the Energy to Lead

Quantification of Risk Associated with Vintage Piping Systems and Tools to Optimize Mitigation Strategies

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gti

Addressing Legacy Materials

- **Identified Needs / Gaps**:
  - **Industry-standard, risk-based model for main replacement programs;** to include cast iron, PE, and steel piping systems. Utilities need to be able to prioritize assets with a focus on safety and reliability.
    - Identification of high risk materials and prioritization of highest risk pipes/segments.
    - Material and environmental assessment to assist with prioritization of high risk materials (assist with prioritization)
  - **Alternative pipe replacement options**; splitting, insertion, etc.
  - **New material acceptance**; composite piping systems and structural liners
  - **Tracking and traceability for new piping systems;** standardized information on materials, assembly details, operator information, etc.

A Few Current Programs

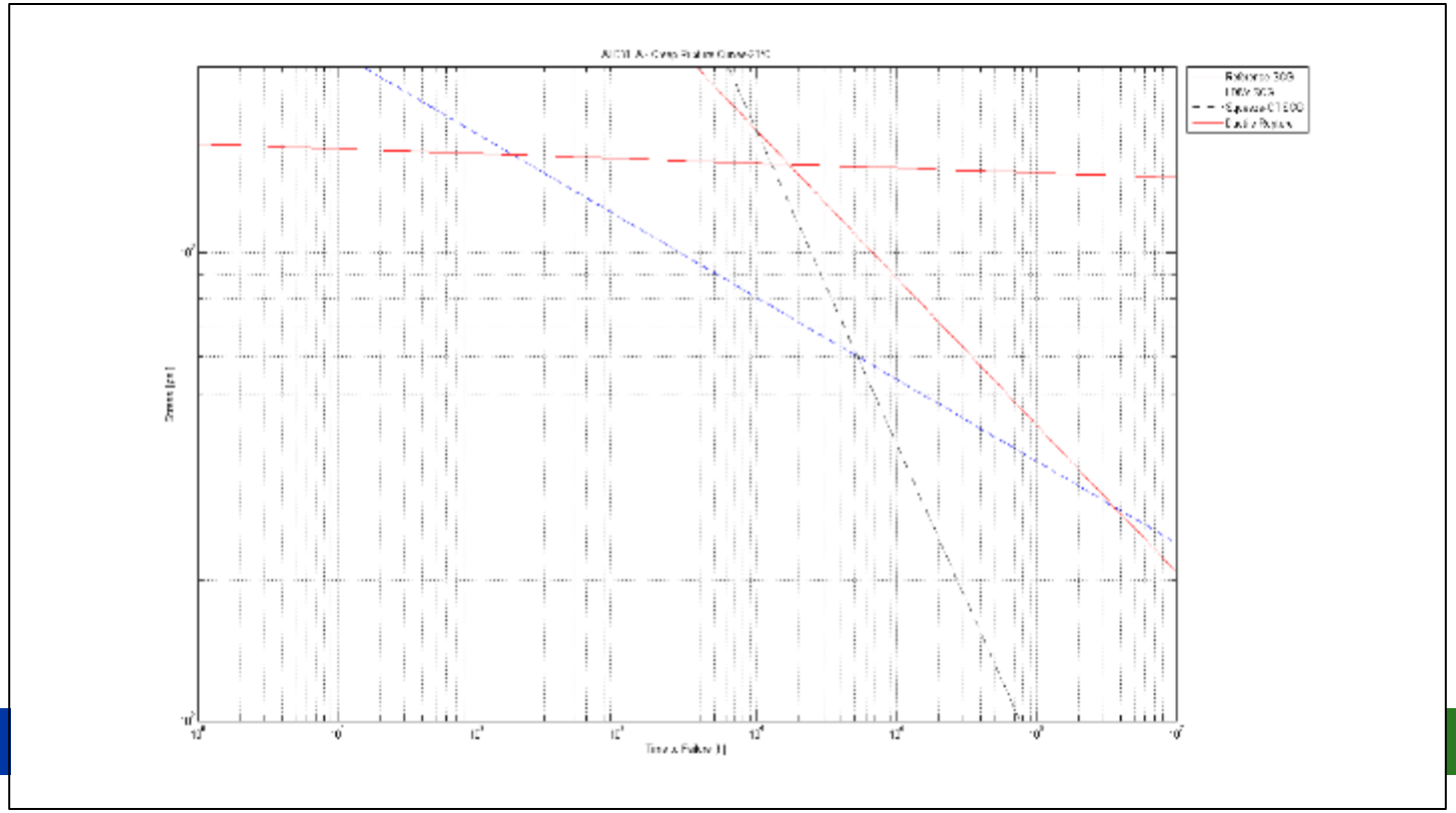
- **Vintage Piping Identification/Analysis**
  - Analysis and understanding risk/life of various aged assets.
  - Collect information on material and identify threats.
- **Threat Identification and Smart Forms**
  - Program to collect potential threat information from operators and regulators.
  - Provide information on existing and emerging threats to operators for their use in identifying and assessing risks.
- **Composite pipe / Structural liner program**
- **PE pipe splitting guideline project**
- **Material and Fusion tracking and traceability project**

Vintage Piping Identification/Analysis

- **Need:**
  - Enable utilities with vintage piping systems (Aldyl A polyethylene, cast iron, and other vintage materials) to develop risk profiles of these system to allow for the prioritization of replacement.
- **Current projects –**
  - Identify risk associated with specific vintages and/or areas of Aldyl A pipe.
  - Assessment of Frost Impact on Cast Iron Pipes
    - Provide a relative risk-based approach to enhance the response to frost impact on cast iron (CI) piping systems
  - Risk and Decision Analysis (RDA) program
    - Leak Rupture Boundary Model (fail by leak or rupture)
    - Advanced Crack Propagation Model (correlates pressurizations to crack growth rates)

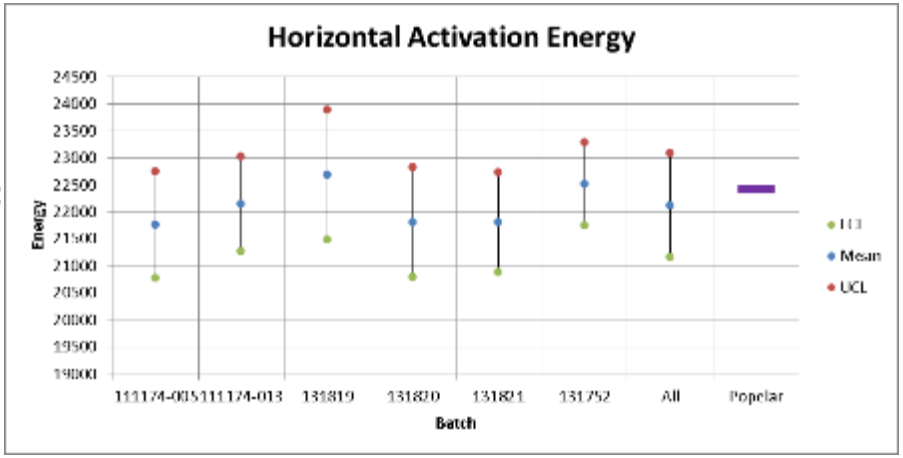
Aldyl A Material: Rate Process Method (RPM)

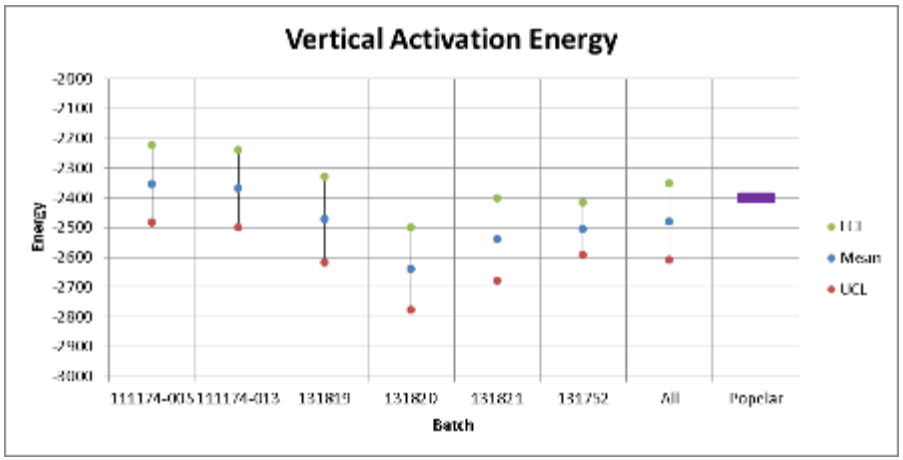
- Hydrostatic test data covering various vintages of material/pipe has been and continues to be assembled.
- RPM models have been generated for reference



Aldyl A Material: Bi-Directional Shift Factors

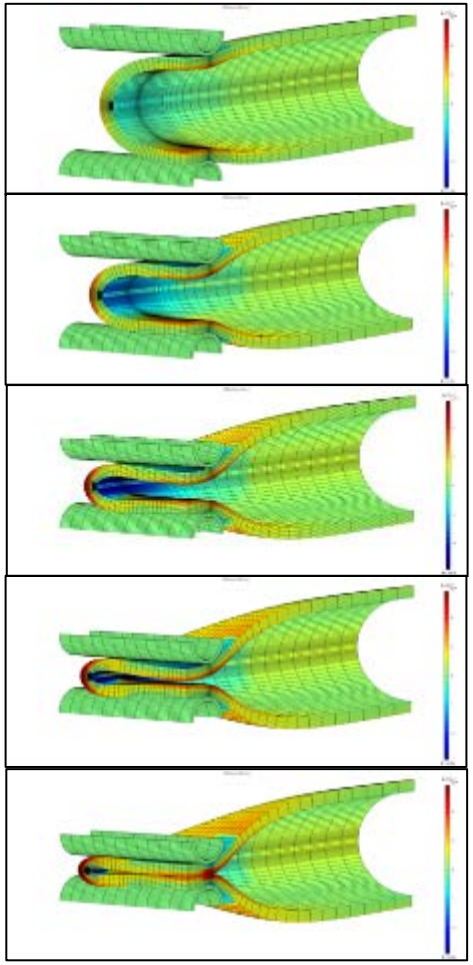
- Bi-Directional shift factors are developed based on test data for each batch of pipe sampled
- Pipe batches include:
  - Various vintages
  - Different resins
  - Various geometries and field conditions
  - Etc.

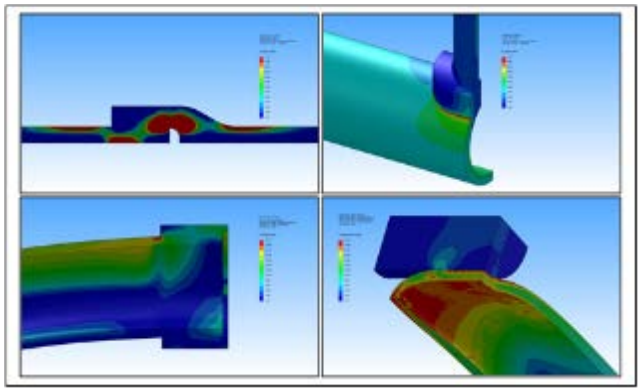


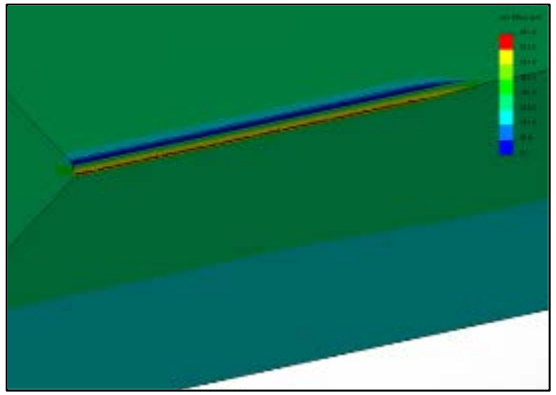


Aldyl A Material: Finite Element Method (FEM) to Determine Application Stress

- Application stresses are determined in order to:
  - Assess the likelihood of introducing damage through short term loading such as squeeze-off
  - Determine the stress concentration factors for various geometries or likely damage configurations

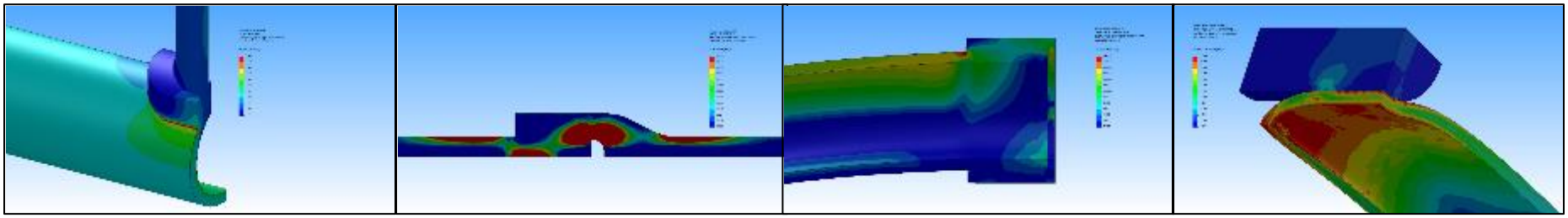






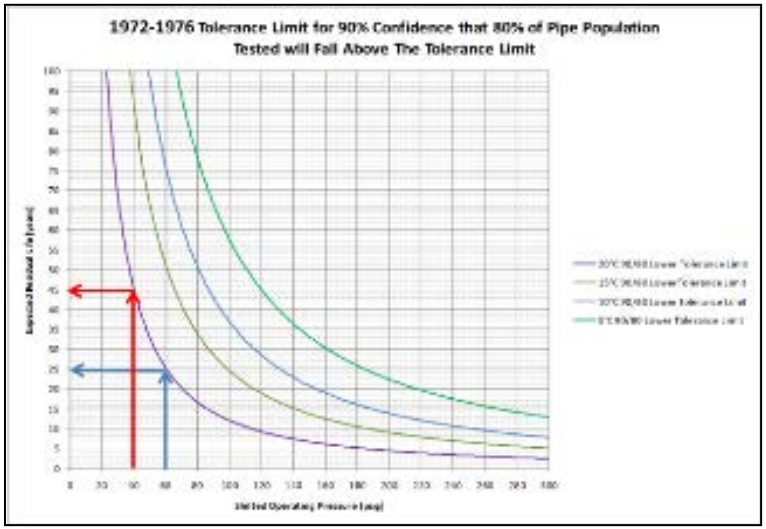
Stress Risers due to Geometry & External Loading

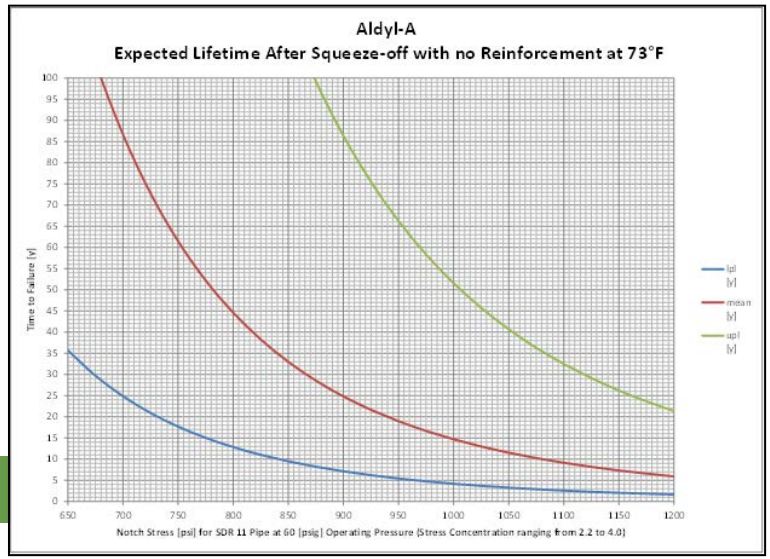
Pipe or Fitting Configuration (All with 60 psig Internal Pressure, SDR11)	Stress Intensification Factor
Socket Coupling – Coupling Edge	1.25
Saddle Tee	2.7
Socket Coupling – Coupling Center	1.8 – 2.9
Pipe with Bend Radius of 100 Pipe Diameters	3.0
Pipe with Bend Radius of 80 Pipe Diameters	3.6
Pipe with Bend Radius of 50 Pipe Diameters	4.7
Socket Coupling with Bend Radius of 100 Pipe Diameters	4.8
Socket Coupling with Bend Radius of 80 Pipe Diameters	5.8
Socket Coupling with Bend Radius of 50 Pipe Diameters	7.5
Squeeze-Off	8.5 – 10.5



Methodology: Combining FEM and RPM

- Detailed knowledge of the true stress states in the field application allow specific performance curves to be developed
- These specific performance curves enable operators to develop the appropriate mitigation strategy for their application





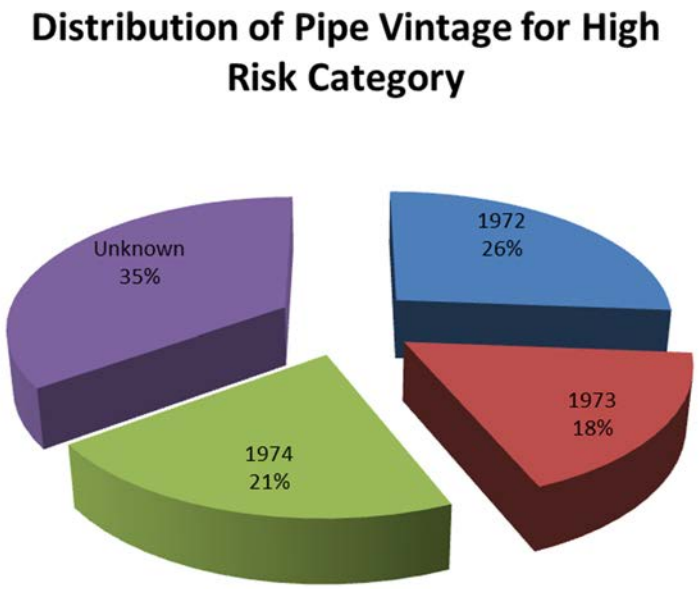
Comparing Current Lifetime Expectancies to Reference Data

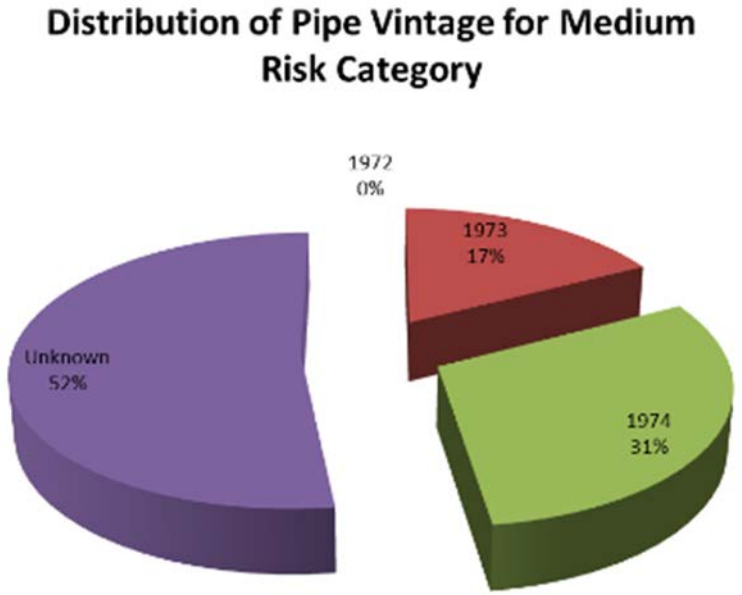
- GTI has developed a **3, 2, 1** risk ranking methodology for Aldyl A pipe
- The method uses well conditioned historic data sets for material known to exhibit LDIW characteristics and pipe known to meet the design requirements of Aldyl A as defined by DuPont (non LDIW)
- High Risk — **3 Performance < LPL of LDIW reference model**
- Medium Risk — **2 Performance > LPL of non LDIW reference model**
- Low Risk — **1 Performance > Mean of non LDIW reference model**

LPL – Lower Prediction Limit

LDIW – Low Ductile Inner Wall

Correlating Risk Category to Vintage





1972 – High Risk Only
1973 – High and Medium Only
1974 – High Medium and Low
Unknown – High and Medium Only
Low risk – Less than 2% of samples
1974 vintage only

Correlating Risk to Pipe Surface Condition

- The core properties of Aldyl A pipe do not deteriorate over time
- Pipe that has been in service for >40 years has similar material properties to virgin pipe
- Degradation does occur at the pipe surfaces (both)
- Specifically the inner wall
- GTI is developing a set of key surface indicators that correlate to lifetime expectancy

Correlating Risk to Pipe Surface Condition – Ongoing Work

- Carry out targeted sampling of Aldyl A pipe
  - Specific geographic locations
  - Specific vintages
  - Specific sizes
- RPM models, Bi-directional Shift Factors and Surface Characterization are being carefully carried out to validate the current set of indicators
- The results will be incorporated into a hybrid causal model for risk ranking and lifetime prediction

Pipe Surface Condition Benefits

- Comprehensive understanding of:
  - Material characteristics
  - Influence of vintage of pipe
  - Influence of installation conditions
- Surface characterization methodology enables:
  - Less hydrostatic testing
  - More detailed risk ranking
- Historic data sets allow for better risk ranking and detailed mitigation strategies to be developed

Assessment of Frost Impact on CI Pipes

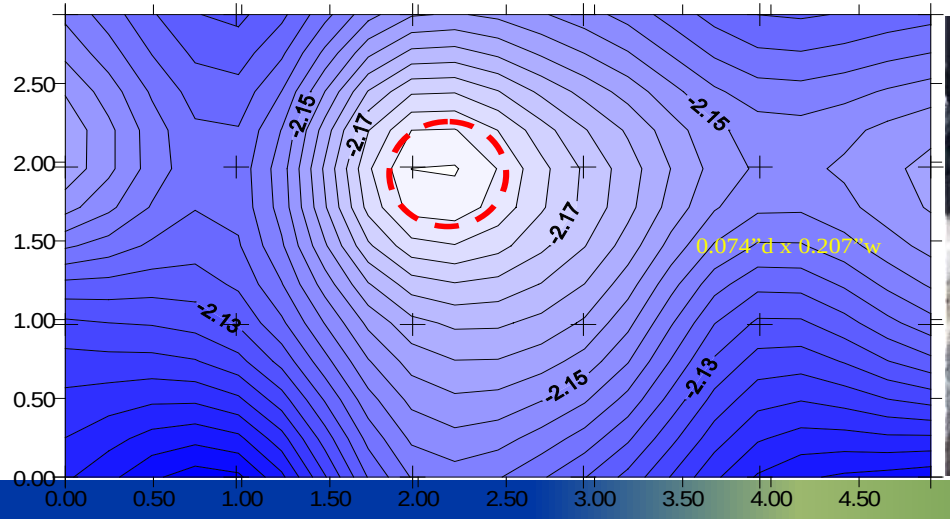
- Objective
  - To provide a relative risk-based approach and recommendations to enhance the criteria which operators use to identify the locations, durations, and frequencies for their surveillance of CI systems during winter operations.
- Initial findings…
  - Pipe size did not correlate to leaks.
  - Pipe size correlated to pipe breaks: Smaller diameters had more breaks.
  - No breaks were recorded for pipes > 18-inch diameter.
  - No correlation to age of pipes for pipes from 70-110 years.
  - Material assessment (microscopic and NDE) can assist in determining higher risk CI pipe segments.

Assessment of Frost Impact on CI Pipes

> Integrity of cast iron piping systems – BEM inspection technology

> Amount of graphitic corrosion is a factor related to breaks.

Region A entire wall cross section showing approximately 0.372” corrosion over 0.5” total wall thickness



Smart Leak Repair Forms

- **Objective of Smart Forms:**
  - To develop logic for a smart leak form to:
    - Improve the data collection process, and
    - Assist in identification of the root cause during the leak repair process,
  - Provide “smart” questions and answer options to:
    - Guide the user through the process of determining the root cause,
    - Ensure that the correct root cause is identified and appropriate supporting information is provided.

Smart Forms - Current Need

- Integrity Management, PPDC, and other data/failure collection requirements:
  - Collect data as needed for mechanical fitting failures resulting in hazardous leaks
  - Data to assist in identifying threats
- PHMSA states: “High-quality data is core to an effective risk assessment”.
- PHMSA also states that the ability to identify existing and potential threats is an area of needed improvement.
- The use of “other” in leak forms is very problematic.
- Need for smarter leak forms to improve data quality.

Smart Forms - Current Need

> According to PHMSA current issues include:
  - Data quality - it is often outdated, incomplete, and has obvious errors.
  - OTHER as a leading cause in reporting

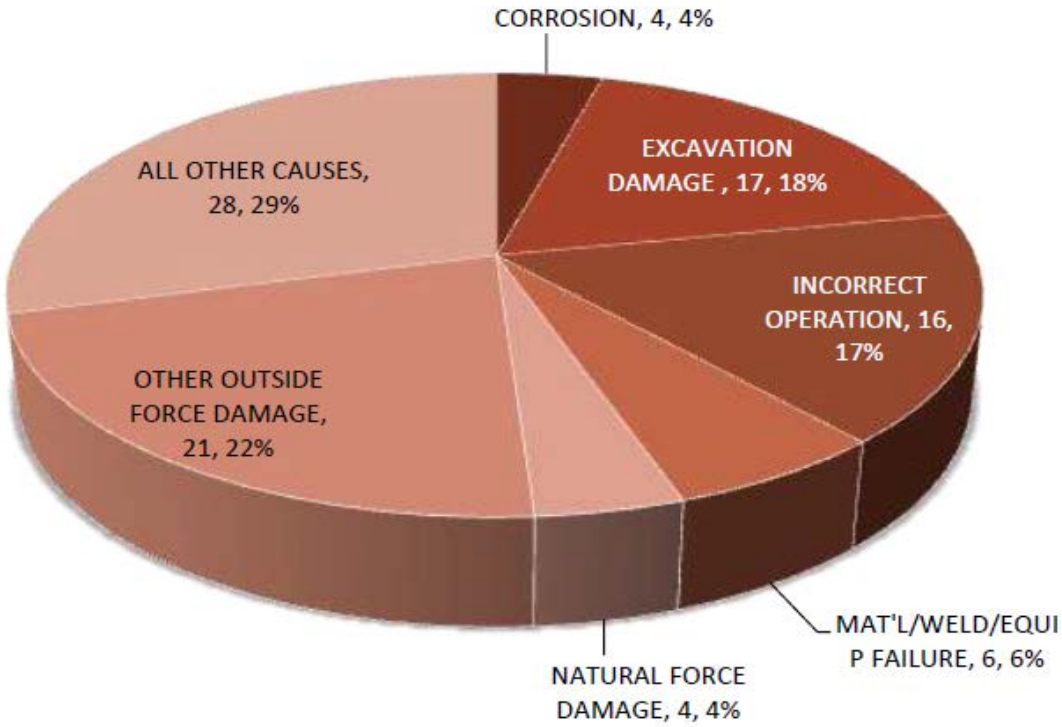


Figure 3 Significant Distribution System Incidents by Cause (2008-2010)

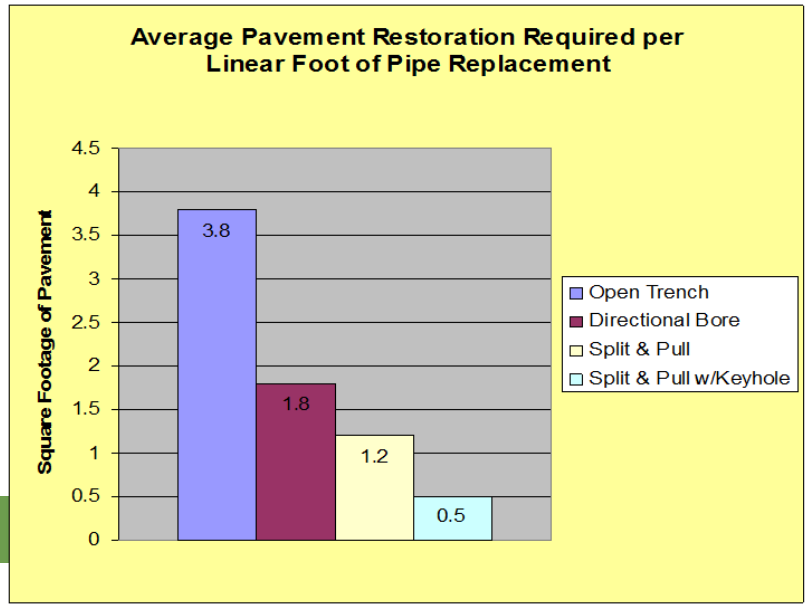
Benefits of Proposed Smart Leak Form

- Well defined, consistent and coherent logic
- “Other” category avoided
- Potential for industry standard
- Readily implemented in electronic format
  - Integrate with mobile data apps
  - GIS integration possible
  - Tracking and Traceability integration possible
- Data collected can be fed directly into risk and consequence models (consistent structure)

Pipe Replacement Alternatives

- **PE Pipe Splitting**
  - Need alternative construction systems to replace vintage PE pipe. Splitting technologies is one alternative.
  - Issues:
    - The availability of standard commercial
    - Guidelines for applications and use of splitting equipment.
    - Best practices

Pipe splitting can offer cost savings while performing the operation more efficiently with less disruption to traffic and the general public



Composite Materials Program

- GTI's Composite Materials (CM) program is facilitating the implementation of composite materials and technologies for the rehabilitation of distribution and transmission pipelines.
- Need:
  - Selection and design of composite pipe / structural liner pipe rehabilitation for distribution and transmission systems,
  - Establishing and performing testing for long-term performance prediction of the various composite/structural liner systems,
  - Establishing standards and design criteria necessary for the acceptance and allowable use by the natural gas industry, and
  - Implementation and regulatory acceptance.

Benefits of the CM Program

- Will enable the safe and cost effective rehabilitation of distribution & transmission pipelines without large scale, open trench excavations.
- Composite piping / structural liner systems can provide natural gas operators with options to restore/replace their piping infrastructure.
- Composite materials have the potential to provide for a corrosion free, high strength, and damage resistant piping system.

Asset Tracking and Traceability Program

- Developed a unique identifier for gas components
  - 16 digit base-62 encoding system

- Developed technologies, processes, and standards to facilitate the tracking of assets throughout their lifecycle
  - Provide “Point and Click” GIS that attached operational data to assets
- Standardized PE fusion data capture and operator qualification
- Next Steps
  - Additional fusion data & Op qualification
  - Expand to transmission

TTN: 129NH7487X
Warehouse: Lot ABC
Received: 12-4-1995
Asset: Main
Material:
Pressure: 10 psi
Diameter: 6”
Location: GPS Coordinate
Depth: 3.5’
Installation Date: 1-5-1996
Installation Technique: HDD
Installation Contractor: Good Guys
Joint Type: Butt Fusion
Soil Type: Ottawa Sand
Squeeze: 8-23-2007
Leak: 8-22-2007
Leak Cause: Rock Impingement
Repair Type: Cut-out

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Identifying - Documenting - Sharing

- **Additional Research Needs**
  - More encompassing programs to identify existing and emerging threats to our industry (knowledge).
  - Develop comprehensive library of pipeline material properties.
  - Objective risk analysis and decision tool.
  - Alternative pipe replacement options.
  - Alternative replacement materials such as composite pipes and structural liners.
  - Tracking and traceability for new systems being installed (transmission assets, assembly info, etc.).

Solving important *problems* facing the energy industry and its consumers …

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