



Anomaly Detection Initiatives for Steel & Plastic Pipe

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NYSEARCH, Voluntary R & D for (20)+ Gas LDCs in N. America

- ▶ A research, development, and demonstration consortium, made up of >20 Local Distribution Companies throughout N. America, serving the gas utility industry by identifying and executing research programs to advance the safety, integrity, and efficiency of the gas utility
- ▶ Voluntary based funding
- ▶ High leverage of R&D dollar
- ▶ Unique access to information on state-of-the-art technologies and research in an open setting with other gas utilities who experience similar, if not same, challenges in operations



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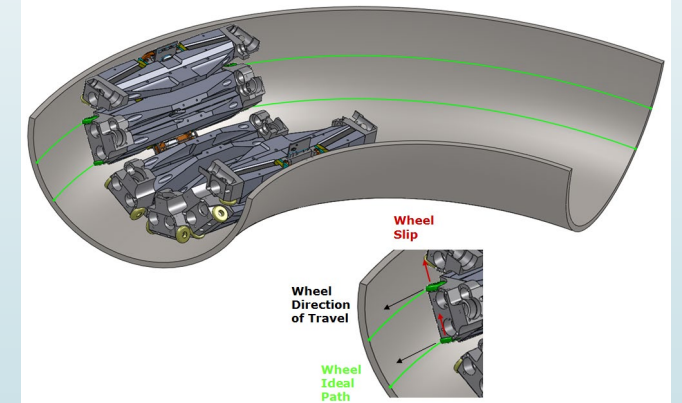
In Line Anomaly Detection in Steel Pipes

- ▶ Explorer family of **robotic platforms for the inspection of unpiggable steel pipelines**
- ▶ Live, tetherless inspection via battery powered robots using wireless communication for control, communication, and data transfer
 - ▶ 6" – 36" pipelines, up to 0.5"WT
 - ▶ Up to 750psig
- ▶ Onboard sensors for detection of:
 - ▶ Metal loss
 - ▶ Main pipe
 - ▶ Along bends
 - ▶ Mechanical damage and ovality
 - ▶ Cracks on welds
- ▶ The adaptation of any sensory technology used on smart pigs on the robotic platform faced major challenges due to limited space and power availability



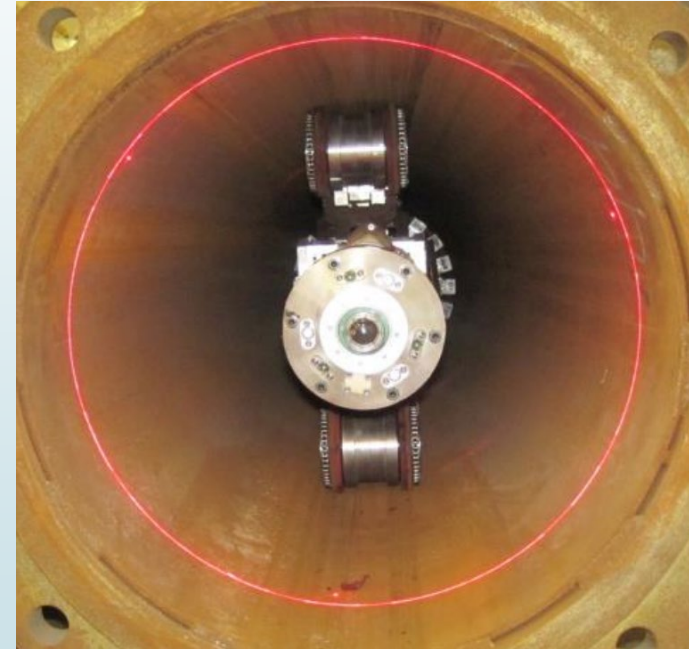
Metal Loss Detection using MFL

- ▶ Standard high performance MFL sensors for **corrosion detection in straight pipe**
 - ▶ Depth accuracy (80% confidence): ± 0.10 WT
 - ▶ Width accuracy (80% confidence): ± 0.75 inches
 - ▶ Length accuracy (80% confidence): ± 0.5 inches
- ▶ Developed sensory systems to **detect corrosion along bends**
 - ▶ Specially designed sensor heads to allow extension to the surface of the bend
 - ▶ 1.5D bends
 - ▶ Accuracy slightly lower than in straight segments
- ▶ Developing new state-of-the-art **High Resolution MFL sensors** for increased detectability and accuracy
 - ▶ Using compact Hall effect sensors in order to detect smaller defects and sizing them at a higher resolution



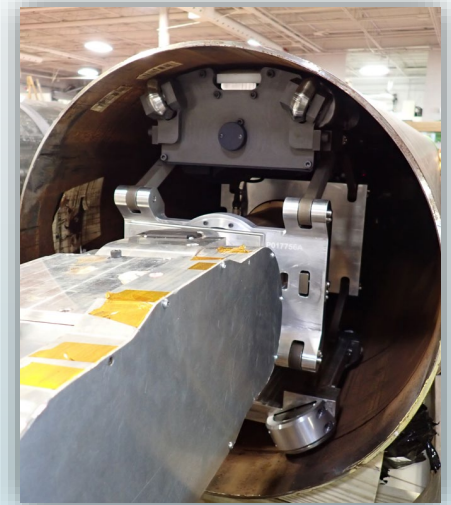
Mechanical Damage and Ovality

- ▶ **Laser based optical system** allows for the detection of mechanical gauges and ovality
- ▶ Advantages over conventional caliber systems
 - ▶ Much lighter
 - ▶ Much smaller
 - ▶ Similar performance
- ▶ Performance specifications
 - ▶ Depth accuracy (80% confidence): $\pm 1\%$ of pipe OD
 - ▶ Width accuracy (80% confidence): ± 2 inches
 - ▶ Length accuracy (80% confidence): ± 1 inch



Weld Crack Sensor

- ▶ Can **detect axially oriented cracks** (internal/external centerline, toe, and root cracks) near the seam weld
 - ▶ 1" long
 - ▶ 30% depth
 - ▶ 0.002" flaw opening
- ▶ Maximum WT: 0.5"
- ▶ Single probe with 4 drive modules
- ▶ Bi-directional



Priority 1	Priority 2	Priority 3
Seam Weld cracks	Girth Weld cracks	Base material cracks
Large flaws (lack of penetration, lack of fusion, mill flaws)	Tight Cracks	
Pipes within casings		
Corrosion		
Internal/External cracks		

Anomaly Detection in Plastic Pipes

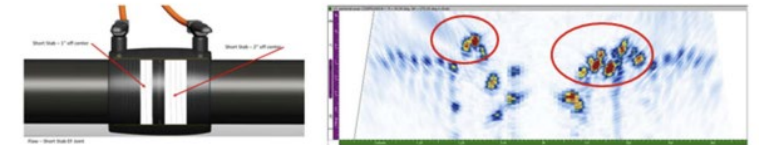
- ▶ Developing systems for detection of defects in PE plastic pipe
 - ▶ External instruments
 - ▶ Internal based on flow propelled or self-propelled systems depending on pipe size
- ▶ **External inspection** for detection of:
 - ▶ Mechanical damage
 - ▶ Corrosion
 - ▶ Cracks
 - ▶ Defective butt fusion welds
 - ▶ Defective electrofusion welds
- ▶ **Sensors used:**
 - ▶ PAUT
 - ▶ X-Rays
 - ▶ Terahertz
- ▶ **Inline inspection** for detection of:
 - ▶ Mechanical damage and ovality
 - ▶ Cracks
 - ▶ Pipe material degradation
- ▶ **Sensors used:**
 - ▶ Cameras
 - ▶ Dry-coupled UT

External Inspection of PE Pipes

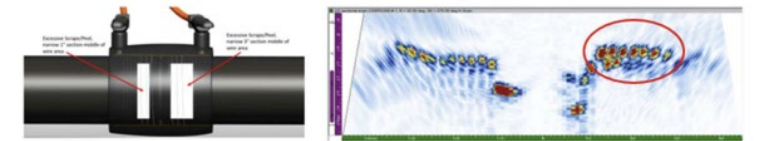
► PAUT inspection of electrofusion joints focusing on portable pass/fail instrument

- Can detect
 - contamination (sand, grease)
 - “burn out” cavities,
 - EF wire misalignment

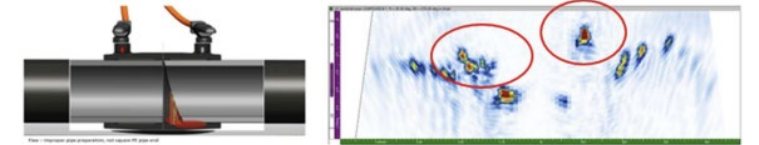
1) Short stab – failure to insert PE pipe into EF coupling



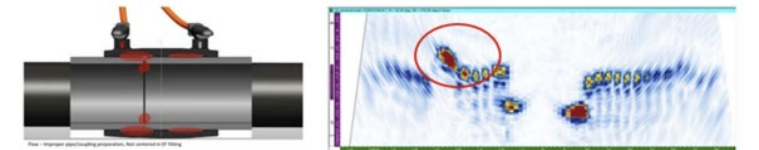
2) Excessive Scrape/Peel assembling PE pipe EF coupling



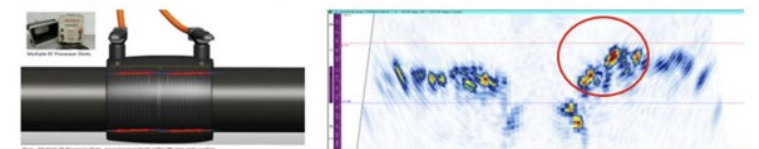
3) Improper pipe preparation, not square PE pipe end



4) Improper pipe/coupling preparation, Not centered in EF fitting

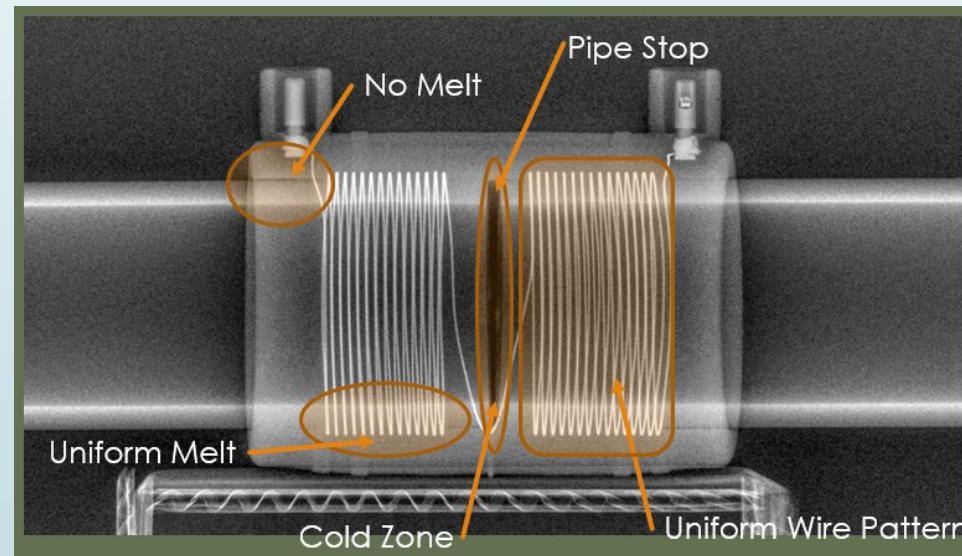


5) Multiple EF processor shots, excessive heat/melt within PE pipe and coupling



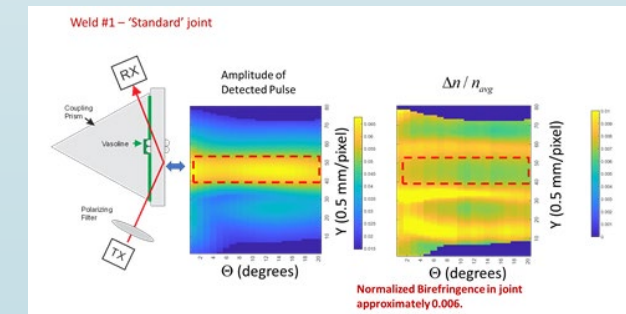
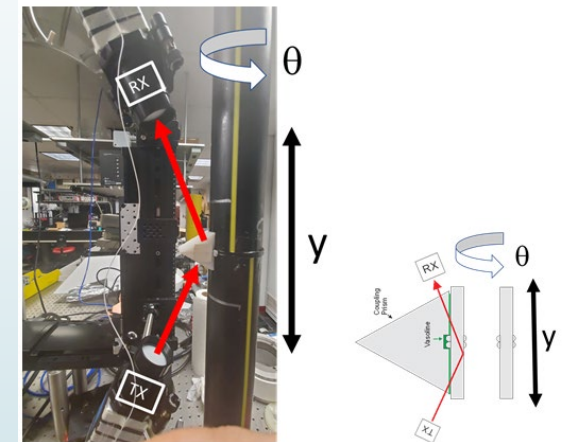
External Inspection of PE Pipes

- ▶ **X-rays for characterization of electrofusion fittings**
 - ▶ Developing a portable red-light/green-light X-Ray based instrument for the characterization of electrofusion welds



External Inspection of PE Pipes

- ▶ **Terahertz (THz) inspection of plastic pipe and butt fusion welds**
 - ▶ Groundbreaking development in detecting defects in the body of PE pipes at a detectability and resolution level an order of magnitude better than state-of-the-art UT systems
 - ▶ Completed laboratory instrument development
 - ▶ Initiating development of portable instrument
 - ▶ Groundbreaking development in characterizing butt fusion weld quality using THz technology
 - ▶ Proved ability to detect defective butt fusion joints



Inline Inspection of PE Pipes

- ▶ Developing systems for the internal inspection of PE plastic pipe focusing on 2" and 4" application:
 - ▶ Early stage work: detection of defects associated with pipe damage and material defects
 - ▶ Latter stage: characterization of fusion joints (butt and electrofusion)
- ▶ **2"- Visual-Inspection-Only System**
 - ▶ Detect and locate visually-identifiable damage to internal surface
 - ▶ Quantify ovality
 - ▶ Identify and locate features in pipe (service tees, etc.)
- ▶ Sensors used:
 - ▶ Camera
- ▶ Specifications
 - ▶ Up to 124 psig
 - ▶ Medium range of 500 – 1500 ft depending on flow rate and pressure
 - ▶ No damage to internal surface of pipe
- ▶ **4"-with-NDE-sensor System** inspection for detection and location of:
 - ▶ Wall loss and ovality
 - ▶ Material degradation
 - ▶ Features in pipe (service tees, etc.)
- ▶ Sensors used:
 - ▶ Cameras
 - ▶ Dry-coupled UT

Gaps in Anomaly Detection – Being Addressed

► Metal Unpiggable Pipelines

- Automated identification of features in pipe
- Identification and high-accuracy measurement of material loss and mechanical damage
- Identification and measurement of defects along long radius bends

► Plastic Pipe

- Inspection for inline detection and location of wall loss, ovality, and material degradation (medium range)
- Inline inspection to identify features in pipe (service tees, etc.)
- Pass/Fail tools for butt fusion and electrofusion joints (external)

Gaps in Anomaly Detection – Need to be Addressed

► **Metal Unpiggable Pipelines**

- Inline detection of cracks in body of pipe material
- Inline inspection of cracks in girth welds
- Identification and measurement of defects along short radius bends

► **Plastic Pipe**

- Inspection for detection and location of defects over long ranges
- Pass/Fail tools for butt fusion and electrofusion joints (inline)

Thank You!

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