Gas Pipeline Incidents at State Highway Crossings

Philip W. Johnson, P.E., Ph.D.
Department of Civil, Construction and Environmental Engineering
The University of Alabama
pjohnson@ua.edu
Agenda

- Introduction
  - What is PHMSA?
  - What were our objectives in the data study?
- Culling the data
  - Why?
  - How?
- Culled data
  - Incident by pipeline type
  - Incidents at crossing
- Conclusions and further research questions....
PHMSA

- US Department of Transportation Pipeline and Hazardous Materials Safety Administration (PHMSA)
- Collects and publishes incident reports for pipelines
- Superb public resource
- Can download into EXCEL
- Can be overwhelming!
Study objectives

- What types of failures are common in pipelines?
- Is there a subset of PHMSA data that can be used to evaluate the usefulness of encasement?
  - If so,
    - Are failures types at crossings the same as in regular pipelines?
    - What failure types predominate at crossings?
    - Do failures differ between cased and uncased crossings?
## Incident Data

- Data taken from incident reports submitted to PHMSA
- Reports grouped by type of pipeline and year submitted:

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous Liquid</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gathering</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Incident Data

- Different forms for each type of pipeline and date range
- Only most recent data indicates cased/uncased
- Most state highway crossings are transmission and gathering or hazardous liquid
- Crossing data set is incomplete
- Not many crossing failures
## Incident Data

<table>
<thead>
<tr>
<th>Type of Pipeline</th>
<th>Crossing Incidents</th>
<th>Total Incidents</th>
<th>% at Crossings</th>
<th>K-Miles</th>
<th>Incidents per k-Mile</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous Liquid</td>
<td>18</td>
<td>3182</td>
<td>0.6</td>
<td>108</td>
<td>29.5</td>
</tr>
<tr>
<td>Distribution</td>
<td>14</td>
<td>1228</td>
<td>1.1</td>
<td>1,850</td>
<td>0.66</td>
</tr>
<tr>
<td>Transmission/Gathering</td>
<td>12</td>
<td>1208</td>
<td>1.0</td>
<td>300</td>
<td>4.03</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>44</strong></td>
<td><strong>5618</strong></td>
<td><strong>0.8</strong></td>
<td><strong>2,308</strong></td>
<td><strong>2.43</strong></td>
</tr>
</tbody>
</table>
PHMSA Pipeline Types

- Hazardous Liquids – all types together
- Gas:

<table>
<thead>
<tr>
<th></th>
<th>Distribution</th>
<th>Transmission and Gathering</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location</strong></td>
<td>Mostly in cities and towns</td>
<td>Mostly rural</td>
</tr>
<tr>
<td><strong>Road crossings</strong></td>
<td>Many, Dominant type</td>
<td>Fewer, Less common</td>
</tr>
<tr>
<td><strong>State Highway Crossings</strong></td>
<td>Fewer</td>
<td>Dominant type</td>
</tr>
<tr>
<td><strong>Pipe Material</strong></td>
<td>Moving to plastic</td>
<td>Mostly steel</td>
</tr>
<tr>
<td><strong>Pressure</strong></td>
<td>Low Pressure is common</td>
<td>High pressure is common</td>
</tr>
<tr>
<td><strong>Diameter</strong></td>
<td>Mostly small</td>
<td>Mostly large</td>
</tr>
<tr>
<td><strong>K-Miles of Pipeline</strong></td>
<td>1,850</td>
<td>300</td>
</tr>
</tbody>
</table>
Culling Incident Data

- Focusing on crossings required a culling process
- Eliminated:
  - Anything that could not be inside a road crossing (valves, stopples, sumps, etc.)
  - Pipes located above ground, under water, or under buildings
  - Pipes with diameter < 4” (eliminates mostly distribution)
  - Pipes with pressure > 1500 psi
  - Cast iron pipes (eliminates distribution incidents)
- After culling comparisons more reasonable
Culling Incident Data

- Results of culling:

<table>
<thead>
<tr>
<th>Type of Pipeline</th>
<th>Crossing Incidents</th>
<th>Total Incidents</th>
<th>% at Crossings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazardous Liquid</td>
<td>18</td>
<td>1736</td>
<td>1.0</td>
</tr>
<tr>
<td>Distribution</td>
<td>14</td>
<td>228</td>
<td>6.1</td>
</tr>
<tr>
<td>Transmission/Gathering</td>
<td>12</td>
<td>387</td>
<td>3.1</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>44</strong></td>
<td><strong>2351</strong></td>
<td><strong>1.9</strong></td>
</tr>
</tbody>
</table>

- Further culling: focused on gas pipelines, except at crossings
Incident Types – the major categories

- Technical
  - Material
  - Equipment
  - Internal corrosion
  - External corrosion

- Operations and management
  - Excavation damage
  - Incorrect operation

- Other
  - Natural force
  - Other outside force
  - Other incident cause
Distribution (228 Incidents)

- Situation is probably improving
  - Data not normalized by
    - Miles of pipe
    - Pipe material
    - Installation activity
- Recession impacted construction
- Dig-ins is a huge problem
  - Standards won’t fix this
  - Management and regulation problem
    - Prosecute?
Transmission/Gathering, 2004 - 2012 (387 Incidents)

- External Corrosion: 126 incidents
- Internal Corrosion: 78 incidents
- Equipment Failure: 83 incidents
- Excavation Damage: 27 incidents
- Incorrect Operation: 22 incidents
- Material Failure: 13 incidents
- Natural Force Damage: 6 incidents
- Other Outside Force: 29 incidents
- Other Incident Cause: 3 incidents
Transmission/Gathering (387 Incidents)

- Data not normalized
- External corrosion and dig-ins probably declining
- Dig-ins are the biggest problem
- Why the surge in material failures?
Combined Gas, 2004 – 2012 (615 Incidents)

- External Corrosion: 58 incidents
- Internal Corrosion: 80 incidents
- Equipment Failure: 22 incidents
- Excavation Damage: 36 incidents
- Incorrect Operation: 95 incidents
- Material Failure: 12 incidents
- Natural Force Damage: 27 incidents
- Other Outside Force: 11 incidents
- Other Incident Cause: 274 incidents
Road crossing incidents

- Relatively rare
- 44 at road crossings out of 2,231 (<2%)
- Probably more crossing incidents, but data is not clear
- How many miles of crossing per mile of pipe?
Cased Pipe Summary (22 Incidents)

- External Corrosion: 10
- Equipment Failure: 2
- Internal Corrosion: 4
- Excavation Damage: 4
- Incorrect Operation: 1
- Natural Force Damage: 1
- Other Outside Force: 2
- Other Incident Cause: 5

- Material Failure
  - 4 Haz Liquid
  - 1 Trans/Gathering
Cased Pipe Summary (22 Incidents)

- External corrosion dominates
  - Can’t monitor directly inside casing
  - Other studies also find corrosion worse inside casing
Uncased Pipe Summary (22 Incidents)

- **Excavation**: 11 incidents
  - 8 Distribution
  - 1 Haz Liquid
  - 2 Trans/Gathering

Other Incident Causes:
- External Corrosion
- Internal Corrosion
- Equipment Failure
- Excavation Damage
- Incorrect Operation
- Material Failure
- Natural Force Damage
- Other Outside Force
- Other Incident Cause

Incidents by Category:
- 3 External Corrosion
- 3 Internal Corrosion
- 1 Equipment Failure
- 2 Excavation Damage
- 2 Incorrect Operation
- 1 Material Failure
- 1 Natural Force Damage
- 1 Other Outside Force
- 22 Other Incident Cause
Uncased Pipe Summary (22 Incidents)

- Excavation dominates
- External corrosion less common
- Too many questions
  - Was dig-in under pavement?
  - Would casing have protected?
  - Miles of lines, casing, crossings?
The Most Recent Data

- Also looked at just the 2010 to present data
  - Includes incidents at crossings
  - Shows cased versus uncased
- Culled from the data
  - All cast or wrought-iron pipe
  - Incidents at
    - Valves
    - Compressor stations
    - Metering stations
    - 3rd party facilities
    - Other appurtenances
The Most Recent Data

Gas Incidents 2010 - 2012 (393 Incidents)

Gas Incidents at Road Crossings 2010 - 2012 (22 Incidents)

*Data also included 3 bridge crossings, 1 railroad crossing, and 3 water crossings.
## The Most Recent Data

<table>
<thead>
<tr>
<th>Cause</th>
<th>Cased</th>
<th>Uncased</th>
<th>Uncategorized</th>
</tr>
</thead>
<tbody>
<tr>
<td>Corrosion, external</td>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Corrosion, internal</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Equipment failure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Excavation damage</td>
<td>2</td>
<td>9</td>
<td></td>
</tr>
<tr>
<td>Incorrect operation</td>
<td></td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Material failure</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural force damage</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other Cause</td>
<td>1</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>5</td>
<td>16</td>
<td></td>
</tr>
</tbody>
</table>
The Most Recent Data

- Small data set on crossing failures
  - To small to draw firm conclusions
  - Probably more than 10 times as many uncased as cased crossings
    - Most crossings in cities are uncased distribution lines
    - Crossings in cities are more frequent per mile than in rural areas
    - Distribution line length is 5 times that of transmission & gathering
- About 5% of failures in the pipe are at crossings
- Dig-ins are clearly the most common crossing failure
- By far the most dig-ins are at uncased crossings
  - Are they actually where casing would have protected the pipe?
Conclusions

- Failures at road crossings are probably rare
- Cased crossings
  - Corrosion
    - The main problem
    - Casing probably increases the likelihood of corrosion failure
    - The biggest issue is monitoring inside casing
  - Only one reported dig-in
- Uncased crossings
  - Dig-ins are the most reported problem
    - Could be in ROW, outside of zone normally cased
  - Apparently less corrosion
Further research questions

- How many miles of pipeline and crossings are there by type?
  - State versus city
  - Pipe, steel or plastic
  - Cased versus uncased
  - Gas (transmission and distribution) versus liquid
- Uncased crossing dig-ins – what really happened?
- How does plastic compare to steel?
- What is the story on hazardous liquid pipelines?