Pipeline Safety Research, Development and Technology

Natural Gas Infrastructure R&D and Methane Emissions Mitigation Workshop

Nov 2014
Thank You!

- We appreciate the opportunity to share!
- Much to share about DOT natural gas infrastructure R&D
- Many facets to the fugitive methane issue
- DOT/DOE – We would like to restart the practice of interagency coordination, collaboration and co-funding
Who Is PHMSA?

- We’re one of nine agencies within DOT
- We develop and enforce regulations for the safe, reliable and environmentally sound operation of:

Approximately
- 2.6 M pipeline miles
- 2,600 pipeline operators
- 1M daily hazmat shipments
  - By land, sea and air
What We Regulate

### National Pipeline System Components

<table>
<thead>
<tr>
<th>Pipeline</th>
<th>Mileage</th>
<th>% Total</th>
<th>Operators</th>
<th>% Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous Liquid</td>
<td>182,166</td>
<td>7</td>
<td>350</td>
<td>13</td>
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<tr>
<td>Gas Transmission and Gathering</td>
<td>324,832</td>
<td>12</td>
<td>1,034</td>
<td>39</td>
</tr>
<tr>
<td>Gas Distribution</td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Main line</td>
<td>2,113,643</td>
<td>81</td>
<td>1,285</td>
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<tr>
<td>Service line</td>
<td>881,378</td>
<td>34</td>
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</tr>
<tr>
<td><strong>Total</strong></td>
<td>2,620,642</td>
<td>100</td>
<td>2,669</td>
<td>100</td>
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</tbody>
</table>

### US Pipeline Mileage

- **Total Mileage**: 2,620,642
- **Hazardous Liquid**: 182,166
- **Gas Transmission and Gathering**: 324,832
- **Gas Distribution**: 2,113,643

Data as of 09/2012
Pipeline Safety RD&T

Pipeline Safety RD&T Program Mission:
To sponsor research and development projects focused on providing near-term solutions that will improve the safety, reduce environmental impact, and enhance the reliability of the Nation’s pipeline transportation system.

Key Points
• We employ a collaborative approach to address mutual challenges
• We help remove technical barriers on a given challenge
• We measure our research results/impacts
• We are transparent - http://primis.phmsa.dot.gov/rd/

Pipeline Safety Improvement Act of 2002 established our modern program
### RD&T Program Objectives

<table>
<thead>
<tr>
<th>Developing Technology</th>
<th>Strengthening Consensus Standards</th>
<th>Promoting Knowledge</th>
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</thead>
<tbody>
<tr>
<td>Fostering the development of new technologies so that pipeline operators can improve safety performance and more effectively address regulatory requirements.</td>
<td>Targeting and feeding new knowledge into the process of keeping standards relevant to their purpose.</td>
<td>Generating and promoting general knowledge to decision makers.</td>
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</tbody>
</table>

### Authorizations vs. Appropriations

<table>
<thead>
<tr>
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<td>$10M</td>
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<td>$11.7M</td>
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<td>$6.92M</td>
<td>$6.92M</td>
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<td>$6.9M</td>
<td>$6.9M</td>
<td>$6.9M</td>
<td>$6.92M</td>
<td>$12.2M</td>
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</table>
Collaborative and Coordinated Program Process

1. Stakeholder based, consensus driven research agendas and roadmaps
2. Interagency review of competitive pre-award process to reduce duplication, leverage resources and secure best researchers
3. Paperless & secure 21st Century solution used to monitor, report and assure contract performance
4. Post-award peer review process executed annually
5. Tech demonstrations and full use of contract authority to commercialize, disseminate and promote results
Performance Metrics (since 2002)

Program Status: Technology Impacts

<table>
<thead>
<tr>
<th>Technology Impact Metric</th>
<th>Metric</th>
<th>Meter</th>
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<tbody>
<tr>
<td>Technology Projects</td>
<td>82</td>
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<tr>
<td>Technology Demonstrations</td>
<td>44</td>
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<tr>
<td>Patent Applications (U.S. + Other)</td>
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<td></td>
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<tr>
<td>Commercialized Technologies&lt;sup&gt;A&lt;/sup&gt;</td>
<td>23</td>
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<tr>
<td>Commercialization Success Rate&lt;sup&gt;A&lt;/sup&gt;</td>
<td>34%</td>
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</table>

Programmatic Element & Technology Research Impact

<table>
<thead>
<tr>
<th>Category</th>
<th>Technology Projects</th>
<th>Technology Demonstrations</th>
<th>Patent Applications (U.S. + Other)</th>
<th>Commercialized Technologies&lt;sup&gt;A&lt;/sup&gt;</th>
<th>PHMSA ($M)</th>
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<tbody>
<tr>
<td>Threat Prevention</td>
<td>13</td>
<td>7</td>
<td>3</td>
<td>3</td>
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<td>Leak Detection</td>
<td>10</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>$6.34M</td>
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<tr>
<td>Anomaly Detection</td>
<td>33</td>
<td>21</td>
<td>11</td>
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<td>Anomaly Characterization</td>
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<td>3</td>
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<td>Design</td>
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<tr>
<td>Materials</td>
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<tr>
<td>Welding</td>
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<td>5</td>
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<td>2</td>
<td>$4.92M</td>
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<tr>
<td>Joining</td>
<td>3</td>
<td>2</td>
<td>1</td>
<td></td>
<td>$1.35M</td>
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<tr>
<td>Alternative Fuels</td>
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<td>2</td>
<td>1</td>
<td>2</td>
<td>$1.17M</td>
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</tbody>
</table>

Footnotes:
- A. Note: The measurement of "Commercialized Technologies" only occurs on non-active or completed projects.

Grand Totals: | 82 | 44 | 19 | 23 | $46.04M
PHMSA RD&T SUCCESSES

Hand-Held Tools for In-Ditch Inspections

Guided Wave Ultrasonics

Gas/Liq Leak Detection by Fixed Wing/ Helicopter along pipeline

Hand-Held Tools for In-Ditch Inspections
Performance Metrics (since 2002)

- Logic modeling used to determine best attainable & sustainable metrics
- Info is all publically available at:
# Interagency Research Program Areas & Responsibilities

<table>
<thead>
<tr>
<th>Programmatic Area</th>
<th>Responsibility</th>
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<tbody>
<tr>
<td></td>
<td>DOT</td>
</tr>
<tr>
<td></td>
<td>Onshore</td>
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<tr>
<td>1. Threat Prevention</td>
<td>X</td>
</tr>
<tr>
<td>2. Leak Detection &amp; Mitigation</td>
<td>X</td>
</tr>
<tr>
<td>3. Anomaly Detection &amp; Characterization</td>
<td>X</td>
</tr>
<tr>
<td>4. Anomaly Remediation &amp; Repair</td>
<td>X</td>
</tr>
<tr>
<td>5. Design, Materials, &amp; Welding/Joining</td>
<td>X</td>
</tr>
<tr>
<td>6. Alternative Fuels, Climate Change, &amp; Other</td>
<td>X</td>
</tr>
</tbody>
</table>

**NOTES:**

a. DOT has mutual jurisdiction on Outer Continental Shelf (OCS) transmission pipelines with DOI.
b. DOC was identified as a national expert on materials research via PSIA 2002.
c. DOI is the primary pipeline regulator in the OCS.
Competitive Academic Agreement Program (CAAP): Objectives

• Spur innovation through enabling an academic research focus on high risk and high pay-off solutions for the many pipeline safety challenges

• Intended to potentially deliver desired solutions that can be a “hand-off” to further investigations in this or PHMSA’s core research program

• Expose “students” to subject matter common to pipeline safety challenges and illustrating how their engineering or technical discipline is highly desired and needed in the pipeline field

<table>
<thead>
<tr>
<th>CAAP Summary Totals</th>
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<tbody>
<tr>
<td>Annual Announcement</td>
</tr>
<tr>
<td>CAAP-1-13</td>
</tr>
<tr>
<td>CAAP-2-14</td>
</tr>
<tr>
<td>GRAND TOTALS:</td>
</tr>
</tbody>
</table>
Natural Gas Infrastructure
Technical Challenges
NOTE: Projects can be relevant to more than one pipeline type.

Solicited 6 times for leak detection (LD) projects (not always finding awardable projects). Funded 12 related projects with $5.7M PHMSA + $1.6M resource sharing. Impact – 3 NG - LD technologies now in the market today.
Challenge: Pipe Seams

SAW Failure in San Bruno, CA

ERW Seam Failure in Carmichael, MS

Hydrotest Failure
Challenge: Cast Iron

Gas Dist. Cast/Wrought Iron Main Miles

Gas Dist. Bare Steel Main Miles
Challenge: Anomaly Detection

• More accurate tools for In Line Inspection
• More accurate tools for In-Ditch
• More sensor types for robotic ILI of unpiggable systems
• Priority - Cracking & Interactive Threats
Challenge: Anomaly Characterization

- Need to progress beyond simple loadings
- Need complex loading models to address interactive threats
Replacing Hydrotesting?

- **Why hydro? What benefits?**
  - Pressure & Spike Tests

- **Can ILI tools in concert with leak detection surveys replace a hydro?**
  - Cracking especially in the seam not well detected or sized – R&D underway
  - ILI can’t identify understrength materials

- **NTSB & Congress – strong hydro focus to PHMSA**
  - Recommendations/Mandates
Stakeholder Driven

• What are the right priorities?
  – R&D Forum generates national research agenda
  – Leverages through coordination and reduces duplication

• Pipeline R&D Forum Aug 2014
  https://primis.phmsa.dot.gov/rd/mtg_080614.htm
  – Approx 230 reps & now soliciting 17 topics – awards by Feb 2015
  – Threat Prevention, Leak Detection/Fugitive Methane, Anomaly Detection & Characterization, Materials, Risk Models and LNG

• Pipeline R&D Forum July 2012
  https://primis.phmsa.dot.gov/rd/mtg_071812.htm
  – Approx 215 reps – solicited 20 topics funded 21 research projects
Fugitive Methane: Thoughts, Actions and Research Suggestions
Fugitive Methane

- PHMSA closely following issues and policy development by others
  - White House, Congress and Industry Trade Orgs.
- Coordinating with EPA with meetings and PHMSA participation at EPA Gas Star Program events
- Coordinating with the Environmental Defense Fund efforts and added EDF representation on PHMSA’s congressionally mandated Pipeline Advisory Committee
- Reviewing natural gas regulations to understand leak paths and possible actions germane to our statutory mission
  - However, safety case largely already made in support of hazardous leak reductions
  - Remaining non-hazardous leaks generally economic in nature
- NARUC, FERC and the Congress
Methane Related PHMSA Actions

- **Overall Regulatory Program** – Keeping product in the pipeline and preventing leaks has the ancillary benefit of reducing emissions.

- **Integrity Management (IM) Rulemaking** – Enhanced transmission industry programs to find and fix leaks since 2004.

- **Distribution IM Program Rulemaking** – Requirements to find and fix leaks in the distribution system since 2011.
Methane Related PHMSA Actions

- **Research & Development** – A collaborative and co-funded program since 2002 is bringing several technology solutions to market
  - Tools for Reducing failure rates
  - Tools for Minimizing leaks

- **Excess Flow Valves** – Mandatory installation of EFVs on new and replaced residential service

- **Increasing Pipeline Capacity** – Conducted rulemaking to improve throughput efficiency in cross border pipelines – 72% to 80% SMYS
Potential Methane Leak Paths

- **Natural Gas Gathering, Transmission, Distribution and LNG systems**
  - Piping (various), Flanges, Gaskets, Meters, Compressors, Line Valves (various), Relief Valves, Drip Traps, Pig Launchers/Receivers, etc.
  
  - **Gas permeation** – constituents of natural gas are somewhat permeable through PE/PA pipe
  
  - Leak rates vary due to...
    
    - Gas pressure, quality, temperature, dew point, etc. & Pinhole leak or full rupture
Potential Methane Leak Paths

- Natural Gas Gathering, Transmission, Distribution and LNG systems
  - Example of Challenge - Pressure relief devices that vent gas have a major safety function and can’t be easily eliminated
  - Perhaps capture gas?

- Hazardous Liquid Systems
  - Vapor from Breakout Tanks
Research Suggestions - DOE

- Questionable value of much more methane detection research
  - Dozens of companies now offering service – Google it and see!
  - Leverage prior/ongoing PHMSA, Industry tech successes and factor ARPA-E coming investments

- These two reports via the EDF spell out a variety of energy supply chain options for reducing methane

- Research in these suggested areas can:
  - Improve economics of existing products/technology
  - Develop new technology and more options for the industry to consider
EDF – Leaking Profits Report

1. **Green Completions** to capture oil and gas well emissions
2. **Plunger Lift Systems** or other well deliquification methods to mitigate gas well emissions
3. **Tri-Ethylene Glycol (TEG) Dehydrator Emission Controls** to capture emissions from dehydrators
4. **Desiccant Dehydrators** to capture emissions from dehydrators
5. **Dry Seal Systems** to reduce emissions from centrifugal compressor seals
6. **Improved Compressor Maintenance** to reduce emissions from reciprocating compressors
7. **Low-Bleed or No-Bleed Pneumatic Controllers** used to reduce emissions from control devices
8. **Pipeline Maintenance and Repair** to reduce emissions from pipelines
9. **Vapor Recovery Units** used to reduce emissions from storage tanks
10. **Leak Monitoring and Repair** to control fugitive emissions from valves, flanges, seals, connections and other equipment
EDF – Economic Analysis Report

Recovered Gas at $4/Mcf

Source – Reduction Measure

- LDC Meters and Regulators--LDAR
- Reciprocating Compressor Rod Packing--Rod Packing
- Well Fugitives--LDAR
- Compressor Stations (Transmission)--LDAR
- Oil Well Completions - with Fracturing--Flares
- Intermittent Bleed Pneumatic Devices--Low Bleed
- Gathering and Boosting Stations--LDAR
- Transmission Station Venting--Gas Capture
- Liquids Unloading - Uncontrolled--Plunger Lift
- Chemical Injection Pumps--Solar Pumps
- Pipeline Venting--Pump-Down
- Oil Tanks--VRU
- Stranded Gas Venting from Oil Wells--Flares
- Reciprocating Compressor Fugitives--LDAR
- High Bleed Pneumatic Devices--Low Bleed

Total 163 Bcf methane reduced
40% of onshore emissions
Net cost $108 M/year
$0.56/Mcf of methane reduced
Less than $0.01/Mcf of natural gas produced
PHMSA Research Focus on Fugitive Methane

Refine/Enhance/Develop Methane Leak Survey Technologies and Methodologies to Quantify Detected Emissions from Relatively Small Volume Rate Leaks to Prioritize a Remedial Action Plan

- EDF/EPA/DOE, 2 dozen plus operators and tech vendors helped craft the topic

- Facets of this topic:
  - Focus on volumetric measurement of non-hazardous leaks
  - Utilize industry leak grading system
  - Develop framework to integrate leak and other required information into remedial plan – Dovetails with other R&D!

Award(s) anticipated by Feb 2015.
PHMSA Research Focus on Cast Iron

Research Goal - Support prioritizing replacement of higher risk cast iron pipe

- Ongoing research work with detecting graphitic corrosion and post mortem analysis on Cured in Place Liners

- New Research commencing by Feb 2015 on:
  - Structural Evaluation of Corroded Cast Iron Pipe
  - Engineering Critical Assessment of Cured in Place Pipe Liners at Bends, Valves and Service Taps

  - Goes beyond ongoing CIPL work
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