress corrosion cracking (SCC) as a main cause of failures in Argentine pipelines, but as the pipeline system became of a certain age this mechanism started to have an important impact on reliability.

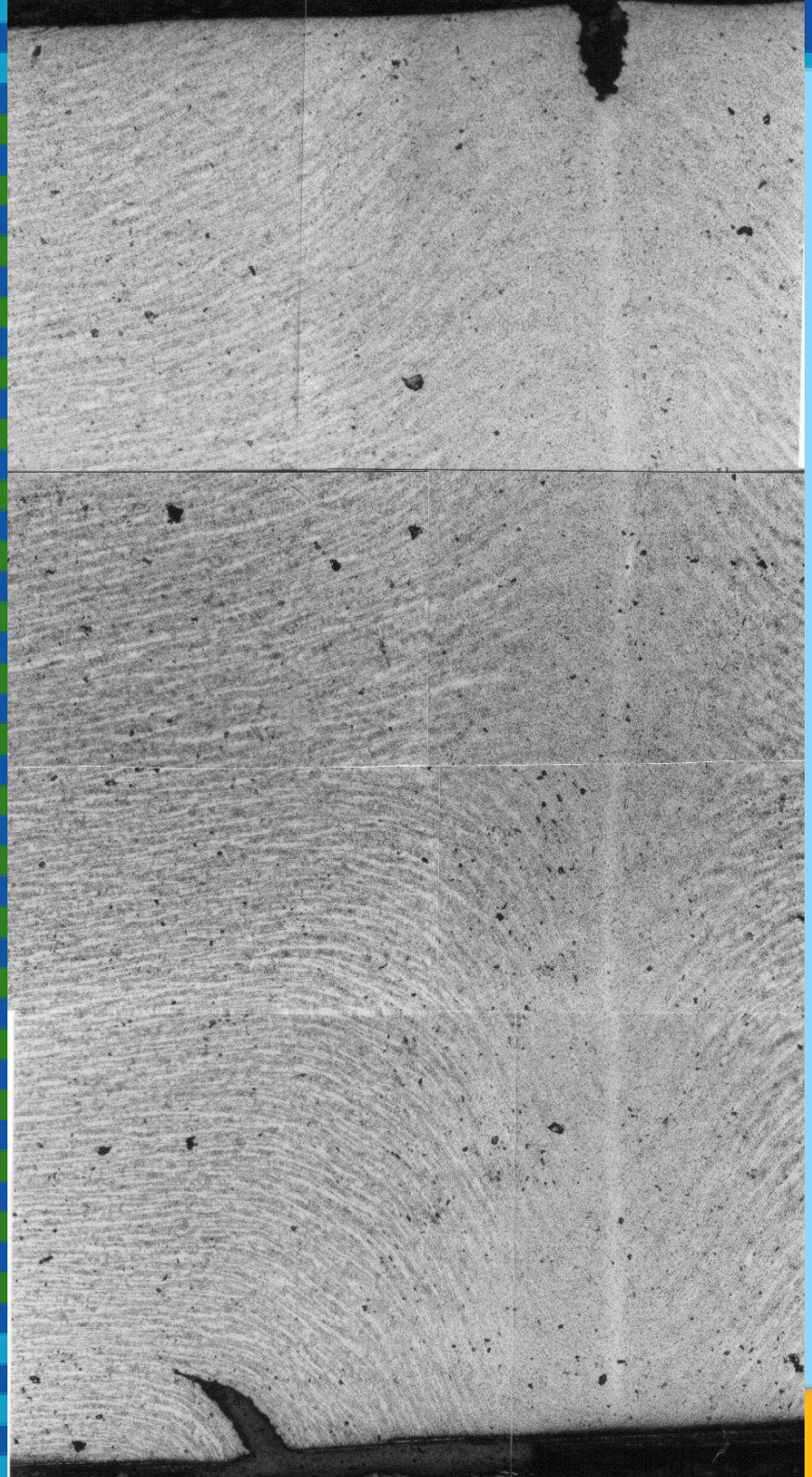
Several blowouts attributed to high pH SCC in different oil and natural gas transmission pipelines, which occurred by the sudden propagation of longitudinal cracks at the outer surface of the pipes.



Visual aspect of the SCC failure in a 14 inch ERW oil pipeline.

Failure in a natural gas pipeline, 23 km downstream from the closest compressor station.

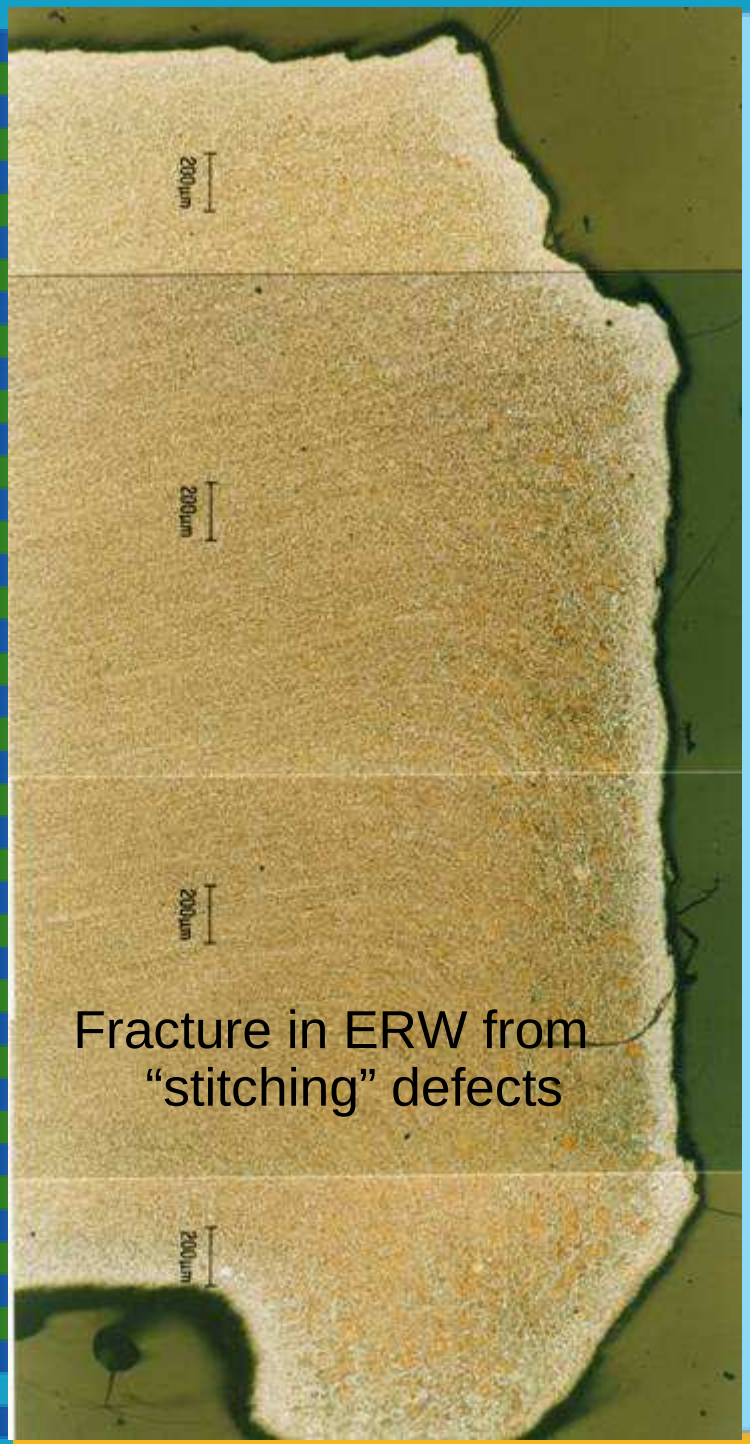
Secondary cracks: colony.



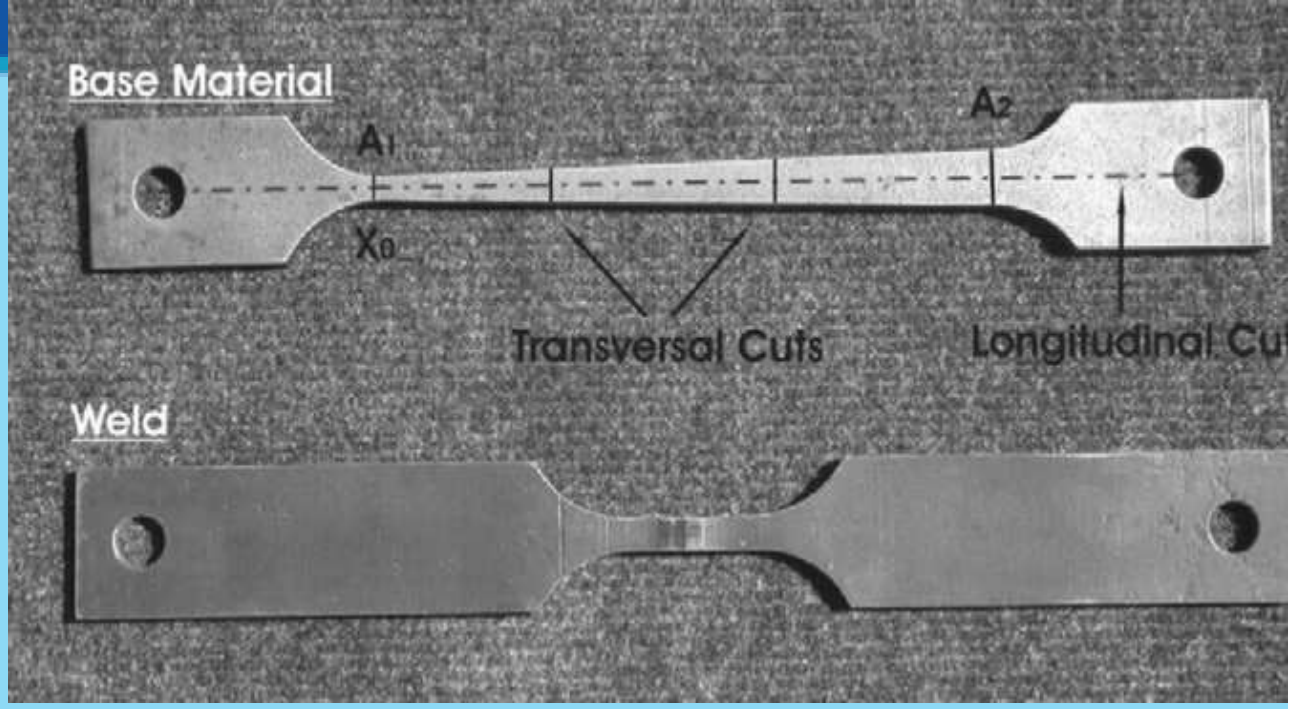
Old Pipelines in stable ground: ERW and old repairs

DEALING WITH LOW-FREQUENCY-WELDED ERW PIPE

(John F. Kiefner) Epecial integrity assessments l made to address potential seam-defect problems in lo frequency-welded ERW (electric-resistance-welde pipe materials, in high consequence areas.



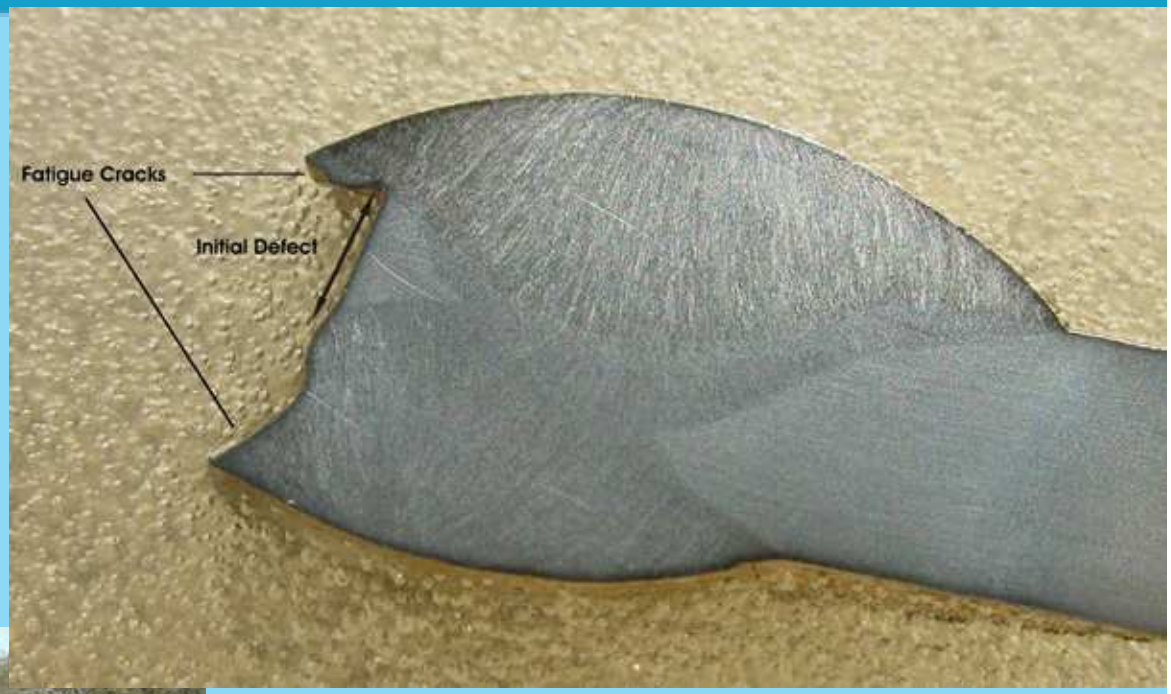
Fracture in ERW from "stitching" defects

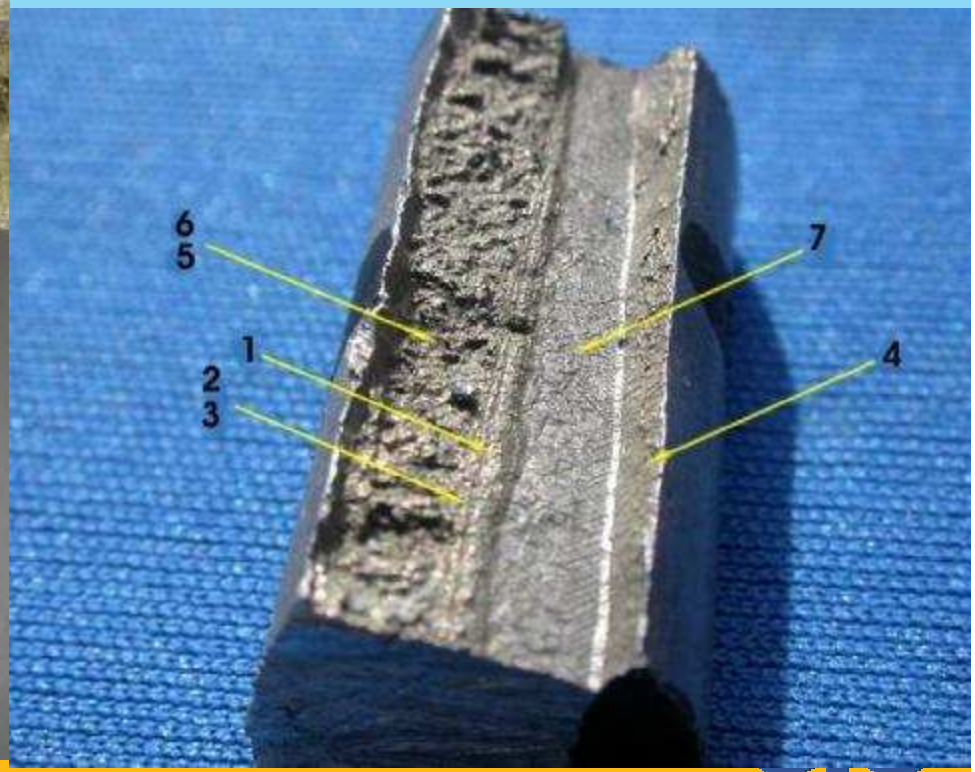


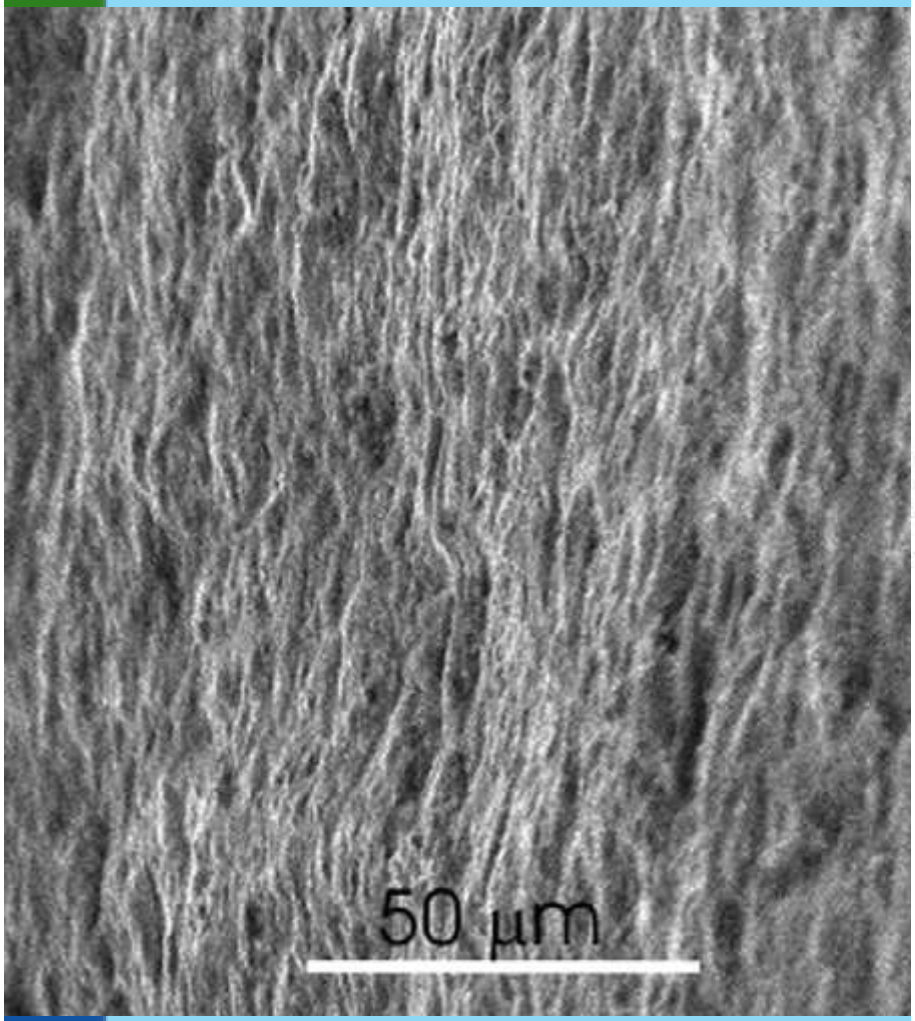
Experimental determination of stress corrosion cra rates and service lives in a buried ERW pipeline
Intl J. Pressure Vessels and Piping 84 (2007) 739–748

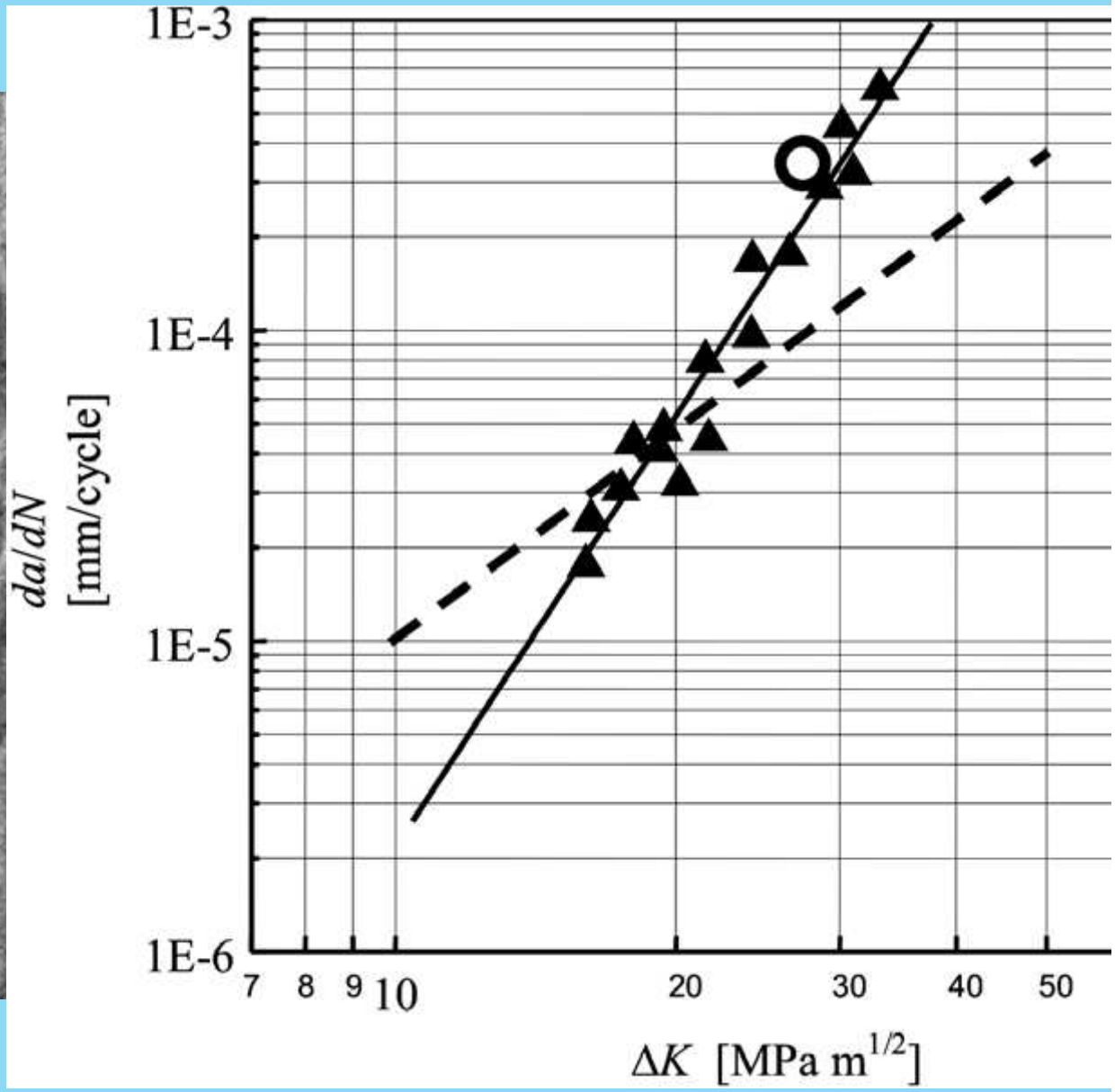
Fatigue assessment of a double submerged arc welded gas pipeline

International Journal of Fatigue 29 (2007) 1115–1124






50 µm

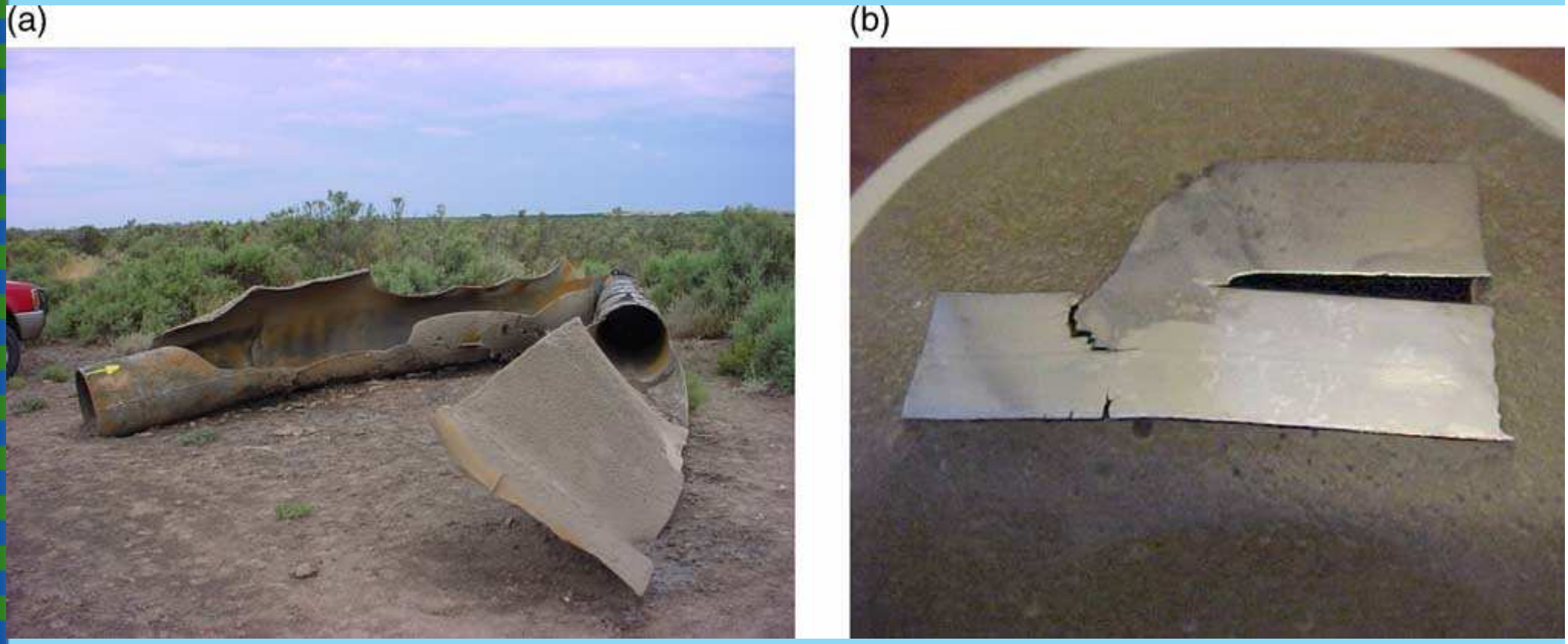

1E-3
1E-4
1E-5
1E-6
da/dN [mm/cycle]
7
8
9
10
20
30
40
50
ΔK [MPa m^1/2]

Weld failures in sleeve reinforcements of pipelines
J.L. Otegui et al . Engineering Failure Analysis 8 (2001) 57±73

Influence of multiple sleeve repairs on the structural integrity of gas pipelines.
J.L. Otegui et al, Intl J.Pressure Vessels & Piping 79 (2002) 759–765

A tract of pipe with multiple sleeve repairs being prepare for hydrostatic burst testing.

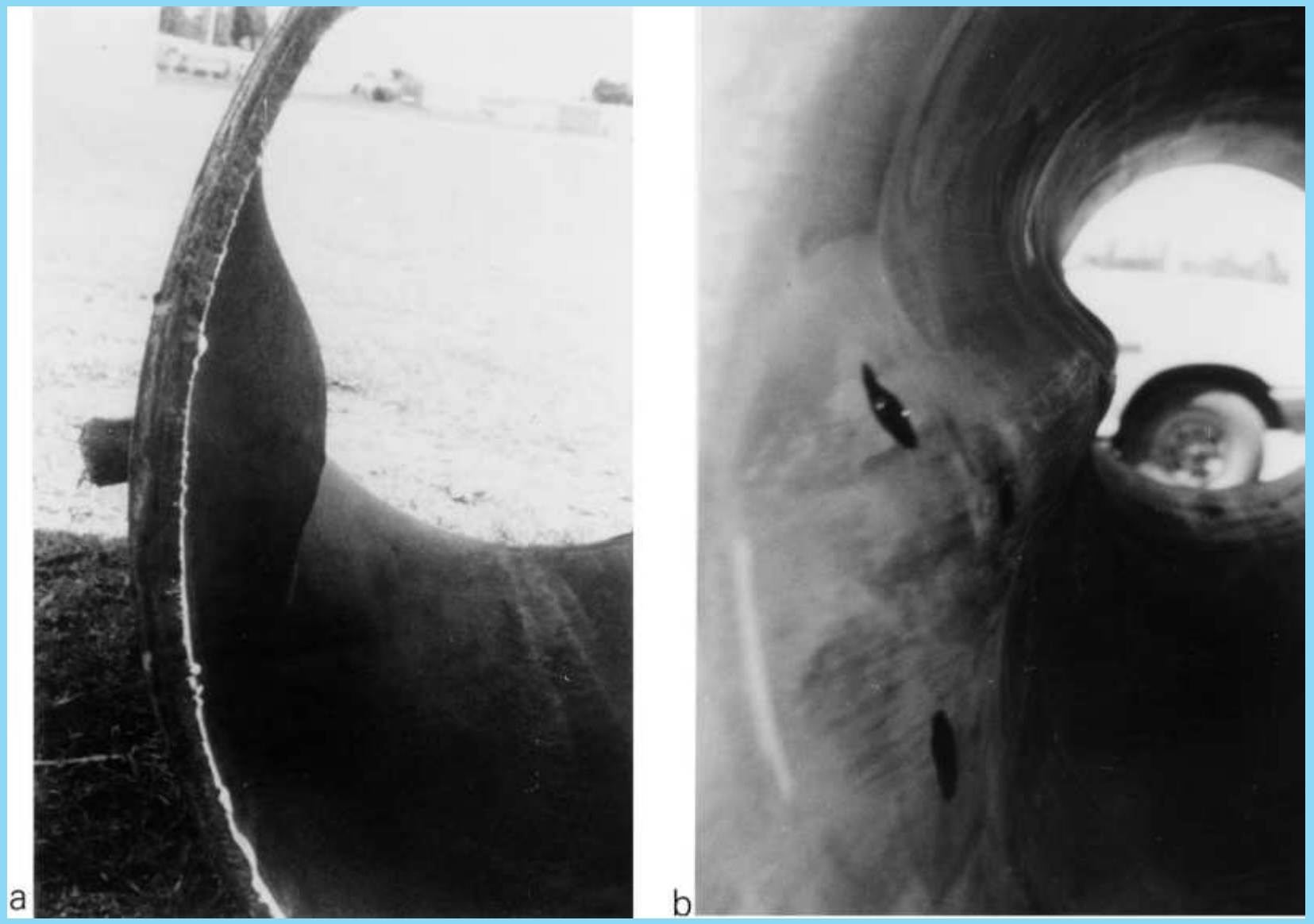
Influence of old rectangular repair patches on the burst pressure of a gas pipeli
International Journal of Pressure Vessels and Piping 83 (2006) 27–34



Burst of a 24 in. gas pipeline, started by a rectangular repair patch.

Local collapse of gas pipelines under sleeve repairs

International Journal of Pressure Vessels and Piping 77 (2000)

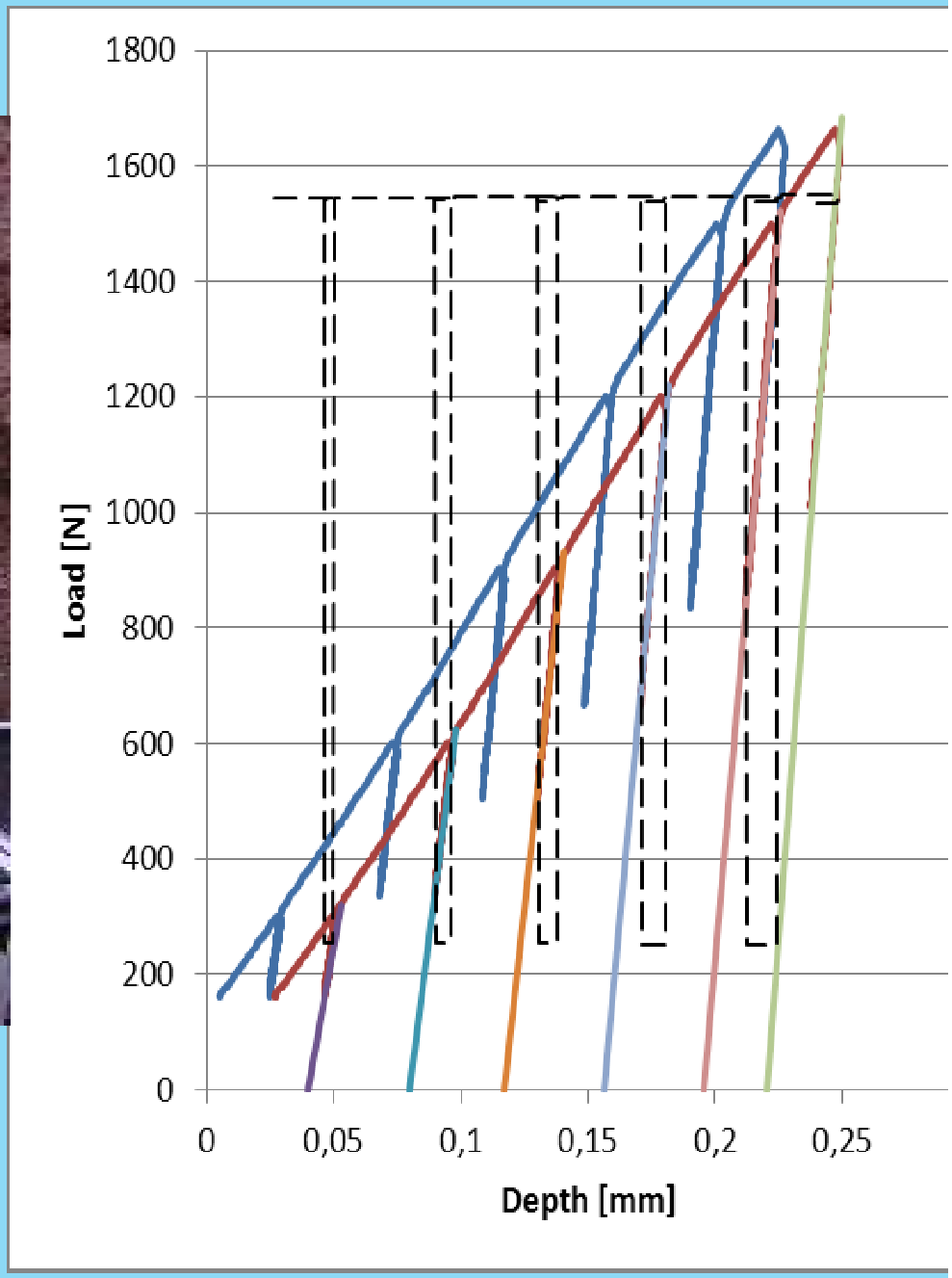


Old Pipelines: Materials identification

Major Argentine gas transportation companies operate old (1960`s) pipelines built and operated by the State.

After privatizations in the 1990´s, they have faced problems in assuring fitness for purpose due to lack of information about pipe materials.

ABI (automated ball indentation) is a non destructive test designed to determine yield stress of line pipes, thus allowing characterizing pipe strength.


1800
1600
1400
1200
1000
800
600
400
200
0
Load [N]
0
0,05
0,1
0,15
0,2
0,25
Depth [mm]

ESYS 10

Mechanical Properties Acquisitor

Asset Integrity Management

www.qiemdp.com.ar

The **ESYS 10** is an instrumented indentor capable of taking in-field and lab measures of the parameters that characterize metals:

- YIELD STRESS
- TENSILE STRENGTH
- STRAIN HARDENING COEFFICIENT

How does it work?

The test consists of a spherical tip indentation, carried out in a few cycles, while load and displacement of the tip are registered through analog sensors of high precision and linearity. This data is then used to estimate the material parameters. The test lasts several minutes.

Advantages

Portable

It allows determining the mechanical properties of equipment with no need to put it out of service and move a simple to the lab.

It allows saving the costs involved in repairing the equipment, stopping the plant and profits

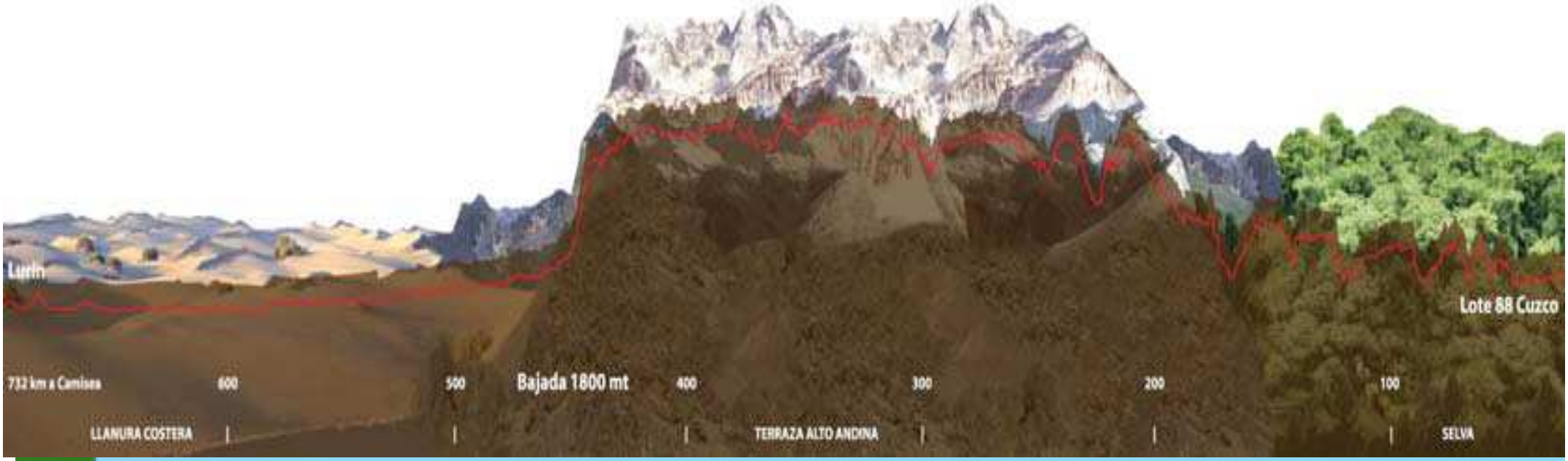
NDT

It is a NON DESTRUCTIVE TEST and it can be carried out, in most cases, while the equipment is operating.

Small specimens

Usually, tensile tests require specimens of a certain size that, additionally, need to be in good conditions. With the ESYS 10, tests can be carried out in small samples, such as nuts and pins.

Peru- Ecuador - Colombia: new pipelines in unstable soil



In jungle:

- Previously unknown conditions
- Steep slopes
- Heavy rains (5,000 mm rainfall in a four month period)
- Land slides
- Soil creep

PREDICTING FAILURE CONDITIONS OF SMAW GIRTH WELDED X70 PIPELINES SUBJECTED TO SOIL MOVEMENT.

IGU World Gas Conference, Buenos Aires, 2009.

No mandatory conditions for designing against axial loads in current standards

José Luis Otegui, Ph.D.

Cases Investigated

- 14” NGL Pipeline in Amazon Basin
  (three failures)

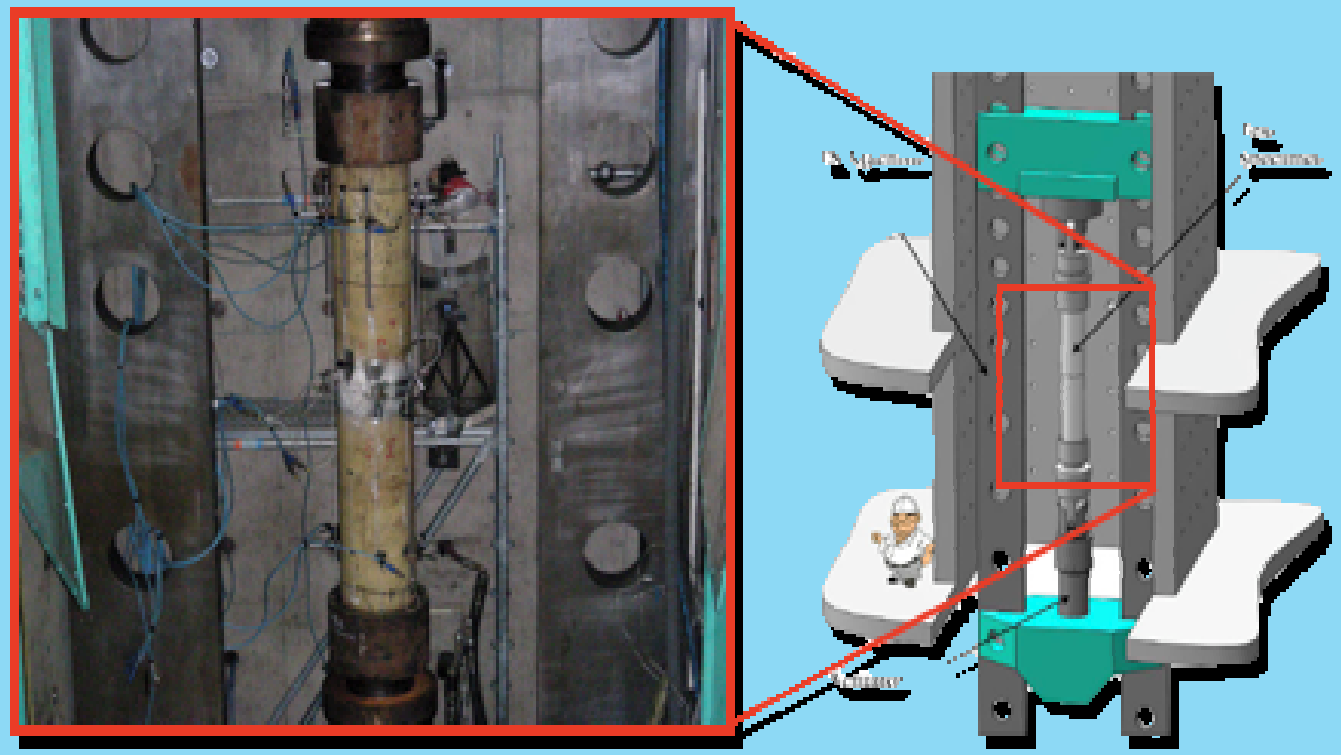
- 20” NG Pipeline in High Mountain
  (during re-routing maneuvers)

- 30” NG Pipeline in a Tropical, dry region
  (pipeline crossed a geotechnical fault)

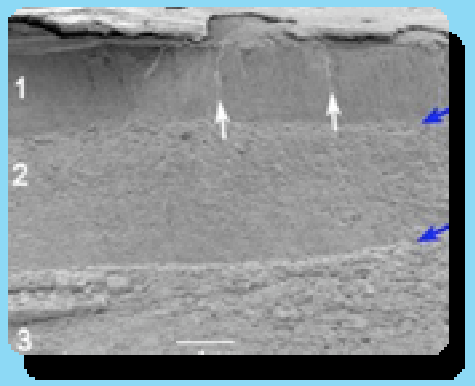
- 24” Oil Pipeline in Tropical forest
  (buckles)

- Gas pipeline in urban soil

Full scale Tests - Staged Cracking



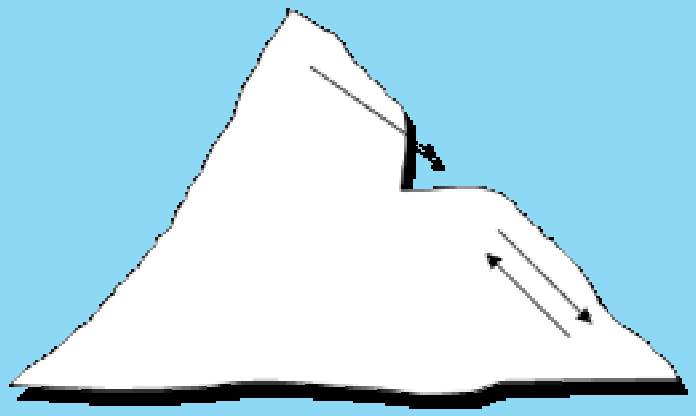
Case 1 - fracture surface



Full scale test - fracture surface

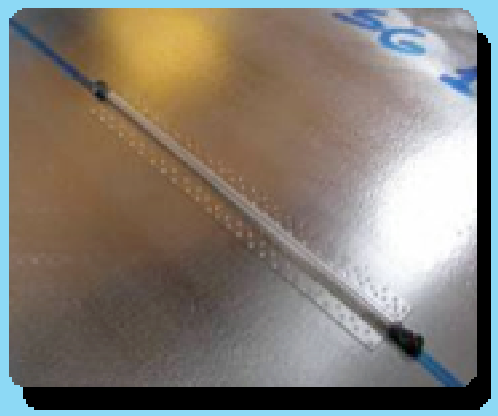
Staged cracking is believed to be caused by progressive soil movement and inhomogenities of the HAZ.

Model of the movement of the ground

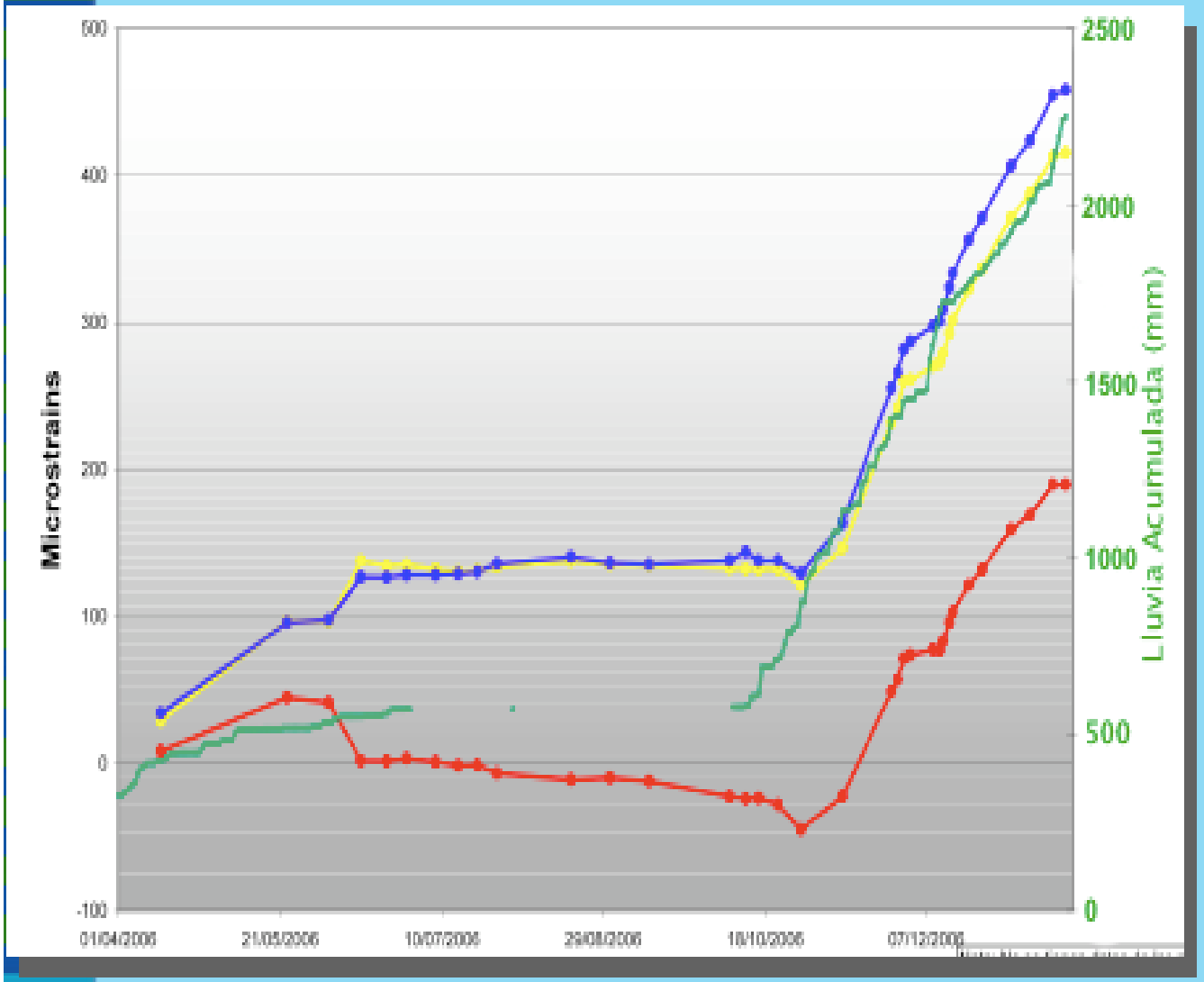


Instrumentation of critical areas

Instrumentation of critical areas



Instrumentation of crytical areas



High Risk zones

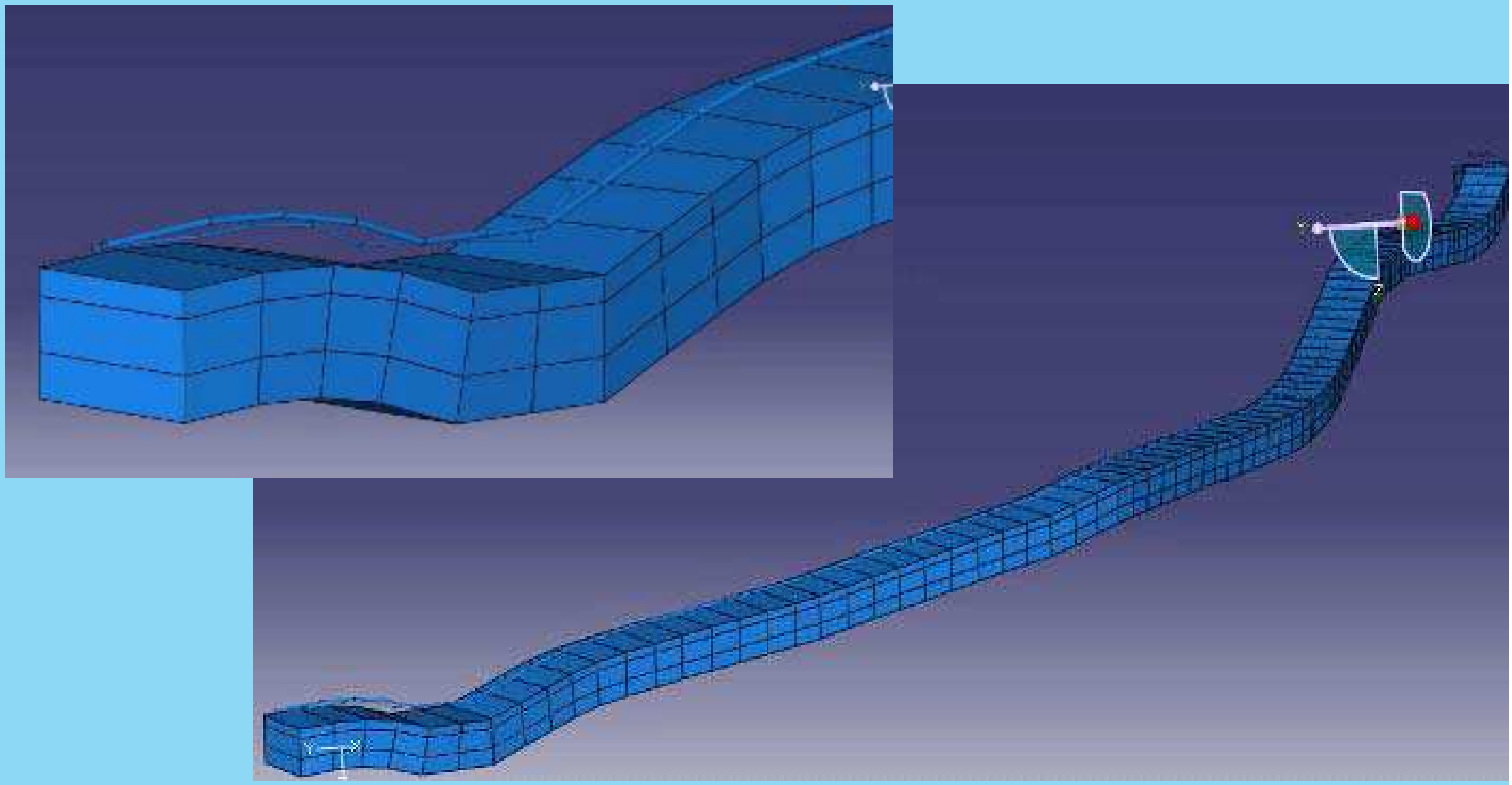
Vibrating wir strain gage instrumentatic

Strains

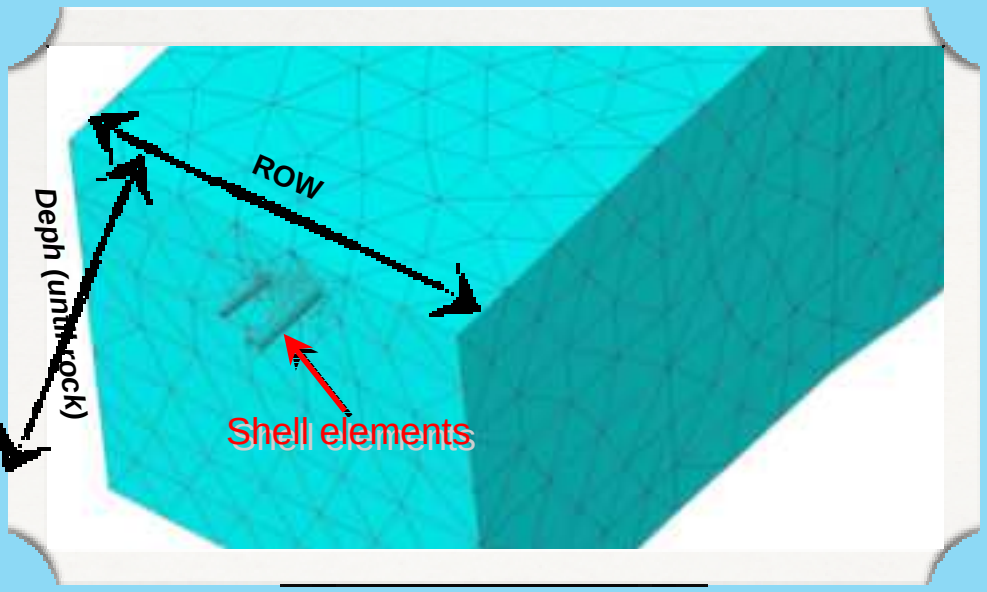
+

Rigid Body Displacements

Nonlinear FEM strategies for modeling pipe–soil interaction
Engineering Failure Analysis 24 (2012) 46–56



Modeling Soil-Pipe Interaction



The Model includes criteria to be used for acceptable corrosion and external damage

Allows Moleling and defining:

- **multiple materials, steel pipes, mud elements and rock.**
- **behavior of metals, rocks and mud, according to geotechnical measurements**
- **conditions of contact mud – pipe.**

Modeling Soil-Pipe Interaction

Conditions of drainage:

- **State of ground saturation is important for slope stability**
- **Conditions based on seasonal conditions and works of drainage.**
- **Displacement differentials by layers: sliding of the lower layer would drag the upper ones**

Boundary conditions:

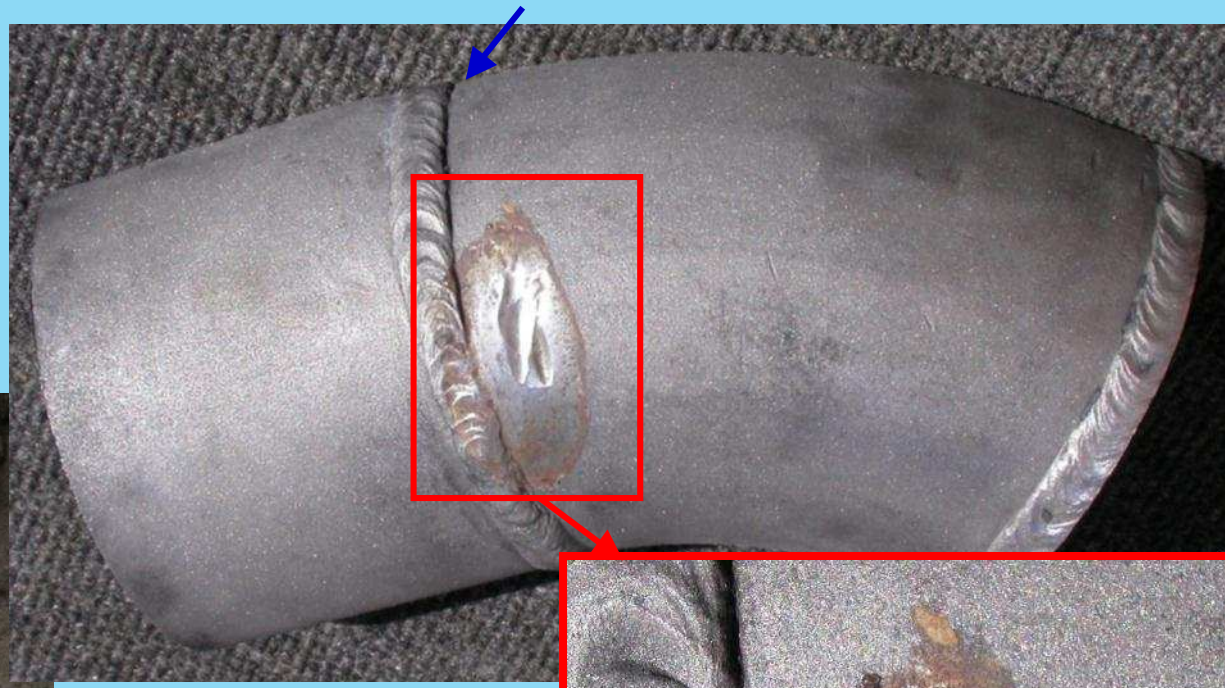
- **Extreme fixed points**
- **External lateral displacements throughout both faces: induced by rotational sliding of the bordering slopes that affect on the produced ones by weight own throughout the track.**

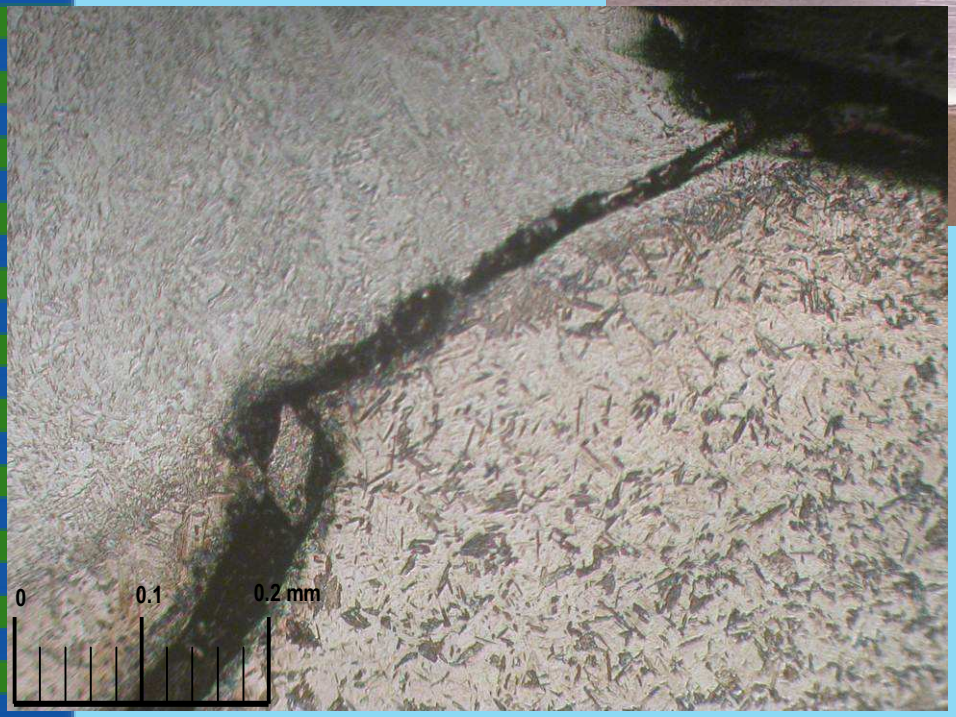
Scenes to model

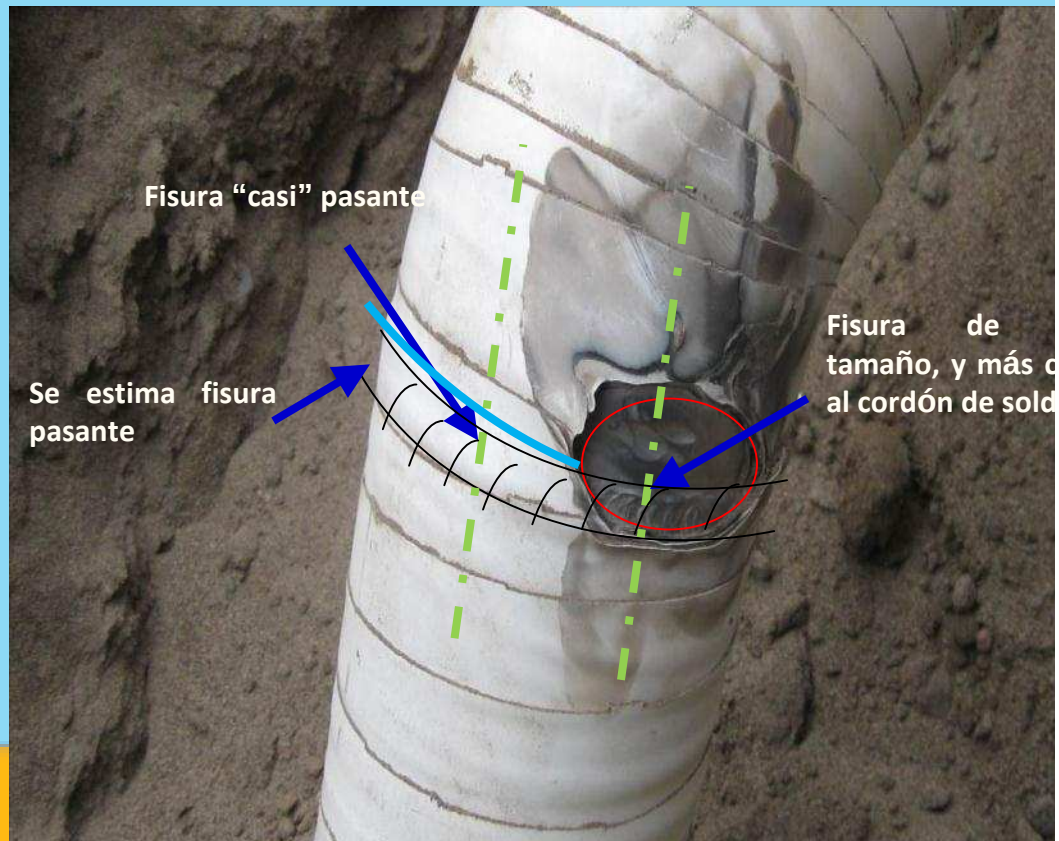
- Initial condition up to failure: focuses in the simulation of what happened, in order to validate models and coefficients.
- Present situation: is oriented to assess the effectiveness of interventions already made, with the validation by means of inclinometers, strain gauges, etc.
- Future scenes: focuses in simulating actions to take, based on the previous results, using the model as a prediction tool.

Gas pipeline leakage in urban subsurface soil.

Procedia Materials Science
Vol.pp. 289 – 296; 2012





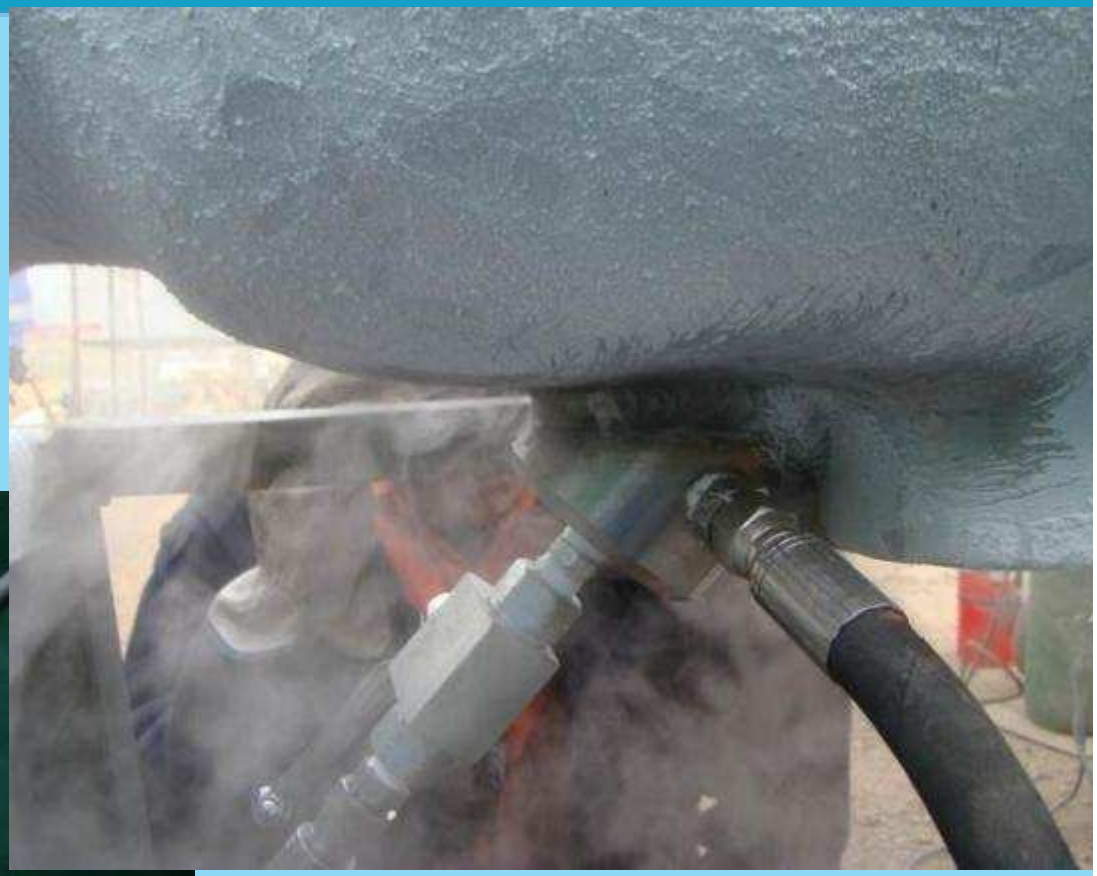


José Luis Otegui, Ph.D.

Chile has only very recently become involved with Natural Gas energy, with the Quintero LNG regassification plant.

- Most cryogenic pipes made of austenitic 316L steel.
- Up to now, they have had minor incidents, related to small leaks.
- Placed in a maritime + industrial environment (Cl and S)
- Corrosion leaks in thin bellows.
- Leaks in flexible hoses (to trucks) and connection to ship
- Leak in threaded plug in ball valve.

Simulated in-service repair of a leaking threaded plug in a cryogenic LNG ball valve (-160ºC)



Asset Integrity Management
www.giemdp.com.ar

José Luis Otegui
jotegui@giemdp.com.ar

THANK YOU!

If You have further comments or questions, please send me an e-mail