

# Technologies for Pipeline Inspection

> Government/Industry  
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# Available Technologies

Caliper	Measures pipeline ovality and dents using mechanical fingers or non-contact acoustic or eddy current methods	Widely available. Simplest of useful pigs
Inertial Mapping	Uses accelerometers to locate and map the pipeline in 3 dimensions relative to survey marks	
Magnetic Flux Leakage	Uses massive magnetizers to magnetize the pipe and Hall effect sensor to measure flux leakage at defects.	Most common corrosion inspection method. Inexpensive, simple and vendors have lots of experience with it. <i>Good accuracy but not enough to avoid investigative digs.</i>
Ultrasonic	Uses ultrasonic transducers to accurately measure pipe wall thickness.	Very accurate Only good method for measuring and detecting cracks <i>Very expensive, especially the crack detection.</i>

# Available Technologies

<p>Elastic Wave Vehicle</p>	<p>Uses liquid filled wheels to send ultrasonic waves around the circumference of the pipe. Developed for crack detection in gas pipes</p>	<p>Finds and measures cracks Finds disbonded coating <i>Too many false calls, but recent analysis improvements may greatly reduce them</i></p>
<p>EMAT</p>	<p>Uses electromagnetic acoustic transducers to send ultrasonic waves around the circumference of the pipe. Developed for crack detection in gas pipes.</p>	<p>Finds and measures cracks Commercially available <i>Too many false calls?</i></p>
<p>High-Low Field MFL</p>	<p>Determines stress levels and patterns by subtracting high field results from low field results. Used to find mechanical damage.</p>	<p>Characterizes mechanical damage <i>Qualitative results only Has not yet been used commercially</i></p>
<p>Circumferential MFL</p>	<p>Uses circumferential magnetization to better measure long defects, and improve circumferential resolution. Used to find mechanical damage, but also improves corrosion inspection</p>	<p>Finds mechanical damage Improves corrosion assessment <i>Qualitative results only Has not yet been used commercially</i></p>

# Under Development

<p>Nonlinear Harmonics</p>	<p>Uses changes in amplitude of the 3<sup>rd</sup> harmonic of the detected caused by changes in the magnetic hysteresis curve to determines stress levels and patterns</p>	<p>To be used in conjunction with High-Low field MFL or circumferential MFL to better characterize mechanical damage</p>
<p>Standard MFL</p>	<p>Analyze standard MFL signals to detect and characterize mechanical damage.</p>	<p><i>Strictly experimental for now.</i></p>
<p>Gas Coupled Ultrasonics</p>	<p>Uses specialized transducers to couple enough ultrasound into high pressure gas to enable ultrasonic inspection of gas pipelines.</p>	<p>Planned deployment for calibrating MFL pigs next year <i>Progress has been slow</i></p>
<p>Remote Field Eddy Currents</p>	<p>Uses eddy currents at a defect to measure its severity. The primary use is for unpiggable pipelines. The drive coil is at least two pipe diameters from the inspection point</p>	<p>Commercially available for non pipeline use Precision comparable to MFL <i>Slow inspection speed</i> <i>Power consumption</i></p>

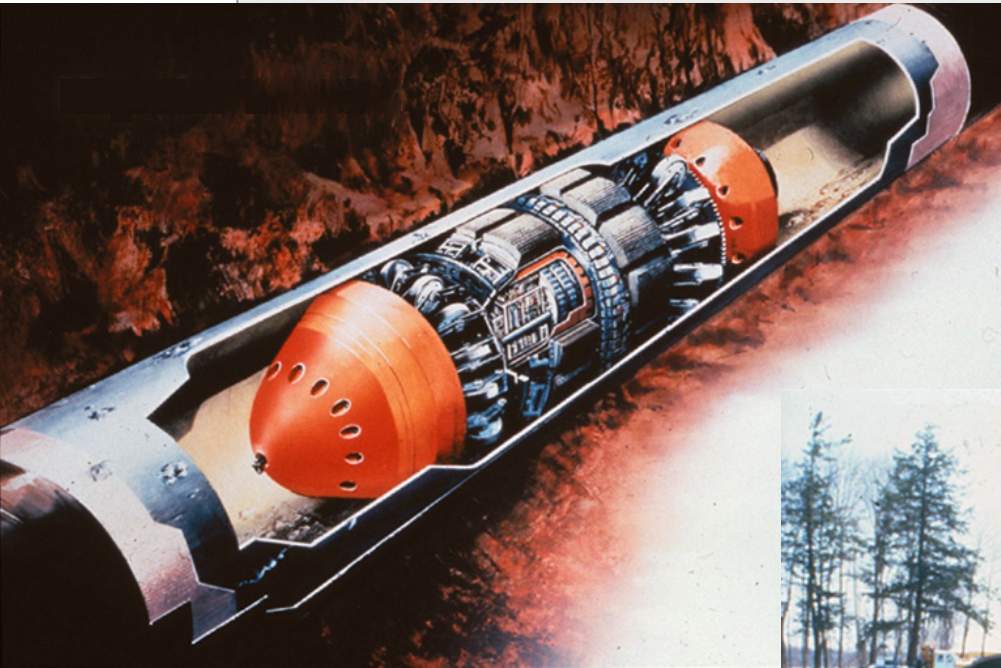
# Under Development

NoPig	Uses analysis of multiple frequency current impressed on a pipeline to detect and measure corrosion	Above ground method Only needs access to a pipeline at 1km intervals <i>Inspection is slow</i>
Remote Detection	Ultrasonic waves that reflect off defects are sent down the length of a pipeline. Reflection timing gives location. Reflection amplitude is a measure of severity.	Commercially available and in use at refineries and chemical plants R&D to increase the range and accuracy <i>Maximum range 100 feet and can be less than 10 feet.</i>
ECDA ICDA SCCDA	Exterior Corrosion Direct Assessment is available, but the other two still need further development. New non in-line techniques can be added as they are developed.	Use existing non in-line methods in a formal protocol to determine pipeline integrity <i>Direct Assessments are qualitative – in-line inspection gives far more information</i> <i>Expensive for the amount and quality of the information</i>

# Pipeline Monitoring Methods

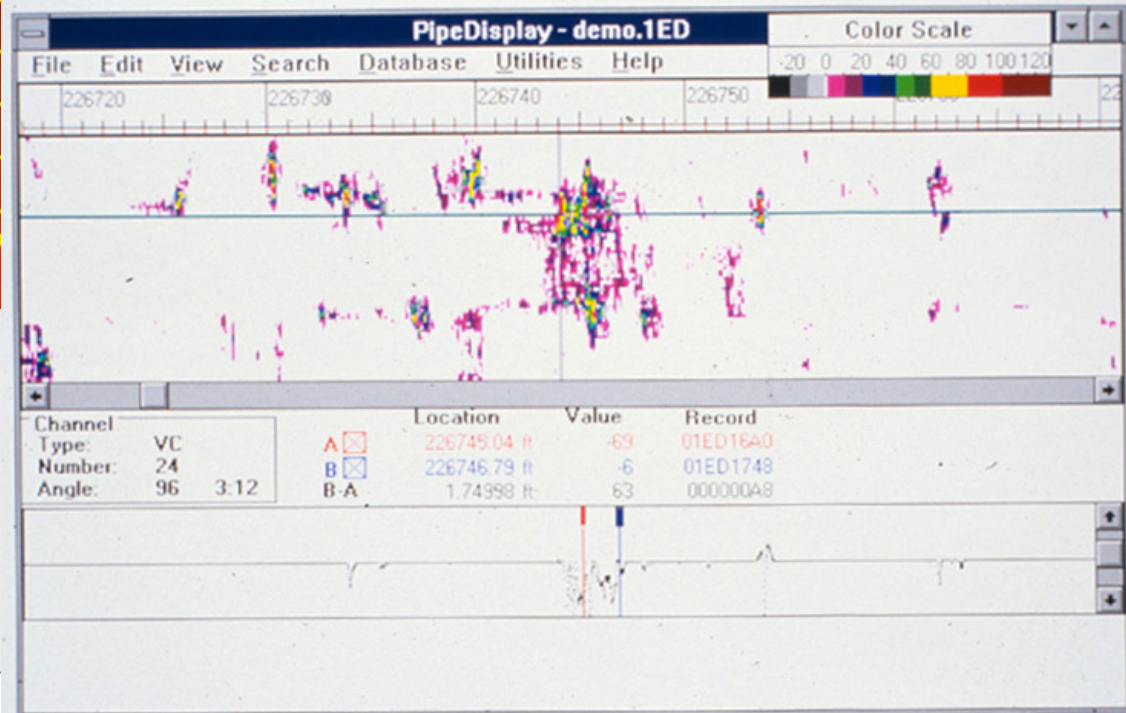
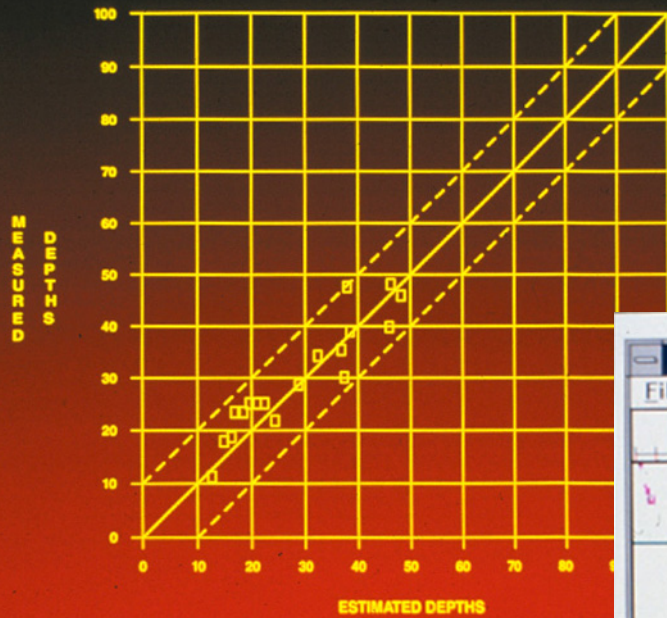
Acoustic Monitoring	Sound generated by a backhoe is detected up to several miles away	Undergoing field trials
Time Domain Reflectometry	Optical fiber detects the sound generated by machinery on the right of way	Being tested under field conditions with artificial simulations.
Other Right of Way Monitoring	Trip wires Infrared cameras Microwaves Ultrasonic motion detection Impedance spectroscopy Multi spectral satellite monitoring Radar satellite monitoring Backhoe mounted sensors	

# Magnetic Flux Leakage Inspection



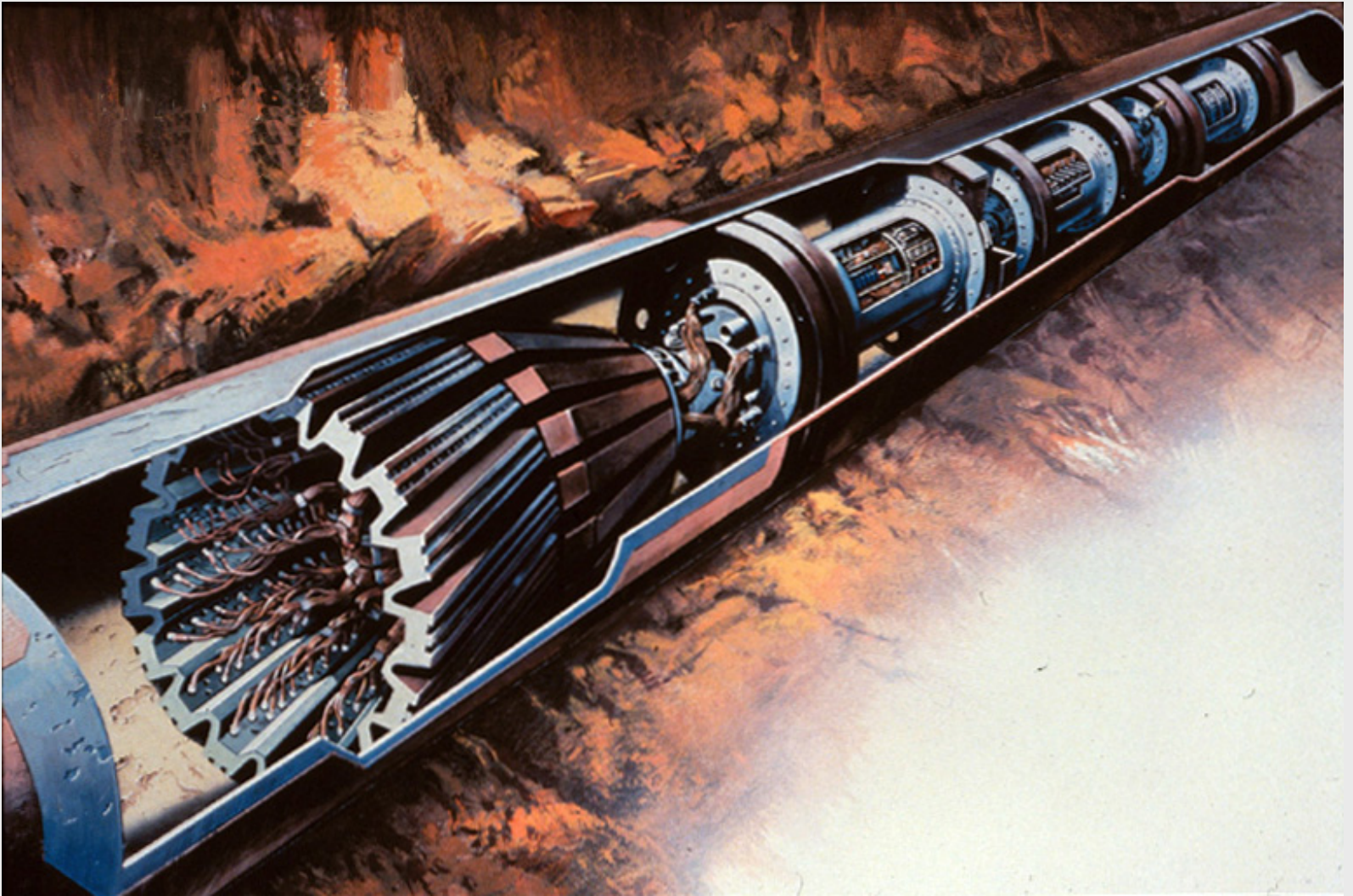


# Magnetic Flux Leakage Data





# Ultrasonic Inspection



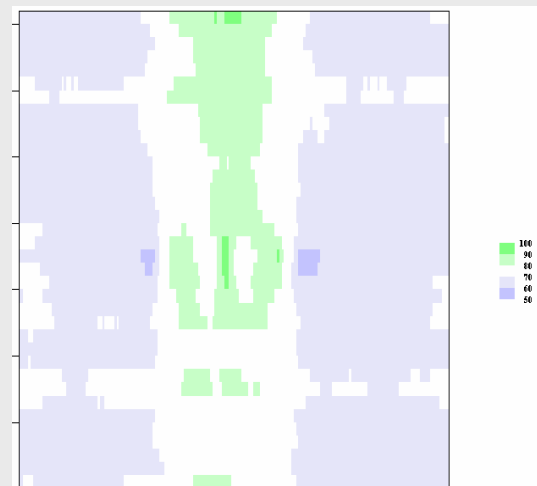
# EMAT Pigs

- > EMAT – Electromagnetic Acoustic Transducer
  - It is a technique for inducing ultra sound waves in a pipe wall without the need for a couplant
  - Used to detect cracks in pipelines and in particular SCC (stress corrosion cracking)
  - Interpretation has been difficult and guided wave calculations have been used to improve interpretation
  - Tuboscope and PII are both developing EMAT pigs. PII has run theirs

# Circumferential MFL

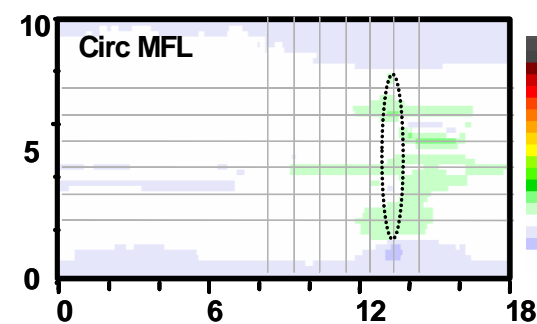
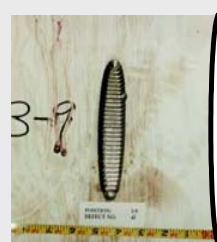
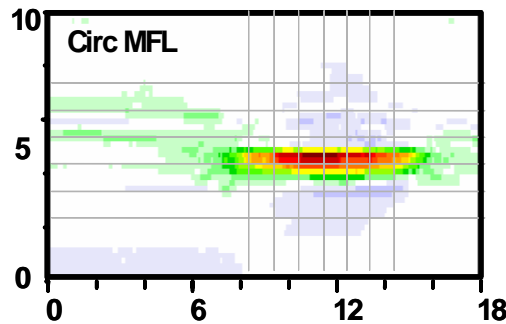
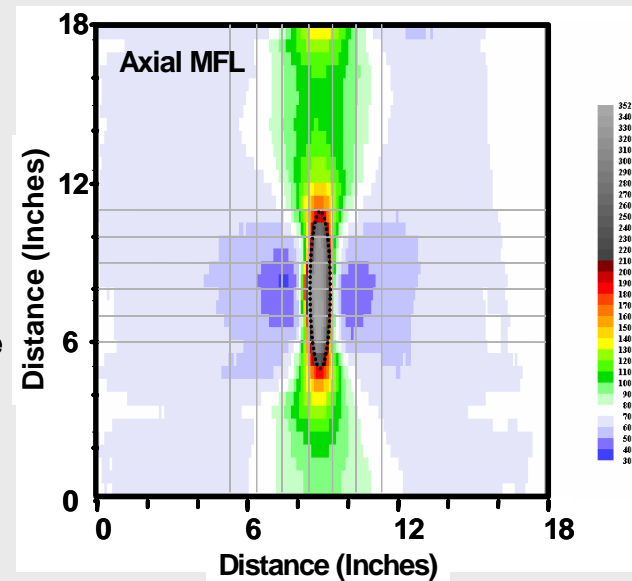
- Defect 69**
- 50% deep
  - 6 inch long
  - 1 inch wide

Distance (Inches)



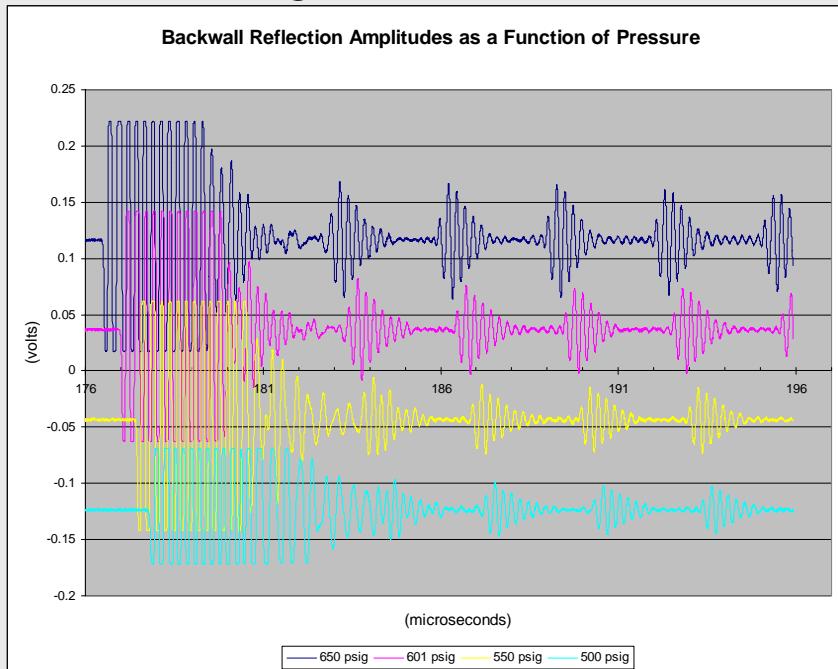
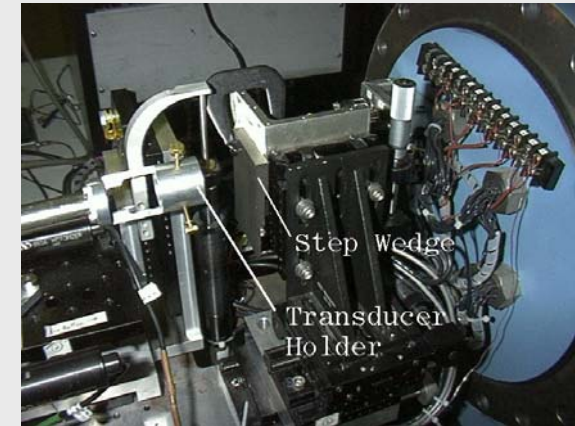
- Defect 45**
- 50% deep
  - 1 inch long
  - 6 inch wide

Distance (Inches)



# Gas Coupled Ultrasonics

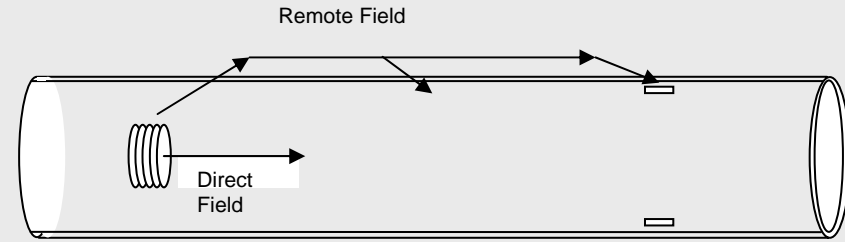
- Direct measurement of wall thickness to a couple of percent vs 10% for MFL
- Direct measurement of crack depths
- Already in use for non contact monitoring of burn victims



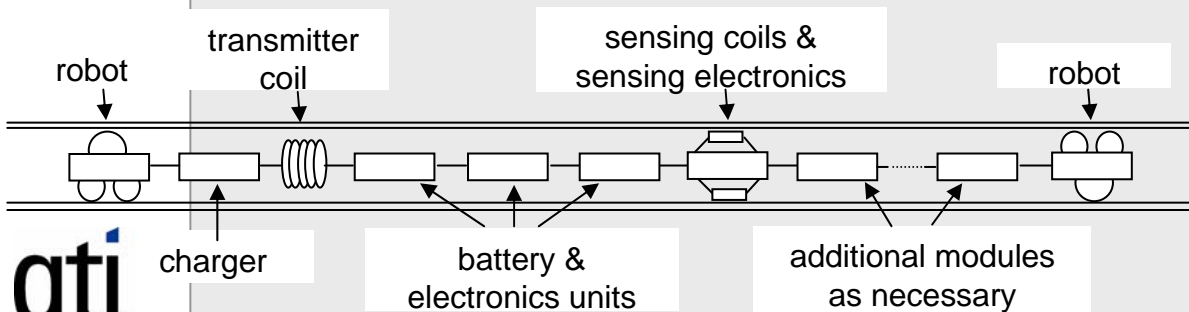
- Reduced sensitivity to material properties
- No liquids or wheels and not sensitive to stand off

# Unpiggable Pipelines

- Simple exciter coil, less than 1/3<sup>rd</sup> of pipe diameter
- Sensor array adjusts to match pipe diameter while passing small openings
- Accuracy comparable to MFL



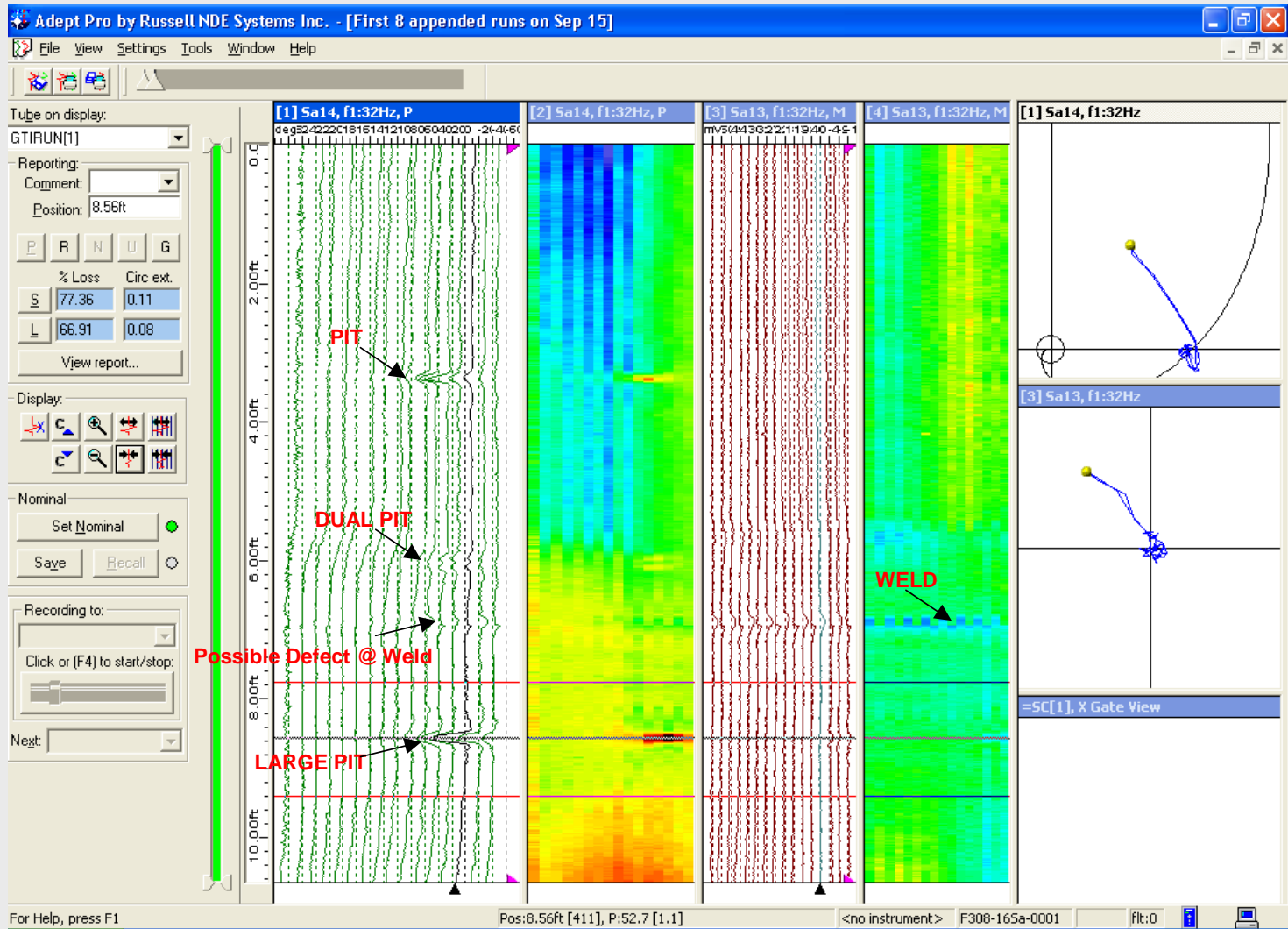
- Bypass valve and bore restrictions
- Inspect multi diameter pipes
- Go through back to back bends
- Go around tight bends and miter bends



gti<sup>SM</sup>



# Unpiggable Pipeline Inspection







# Remote Detection

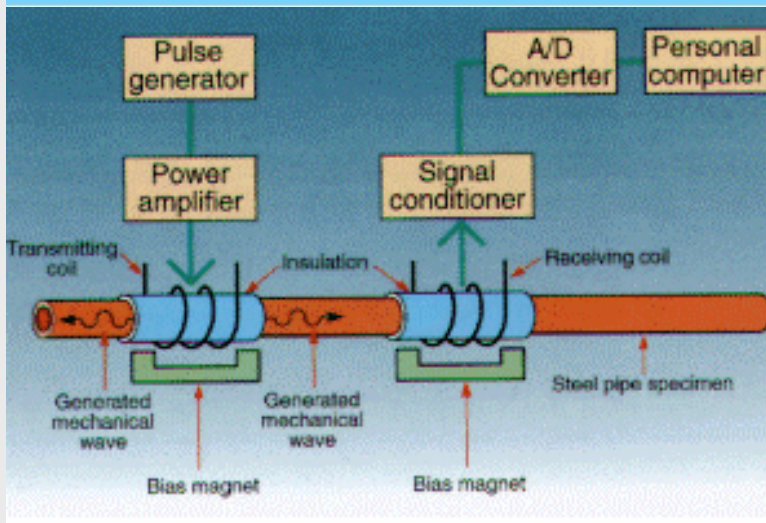
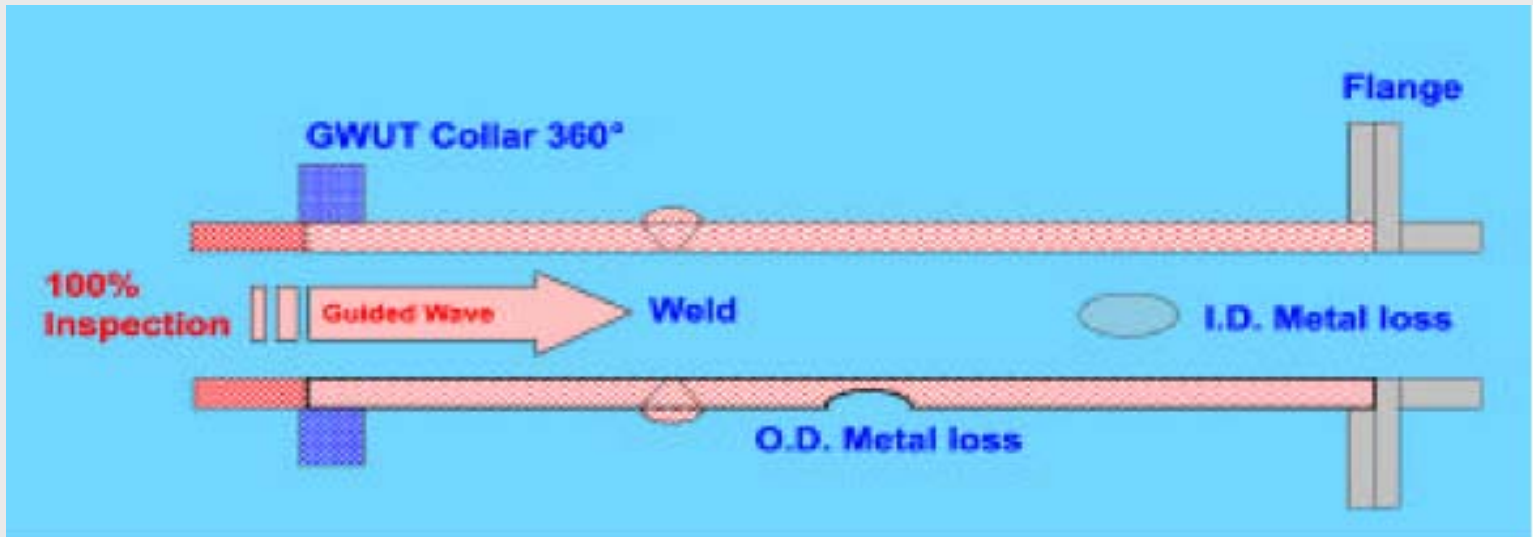


Figure 4

