Inline Inspection (ILI)

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Pipeline Safety
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Pipeline Challenges

• United States has the oldest, most extensive pipeline system in the world
• Increasing population near pipelines
• Increasing pipeline mileage
• Large variation in pipeline population (diameter, wall, grade, seam type, etc.)
• Many types of imperfections
Aging Infrastructure
Aging Infrastructure (% by Decade in USA)

Hazardous Liquid Pipeline Vintage
183,000 miles
55% installed prior to 1970
Aging Infrastructure (% by Decade in USA)

Gas Transmission Pipeline Vintage
59% installed prior to 1970
Gas Transmission

Gas Transmission Significant Incidents by Cause 2010-2016

- ALL OTHER CAUSES: 26%
- CORROSION: 14%
- EQUIPMENT FAILURE: 17%
- EXCAVATION DAMAGE: 20%
- INCORRECT OPERATION: 5%
- MATERIAL FAILURE OF PIPE OR WELD: 7%
- NATURAL FORCE DAMAGE: 4%
- OTHER OUTSIDE FORCE DAMAGE: 8%

# of Incidents
Hazardous Liquid

Hazardous Liquid Significant Incidents by Cause 2010-2016

- Corrosion: 29%
- All Other Causes: 25%
- Equipment Failure: 13%
- Excavation Damage: 12%
- Incorrect Operation: 7%
- Material Failure of Pipe or Weld: 4%
- Natural Force Damage: 4%
- Other Outside Force Damage: 6%

# of Incidents
Pipeline Safety with Context Measures (1988-2016)

Data Sources: Energy Information Administration, Census Bureau, PHMSA Incident Data as-of February 28, 2017
Pipeline Mileage as-of March 26, 2017 (assumes 5,000 mile increase for Hazardous Liquid in 2016)
Recent Incidents

Carmichael, MS

Marshall, MI

Santa Barbara, CA
Recent Incidents where NTSB identified inadequacies in ILI

- **2007 Carmichael, MS (propane, 2 fatalities)**
  - Current inspection and testing programs are not sufficiently reliable to identify features associated with longitudinal seam failures of ERW pipe prior to catastrophic failure in operating pipelines.

- **2010 Marshall, MI (crude oil)**

- **2015 Santa Barbara, CA**
  - The in-line inspection (ILI) tool and subsequent analysis of ILI data did not characterize the extent and depth of the external corrosion accurately.
NTSB: 2007 Carmichael, MS Report Recommendation

Conduct a comprehensive study to identify actions that can be implemented by pipeline operators to eliminate catastrophic longitudinal seam failures in electric resistance welded (ERW) pipe; at a minimum, the study should include assessments of the effectiveness and effects of in-line inspection tools, hydrostatic pressure tests, and spike pressure tests; pipe material strength characteristics and failure mechanisms; the effects of aging on ERW pipelines; operational factors; and data collection and predictive analysis. (P-09-1)
Comprehensive Study to Understand Longitudinal ERW Seam Failures

**Main Objective**

Three primary objectives –

1. Integrate industry and PHMSA data to quantify vintage seam failure statistics with focus on LFERW seams
2. Understand longitudinal ERW seam failures and on that basis quantify the effectiveness of inspection and hydrotesting to manage integrity and ensure safety to avoid/eliminate catastrophic failures
3. Combine outcomes of the first two objectives to help favorably close National Transportation Safety Board Recommendation P-09-1

**Public Abstract**

The project will assist PHMSA in favorably closing NTSB Recommendation P-09-1 arising from the Cammell MS pipeline rupture involving an ERW seam, which directed that PHMSA conduct a comprehensive study of ERW pipe properties and the means to assure that they do not fail in service. The scope is anticipated to validate that periodic use of the current ERW seam integrity assessment methods (hydrostatic testing and in-line inspection using a crack-detection tool) are the best means to prevent ERW seam ruptures.

The work will address the characteristics of ERW seams that make them susceptible to failure, and it will identify the factors the pipeline operators must consider in order to assure that their ERW pipelines are safe.

**Fast Facts**

| Research Award Recipient | Battelle Memorial Institute  
| Headquarters Address: 505 King Avenue, Columbus, OH 43201 Seattlet  
| Address: Suite 400 1100 Dexter Avenue North Seattle, WA 98109-3598  
| Columbus, OH 43201-2696 |
| AOTR | Steve Nannay, steve.nannay@battelle.com, (713)272-2855 |
| Contract # | DTPH66-11-T-00003L |
| Project # | 390 |
| Researcher Contact Info | Bruce Young, Ph: (614)-424-3098, YOUNGB-02@battelle.org |
| Peer Review | More than Effective (PHP-7-2012, Apr 11-24, 2012)  
| Peer Review | Very Effective (PHP-8-2013, Apr 24, 2013)  
| Peer Review | Very Effective (PHP-9-2014, May 20-22, 2014) |

**Technology and Commercialization**

| Technology Demonstrated | Yes  
| Commercialized (in whole/part) | Yes |

**Commercial Partner**

Battelle Memorial Institute  
[https://www.battelle.org/homepage](https://www.battelle.org/homepage)  

**New Improvement**

The project investigations supported the deployment of Battelle's PipeAssess PI™ Axial Crack Software. This software enables evidence-based repair and replacement decisions that can reduce costs through optimization of re-inspection intervals and hydrotesting.

**Financial and Status Data**

| Project Status | Completed |
| Start Fiscal Year | 2011 (05/26/2011) |
Track Record of In-line Inspection as a Means of ERW Seam Integrity Assessment

• 2012 Kiefner & DNV Report
• Identified significant weaknesses in ILI tools:
  – Unreliable defect sizing accuracy
  – Missed defects
  – Inconsistent failure stress calculations
• More rigorous tool verification of tool performance is needed
Figure 1 Remote-Field Eddy Current Testing

Figure 2 Mechanical Damage Inspection Using Magnetic Flux Leakage Technology

Figure 3 Dual magnetization tool- two-magnetizer and caliper arm

Figure 4 SmartBall-free swimming acoustic tool for liquid pipeline leak detection

Figure 5- ILI pull test winch

Figure 6- Electromagnetic acoustic transducer
Inline Inspection

- One of the requirements of Integrity Management in High Consequence Areas:
  - Part 192 Subpart O
  - §195.452
- Must follow ASME B31.8S for selecting appropriate tool for covered segment
- Corrosion & other threats
- Baseline Assessment
- Periodic Assessments
No tool is “Perfect”

- Each tool is designed to detect a specific imperfection type, size and orientation
- All tools have:
  - < 100% POD (Probability of Detection)
  - < 100% accuracy: Sizing error (tool tolerance)
  - Limitations of indirect inspection method, direct inspections needed to validate results
No one tool does it all

Multiple tools are needed
Some holes due to active failures

Other holes due to latent conditions

SUCCESSIVE LAYERS OF DEFENSES
Summary

• ILI is an important part of effective Integrity Management programs
• ILI is a valuable tool, has seen much improvement and needs more improvement
• PHMSA supports technologies to improving safety, including ILI
• PHMSA supports ILI as part of a comprehensive pipeline safety approach
Thank you

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