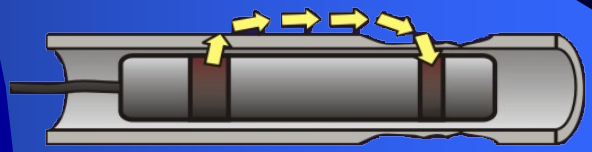
Overview of Inspection Technologies

for Geotechnical Hazards.

Russell NDE Systems Inc.
4909-75 Ave. NW
Edmonton, Alberta, Canada

2016-08-30 - A. Shatat.



Introductions…

Russell NDE was incorporated in 1972, and we are a small but very active group.

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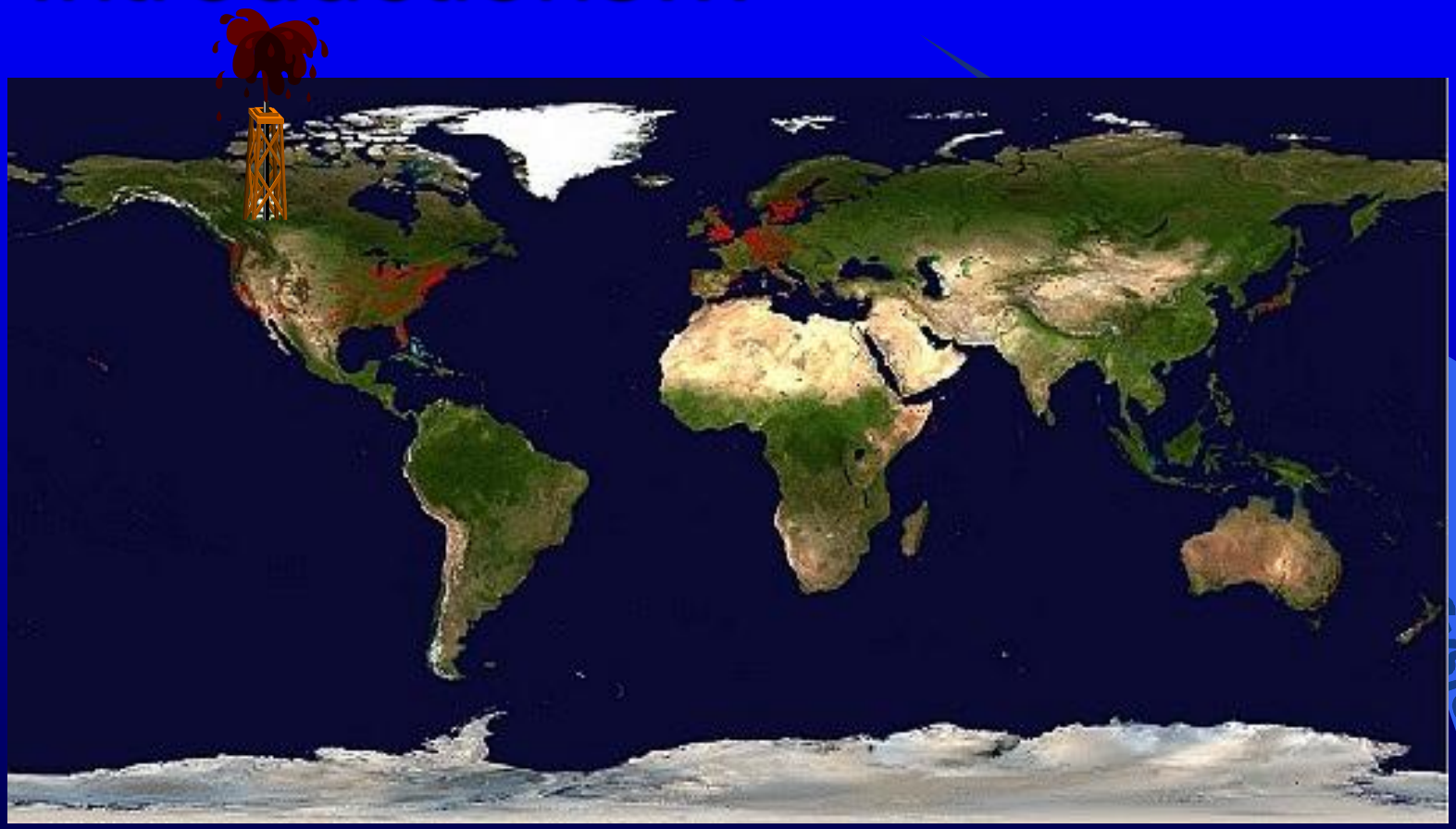

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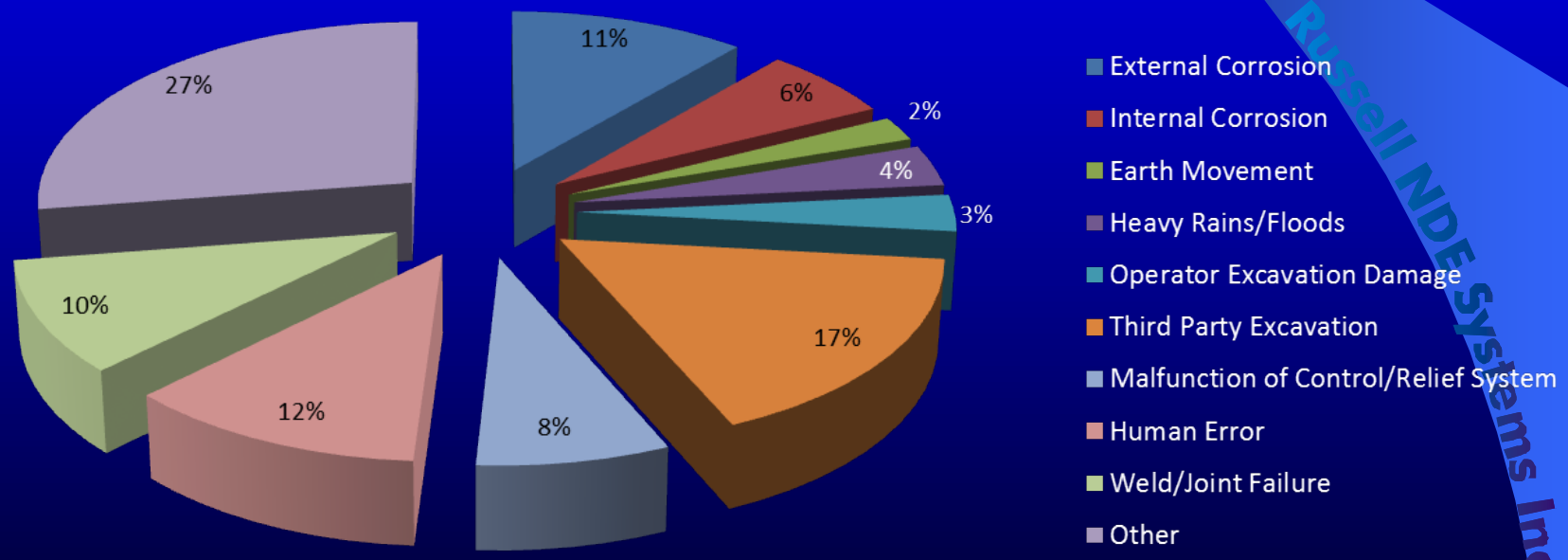
Pipeline Incidents in US

- 321,000 miles (~516,000 km) of natural gas transmission and gathering pipelines.
- PHMSA data from 2002-2009 showed that during that eight-year period, there were 1,032 reportable natural gas piping incidents.
- This equates to 0.0004 incidents/mile/year!

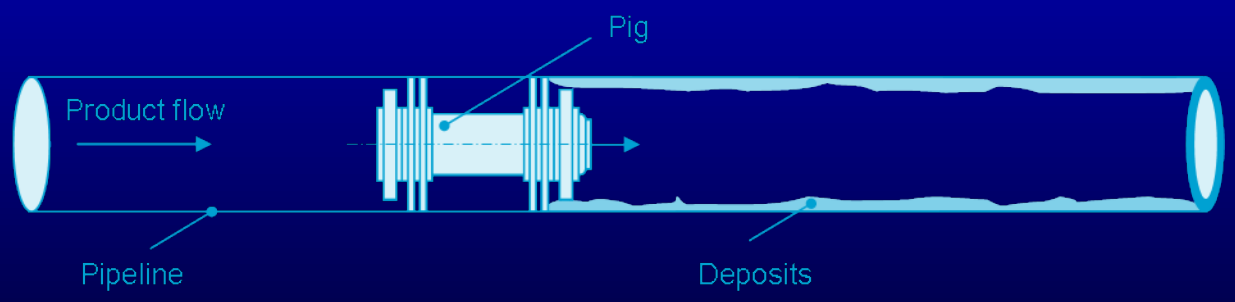
Gas Pipeline Incident Causes

- Focusing on the on-shore reported incidents, the incidents break down as follows:



Pipeline “pigs”.

- A pig is device that is inserted into a pipeline and travels throughout the length of a pipeline driven by flow. They can have many different purposes, like removing deposits, collecting magnetic debris, measuring the pipe diameter etc.



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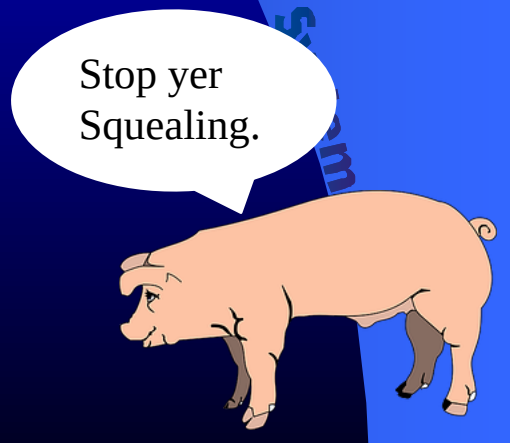


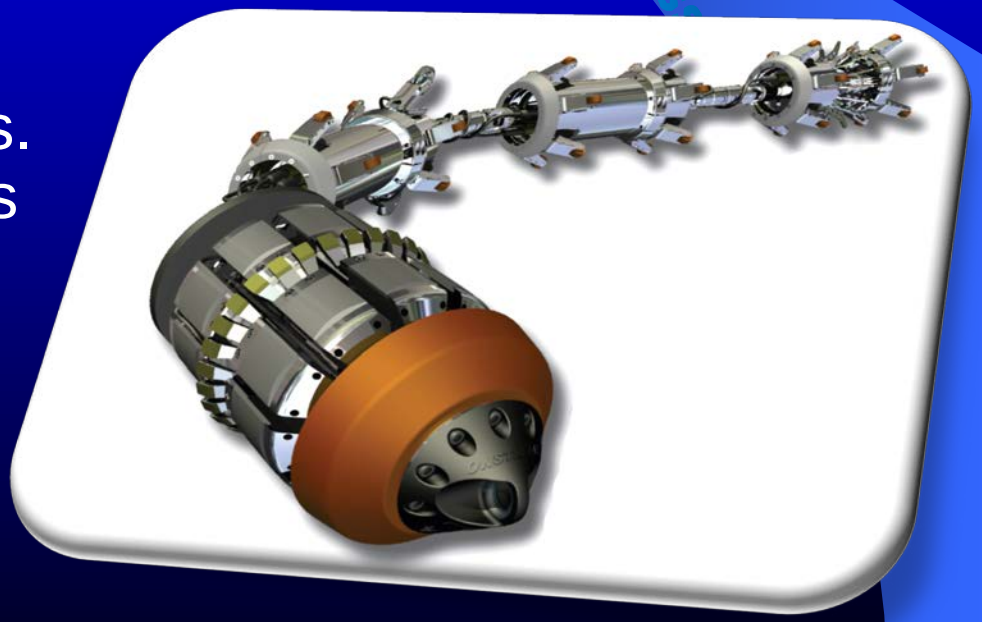
“Smart” Pigs

- PIGs fitted with sensors, electronics, battery power and storage to gauge the health of pipelines.
- These are “State of the Art” devices that must be able to withstand high pressures, vibrations, and aggressive chemicals.
- 50 years ago smart pigs could only handle straight pipe of one diameter at relatively low pressures.

Today's Smart Pigs

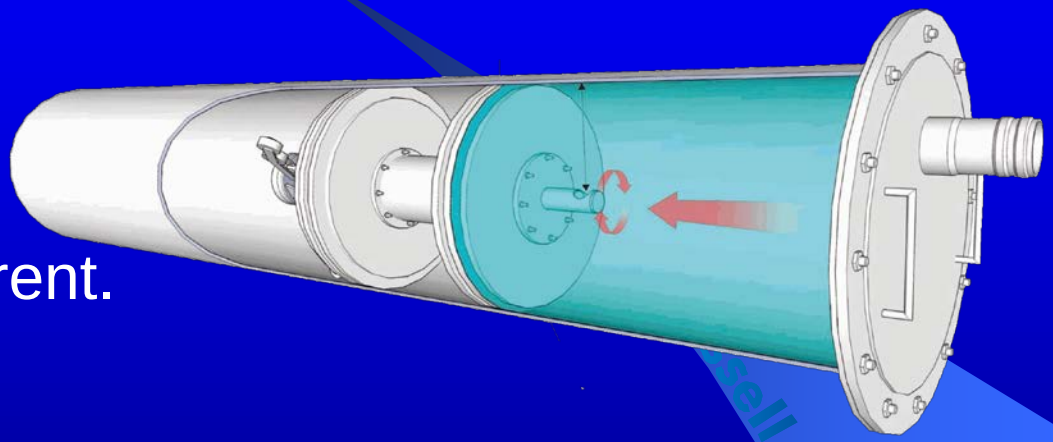
Can:

- Log over 1000km in a single run.
- Handle environments over 4000 psi (275 bar).
- Go around sub 1D elbows.
- Actively control their speed.
- Handle high temperatures.
- Handle Multiple diameters
- Work through Internal Liners and Scale.



Types of “Smart” Pigs

- Magnetic Flux Leakage.
- Transverse MFL
- Ultrasonic.
- Remote Field Eddy Current.
- Calipers.
- Inertial/Geometry.
- ID/OD Proximity Discriminators.
- EMAT
- Leak detection
- Temperature and Pressure logging.
- Video Inspection
- Other: upcoming non-mainstream technologies for coating holiday inspection, SMYS measurement, etc.

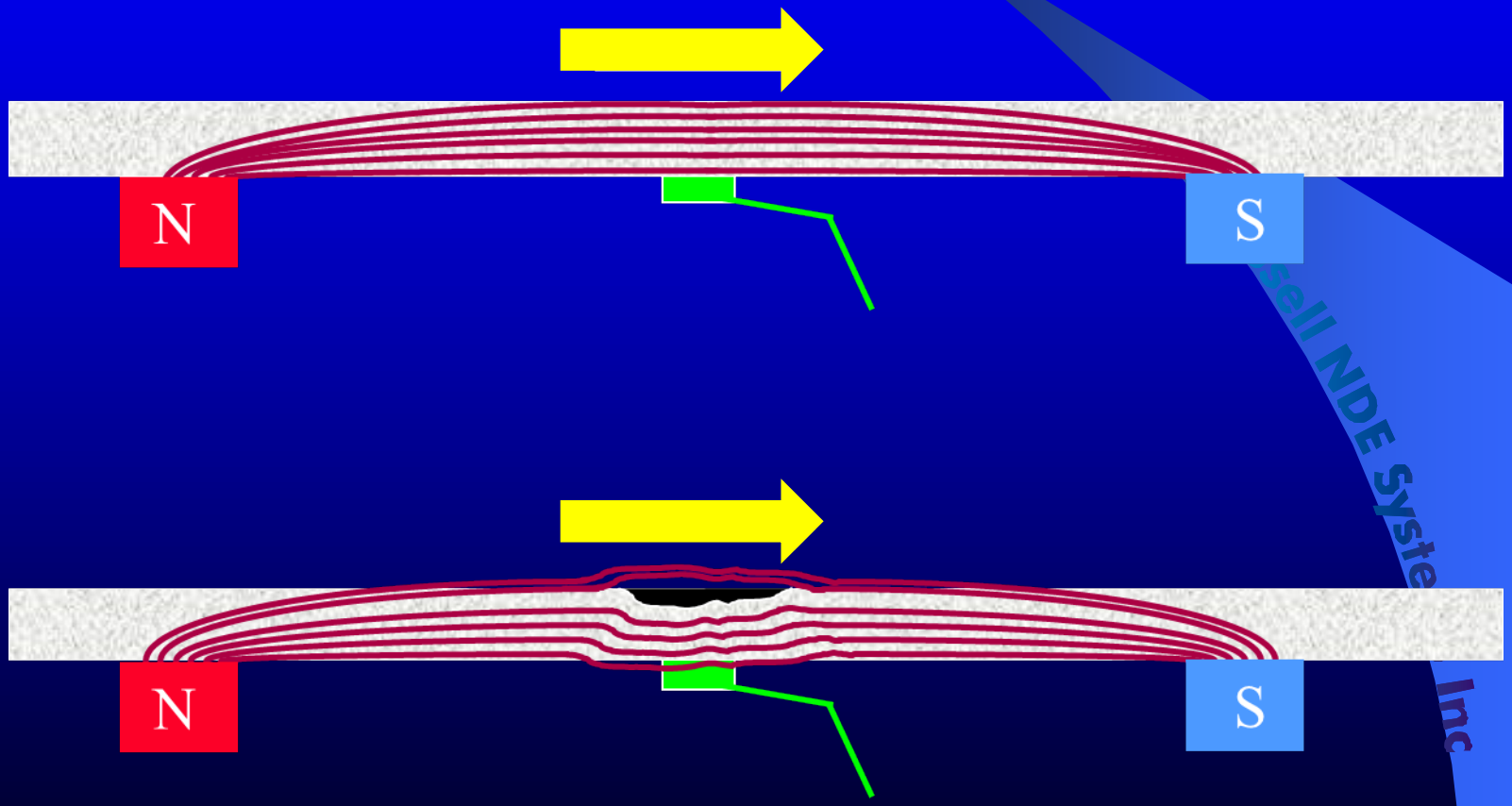


Challenges Imposed by Gas Lines

- Dry (no liquid).
- Often low pressure/compressible gas complicating velocity control.
- Dangerous.
- Potential for tool damage (for example when navigating back to back elbows).

MFL Tools like to run between 1-3 m/s and are today's tool of choice for inspecting gas lines.

MFL – Used for finding Wall Loss



Why the Focus on corrosion detection?

- After third party damage (17+3=20%), corrosion (17%) is the largest threat to pipelines. As such the detection of corrosion pits was prioritized by pipeline operators.
- Operators learnt that in order to successfully prevent bursts, tools had to reliably quantify pit clusters (upped the requirements for tools).
- Stress related anomalies like stress corrosion cracking, and dents with wall loss/gauges were prioritized later.
- The above priorities took the stage….. quantifying stresses/strains also seemed a much more daunting task.

Understanding Stresses on pipes is gaining importance

In Canada:

- For unstable slopes and in geologically unstable terrain, but also:
- Frost heaving, and stresses caused by pipelines crossing permafrost and unfrozen ground.
- Concern is often wrinkling/buckling.

Understanding Stresses on pipes is gaining importance

Upcoming Technnologies:

- Strain Gauges (installed with new pipe or after commissioning).
- FibreOptic Monitoring (will also detect other parameters like leaks, 3rd party intrusion, etc).
  - Grating type
  - Brillouin Scattering
- Inertial Tools
- Magnetic Techniques:
  - Barkhausen Noise
  - Remote Field Testing
  - StressProbe

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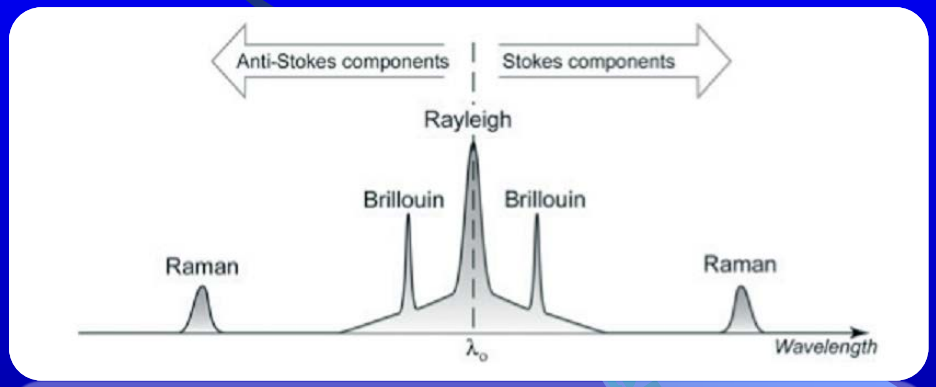
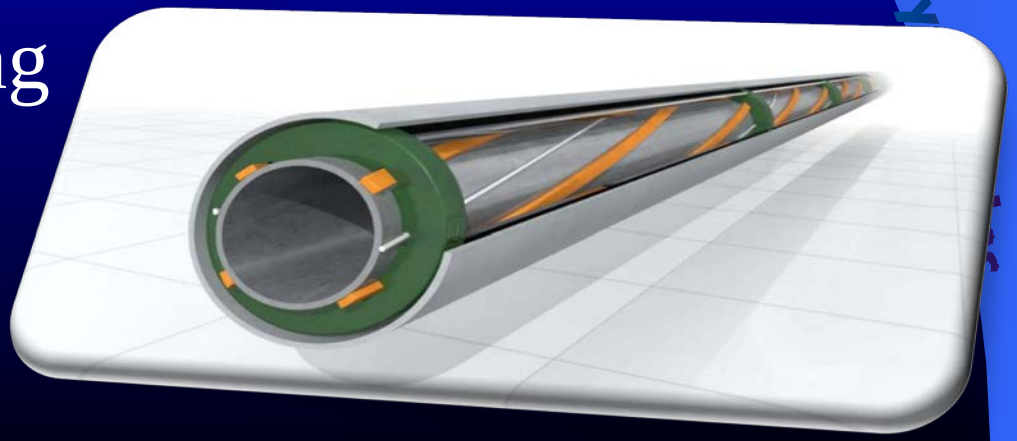
Fiber Optic Monitoring (Brillouin)

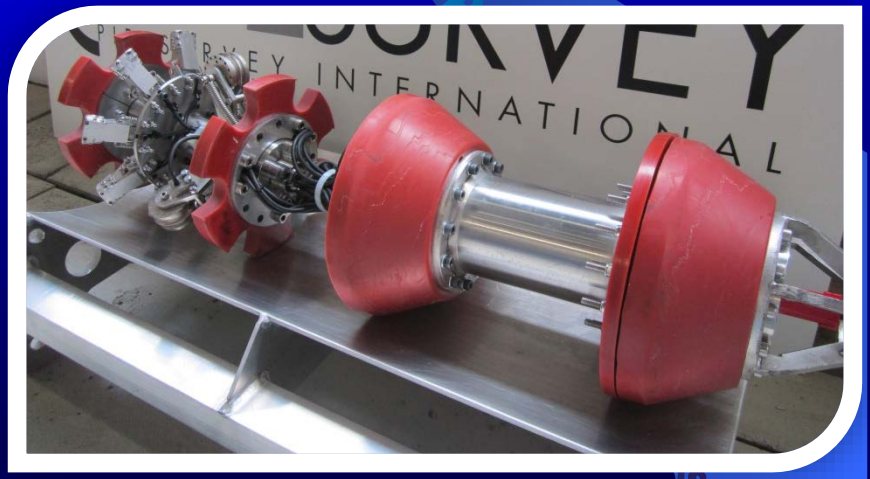
- Long Distances
- No power required
- Distributed
- Cheap (<$0.1/m)
- Robust
- Forward looking
- Omnisens





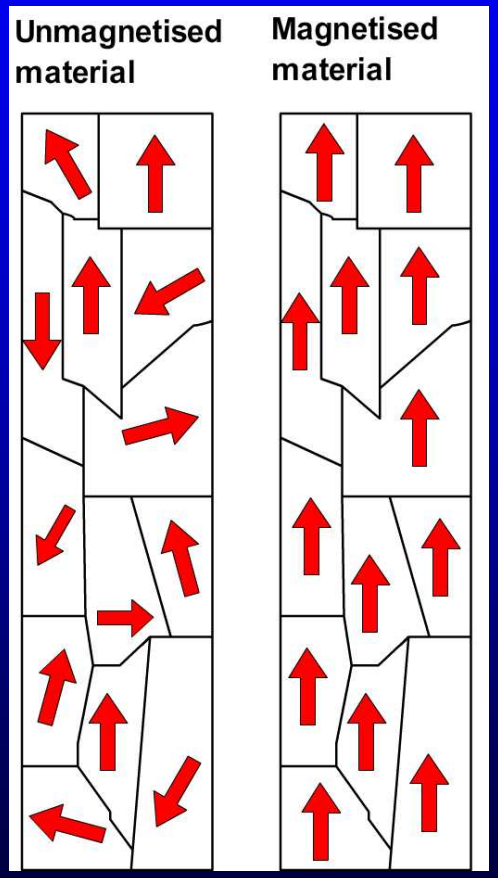
Inertial Tools

- Tools measure the centerline of the pipe using an inertial package.
- The pipeline health is monitored by routine inspections.
- By comparing current pipeline geometry to past logs, areas of strain can be identified.



- Typically does not work for axial strain.

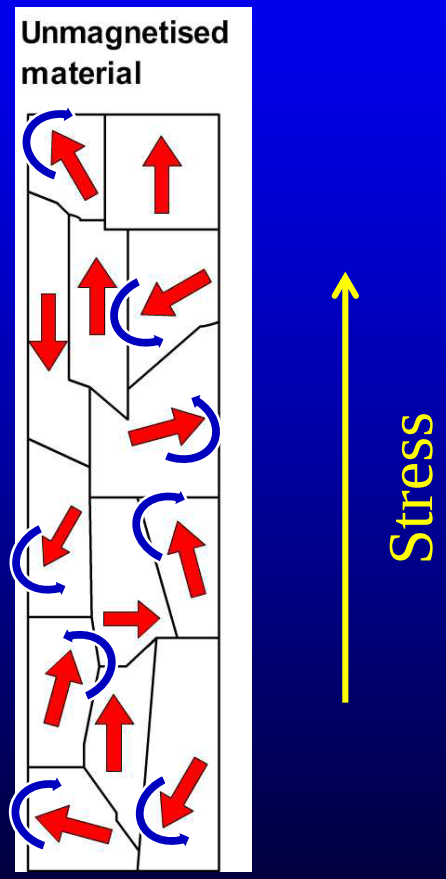
Barkhausen Noise



Are discreet steps in the magnetization process:

- A pick-up coil can register the domain wall movements as the applied magnetic field overcomes pinning sites.
- Barkhausen Noise is believed to occur mainly because of 180° domain wall motion.

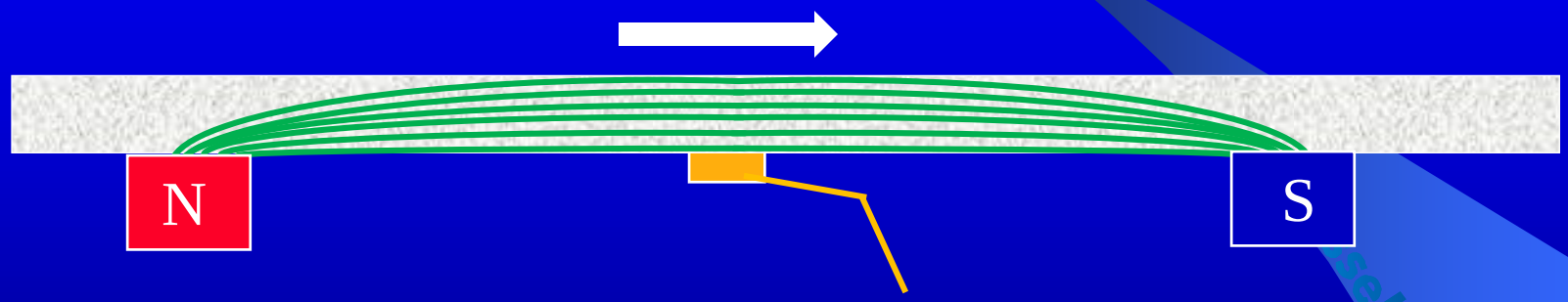
Barkhausen Noise and Stress



An applied stress aligns the magnetic domains along the stress direction:

- The number of 180° domains increases.
- The larger the stress the larger the Barkhausen Noise Signal.

Barkhausen Sensor Locations



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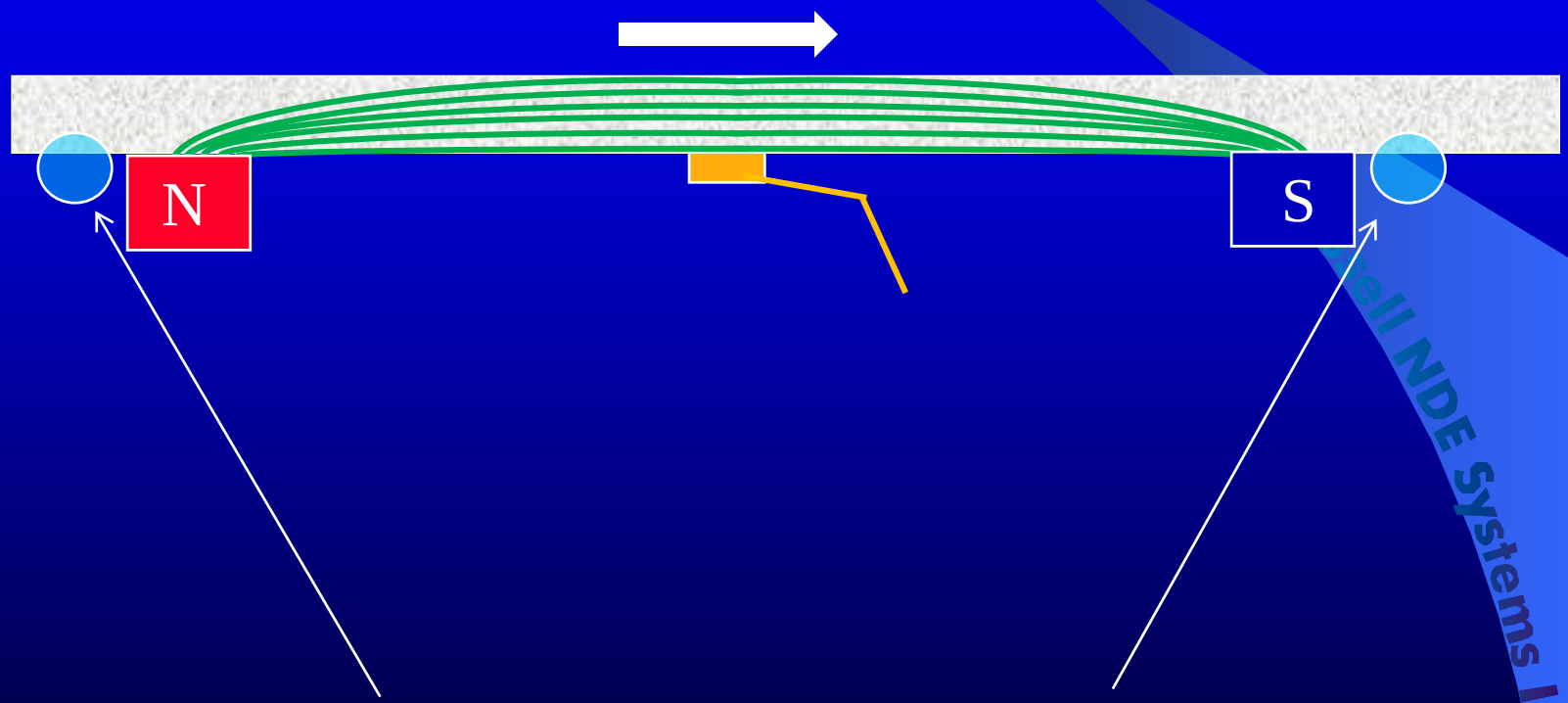


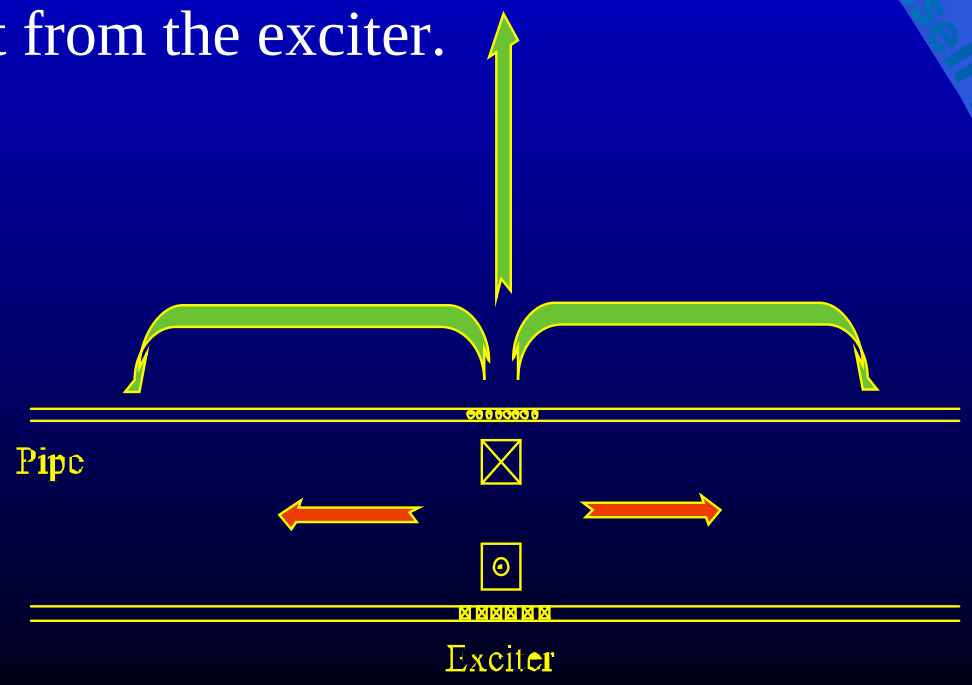
Areas of field change

Magnetostrictive Methods

- Rely on measuring the magnetic properties of the pipe steel.
- StressProbe Tool:
  Free Swimming tool with high Frequency (5kHz) inducing coils to magnetise the Inside surface of the pipe and small sensing coils to measure changes in the magnetic field. Surface Magnetic Parameter.
- Remote Field Tool:
  Tool signals are a function of the wall thickness, electrical conductivity and permeability of the steel combined. Bulk magnetic parameter.

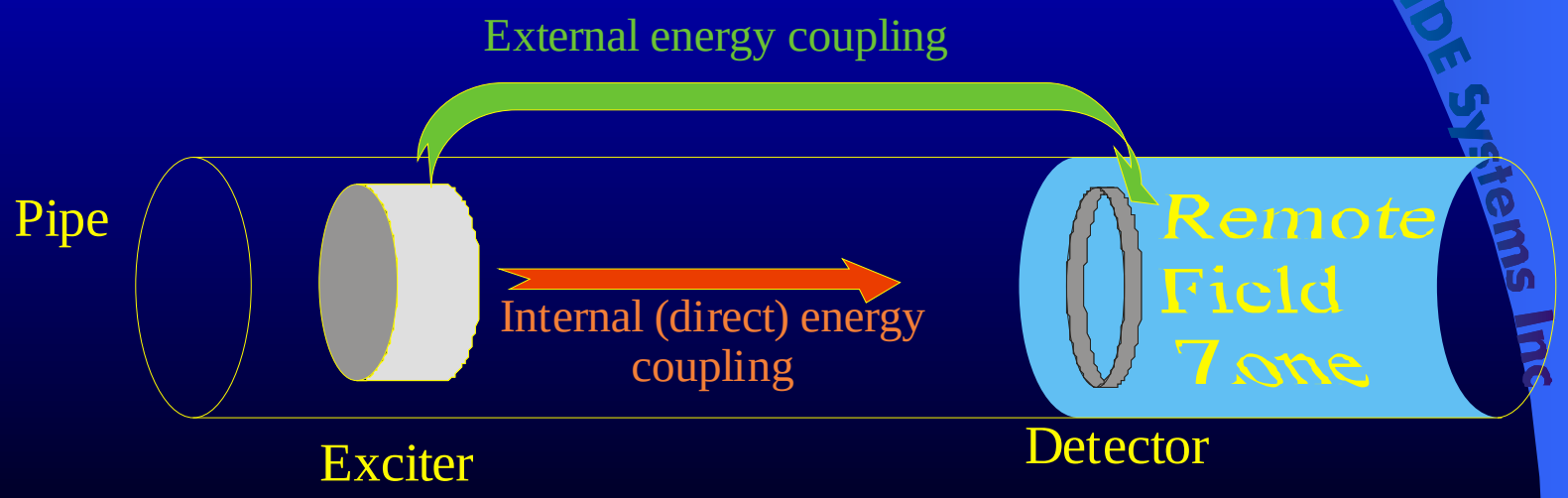
RFT Principle

- RFT is an ELECTRO-MAGNETIC method.
- An “Exciter” coil generates a low frequency sine wave.
- The Electromagnetic energy travels through the pipe wall near the Exciter.
- The excitation field generates eddy currents in the pipe wall which spread out from the exciter.



RFT Principle Cont'd

- At a distance of 2-3 pipe diameters the magnetic field due to the eddy currents in the pipe wall are stronger than the internal field.
- This "Remote Field" energy can be measured and used for condition assessment.



Launch and Receive Setups

Launch Setup

Receive Setup

Defect detected: dent with major LWL:

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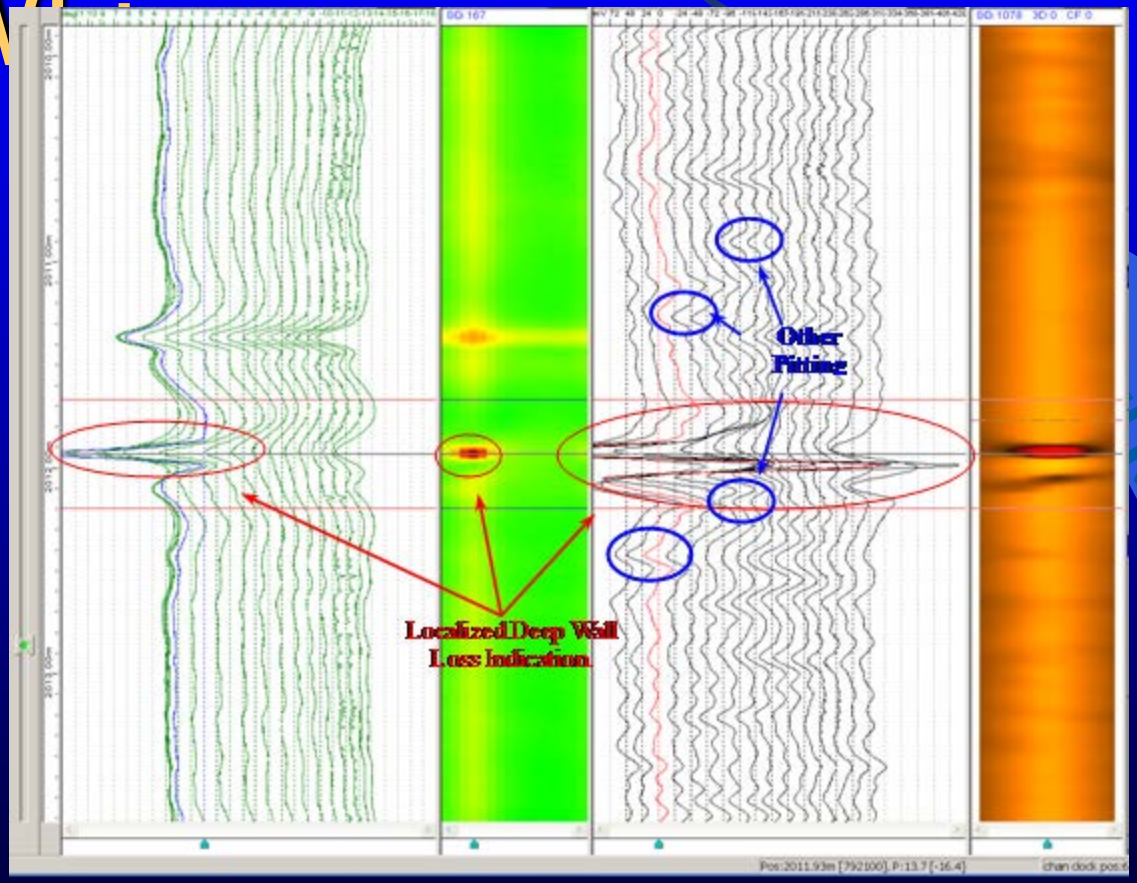
Defect detected: dent with major LWI



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Verification Dig:

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Verification Dig:

Dig Sheet for 6" Waste Disposal Line 14-06 (Sheet #1)

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Client	
Pipeline	168.3mm Thru-Kote Lined Pipe
Location	Alberta
Date	May 11 2009
Launch	Plant
Receive	14-06 Site
Method	Free swimming using water from pumper truck
Reference distances	Measured from launch
NWT	4.78mm
Clock Position	Looking Downstream

Indication	AOI #	Position [m]	Clock Position Looking DS	Estimated Depth	Distance From US Marker AGM080 [m]	Location of US Marker AGM080 [m]	Distance from US GW [m]	Distance from DS GW [m]	Distance From DS Marker [m]	Location of DS Marker [m]
Suspected Local Wall Loss Anomaly	AOI 1a	1997.19	5:30	95%	77.25	1919.94	11.44	3.36	61.74	2058.93
Suspected Local Wall Loss Anomaly	AOI 1b	1997.32	6:00	50%	77.38	1919.94	11.57	3.23	61.61	2058.93
Secondary Indication	AOI 2	2005.47	5:30	0%	85.53	1919.94	4.92	9.91	53.46	2058.93
Secondary Indication	AOI 3	2012.14	11:30	0%	92.2	1919.94	11.59	3.24	46.79	2058.93

← UpStream DownStream →

GW Locations [m]	1970.96	1985.75	2000.55	2015.38	2030.18	2044.13
Joint Lengths	14.79m length	14.80m length	14.83m length	14.80m length	13.95m length	
GW Locations from US Marker [m]	51.02	65.81	80.61	95.44	110.24	124.19
GW Locations from DS Marker [m]	87.97	73.18	58.38	43.55	28.75	14.8

Verification Dig:

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Verification Dig:

Dig Excavation Site Facing West

Dig Excavation Site Facing East

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Findings

Stress Locations Flagged

Example 2

- Steel Gas Line
- HDPE lined with longitudinal Grooves
- Approx. 5 years old.
- External concrete jacket.
- Four segments, up to 5km long.

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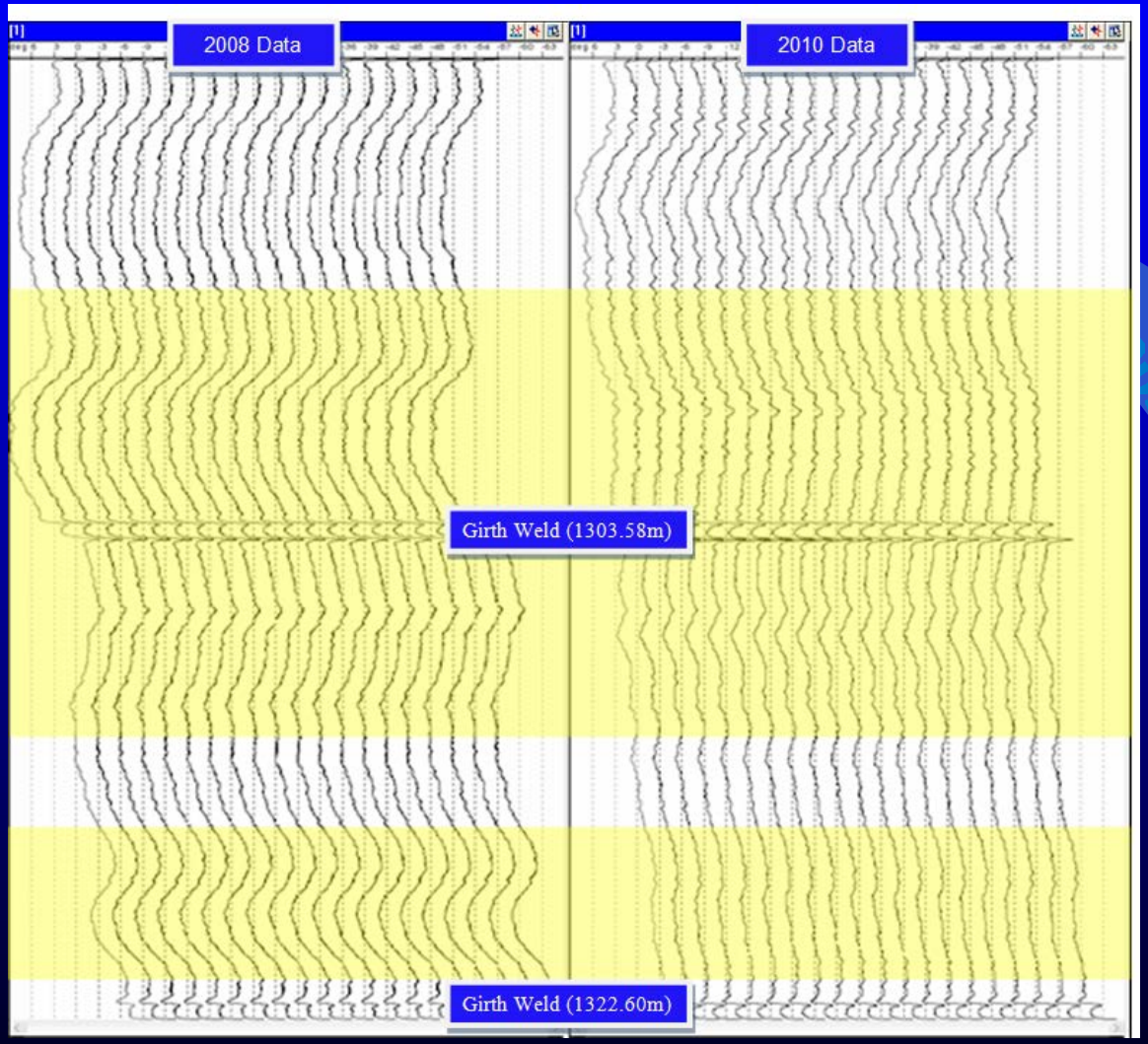
Tool Deployment

RFT Data 2008 -2010



Visualization of Stresses

Conclusions:

- Although detection of corrosion has had priority, detecting stresses in pipelines is becoming more important.
- FibreOptic based systems offer a great solution, but only for new pipe.
- In Line inspection tools are starting to be utilized for identifying areas of stress.
- The inline technologies are still in early stages of adoption, and require comparative analysis.