Introduction to Risk Assessment (Distribution – DIMP)

2014 KCC Kansas Pipeline Safety Seminar
October 28th & 29th
Distribution Integrity Management Plan

Identify Threats & Evaluate and Rank Risk
Most significant Threat?

Significant Incident Cause Breakdown
National, Gas Distribution, 2008-2010

- CORROSION: 25.4%
- EXCAVATION DAMAGE: 24.4%
- INCORRECT OPERATION: 8.8%
- MAT’L/WELD/EQUIP FAILURE: 7.8%
- NATURAL FORCE DAMAGE: 7.8%
- OTHER OUTSIDE FORCE DAMAGE: 7.8%
- ALL OTHER CAUSES: 2.9%

Source: PHMSA Significant Incidents Files March 1, 2011

Note: Fire first incidents are excluded from 2004 onward in national statistics on the PHMSA stakeholder website. Operators are only required to report them when they cause >$50K damage to operator’s facilities.
Threat assessment

Identify types of threats to which the system might be exposed.

Eight Primary Threat Categories

1. Corrosion
2. Natural Forces
3. Excavation Damage
4. Other Outside Force Damage
5. Material or Weld Failure
6. Equipment Failure
7. Incorrect Operation
8. Other
Threat Identification

- Threat categories
  - Time Dependent
  - Time Independent

- Data Gathering, Data Integration, Threat Identification, and Risk Assessment are inter-related and dependent upon each other.

- A failure of one of these processes can result in threats to the integrity of the pipeline not being addressed.

- Threats are Potential Pipeline Failure Mechanisms or Pipeline Failure Cause Categories.

- Identifying Threats is key to Operator Integrity Decisions regarding measures to implement to reduce risk(s).
Identifying threats

- Threat Subcategories
- Potential Threats
  - Trenchless technology – unknowingly bored thru sewer or water lines
  - Future utility/road improvements
  - Customer overbuilt on pipeline
  - Hurricanes
Threat assessment method

Is the threat applicable and a problem?

- Trend historic performance such as:
  - Leaks per mile of main/service from Annual Report
  - 3rd Party Excavator Damages per thousand
  - Corrosion Leaks per mile of bare steel main
  - Cast iron main breaks per mile of cast iron pipe

- What do the trends show?
  - Good or improving? Maintain programs.
  - If not, include the facilities in risk evaluation.

- Is the threat clustered or system wide?
Assemble and analyze data

- Historical Service Leak Data, 1985-2007
- Analyzing percent of cast iron, bare, and unprotected steel services in the system, their leak rate, and the leak rate by cause over time.
Trending example

Bare Steel Mains and Corrosion Leaks - System A

Cast Iron & Wrought Iron Mains - System A
Threat Identification Guidance

• Good practices:
  ◦ Creating threat matrices
  ◦ Summarizing trending of historical leaks/leak repairs
  ◦ Distinguishing future “other” leaks eliminated by replacement
  ◦ Trending “mean year of installation” – older pipe replacement.
Threat Identification Guidance

• **Good practices:**
  - Looking at rolling averages take out yearly anomalies.
  - Identify failures without a release (e.g., overpressurization).
  - Correlating system characteristics to failure rate.

• **Geographic relationship of data is critical**
Facility subdivision

- Too granular of a subdivision may make number of leaks appear insignificant.
  - Facility groups were made so small that leak rate per facility grouping was very low.

- Not granular enough subdivision may hide problems.
  - Facility grouping was so broad that problems driven by individual traits were masked.
Threat assessment Resources

- See GPTC Section 4.3 Sample Threat Assessment.
- See SHRIMP Interview Questions
- But there is more to do than look at Leak & Incident Data for existing threats – look for Potential Threats.
§192.1007 What are the required IM program elements?

(b) *Identify threats.* (cont)
A operator must consider reasonably available information to identify existing and potential threats. Sources of data may include, but are not limited to, incident and leak history, corrosion control records, continuing surveillance records, patrolling records, maintenance history, and excavation damage experience.
Incident Causes or Threats to the Integrity of a Pipeline

There are many sources of information from which an Operator may identify potential threats

- ASME B31.8 S (Transmission)
- GPTC 192-8 (Distribution)
- PHMSA Safety Advisory Bulletins
- Industry Alert Notices
- Manufacturer’s Alert Notices
- Industry Research Reports
- Others
Incident Causes or Threats to the Integrity of a Pipeline from B3 I.8S

- Third Party Damage
  - Third party inflicted damage (instantaneous/immediate fail)
  - Previously damaged pipe (delayed failure mode)
  - Vandalism

- Corrosion Related
  - External
  - Internal

- Miscellaneous Equipment and Pipe
  - Gasket O-ring failure
  - Stripped threads/broken pipe/coupling fail

- Control/Relief equipment malfunction
  - Seal/pump packing failure
  - Wrinkle bend or buckle
  - Miscellaneous

- Incorrect Operations
  - Incorrect operation company procedure

- Weather Related
  - Cold weather
  - Lightning
  - Heavy rain or floods
  - Unknown

- Manufacturing Related Defects
  - Defect pipe seam
  - Defective pipe

- Welding/Fabrication Related
  - Defective pipe girth weld
  - Defective fabrication weld

- Outside Forces
  - Earth movement

- Environmental Cracking
  - Stress corrosion cracking
Threat Categories from GPTC G-192-8

- External Corrosion
  - Bare Steel Pipe (CP or no CP)
  - cast iron pipe (graphitization)
  - coated and wrapped steel pipe (CP or no CP)
  - Other metallic materials
- Internal corrosion
- Natural Forces
  - Outside force/weather: steel pipe
  - Outside force/weather: plastic pipe
  - Outside force/weather: cast iron pipe

- Excavation Damage
  - Operator (or its contractor)
  - Third-party
- Other Outside Force Damage
  - Vehicular
  - Vandalism
  - Fire/Explosion (primary)
  - Leakage (previous damage)
- Blasting
- Mechanical damage: Steel pipe, Plastic pipe, Pipe components
Threat Categories from GPTC G-192-8 (Continued)

- Material or Weld
  - Manufacturing defects
  - Materials/Plastic
  - Weld/Joint
- Equipment Failure
  - System Equipment
- Incorrect operation
  - Inadequate procedures
  - Inadequate safety practices
  - Failure to follow procedures
  - Construction/Workmanship defects
- Other Failure Causes the Operator has experienced
Safety Bulletins

• PHMSA Safety Advisory Bulletins (ex.)
  ◦ Certain Plastic Pipe Materials
  ◦ Cast Iron
  ◦ Drisco 8000
  ◦ TD Williams Repair Leak Clamps
• Manufacturer's Alerts
• PRCI Research Reports
• Others
Threat Identification

An Operator Must:

- Consider and Evaluate Existing and Potential Threats
- Justify Elimination of Threats from Consideration
Threat Identification

So, there is more to do than account for just Time Dependent and Time Independent Threats

- An Operator must look at “near misses”, known threats identified in Industry literature, PHMSA Advisory Bulletins, etc. and understand how threats interact with each other.
- An Operator should also consider that Interactive Threats (interaction of multiple threats) can be a potential threat.
Potential Threats

- Some Operators are struggling with potential threats:
  - Threats the Operator has not previously experienced, but identified from industry or PHMSA information
  - Threats from aging infrastructure and materials with identified performance issues may need to be considered existing threats depending on the materials in question and the operating environment
  - Threats that endangered facilities but have not resulted in a leak (e.g., exposed pipe, near misses).
  - Non-leak threats (overpressure, exposure)
  - Manufacturing and Construction Threats
  - Maintenance history
Potential Threat Identification

- This is a thoughtful consideration of what else could go on that standard risk assessment models do not account for.
- Consider what other threats (and interactive threats) exist in the Operator’s unique operating environment.
- Consideration of near miss events and abnormal operating condition events (just to name a couple of potential threat identification areas) is needed.
- It can be resource intensive depending on the materials and operating environment.
- Sufficient time and resources should be committed to the task(s).
Identified Potential Threats

Examples of potential threats often not being considered:

- Over pressurization events
- Regulator malfunction or freeze-up
- Cross-bores into sewer lines
- Materials, Equipment, Practices, etc. with identified performance issues
- Vehicular or Industrial activities
- Incorrect maintenance procedures or faulty components
- Rodents, plastic eating bugs, tree roots
- Other potential threats specific to the operator's unique operating environment
Interactive (Potential) Threats

- Distribution Operators should look to their Leak and Incident history, O&M history, and other sources to identify interactive threats specific to their system.

- Examples of interacting threats to consider include:
  - Slow crack growth in older plastics where pipeline was pinched during operational event or where over-squeeze occurred due to improper tools or procedure
  - Slow crack growth in older plastics where non-modern construction practices were used
  - Water main leakage areas or areas of soil subsidence with cast iron mains
  - Installation of mechanical fittings without restraint (category 2 & 3) in soils or conditions (excavation damage) that cause pipe to pull out of fitting
Identify Threats to Integrity

- A DIMP must provide adequate details or specificity to address specific threats and risks in the Operator’s unique operating environment.
- Consideration must be given to applicable operating and environmental factors affecting consequence (e.g., paved areas, business districts, hard to evacuate) relating to the Consequence of Failure (COF) when evaluating risk.
- DIMP procedures must provide for the re-evaluation of threats and the identification of new or potential threats.
- Plan must include procedures to evaluate and obtain data from external sources that are reasonably available to identify existing and potential threats.
§192.1007 (c) Evaluate and rank risk. An operator must evaluate the risks associated with its distribution pipeline. In this evaluation, the operator must determine the relative importance of each threat and estimate and rank the risks posed to its pipeline. *This evaluation must consider each applicable current and potential threat, the likelihood of failure associated with each threat, and the potential consequences of such a failure.* An operator may subdivide its pipeline into regions with similar characteristics (e.g., contiguous areas within a distribution pipeline consisting of mains, services and other appurtenances; areas with common materials or environmental factors), and for which similar actions likely would be effective in reducing risk.
Evaluate and Rank Risk

- Risk = Frequency (Threat) X Consequence
- Predictive
- How frequently does it happen?
- If it happens, how significant could it be?
- Does it warrant additional risk reduction measures?
- GPTC Section 5 – example
- There are multiple methods for Risk Modeling
Evaluate and Rank Risk

- **Cumulative threats model**
  - Operator subdivides the system geographically
  - Determines likelihood & consequence weighting
  - Aggregates the risk due to each threat to the system

<table>
<thead>
<tr>
<th>Risk Score for Groups of Facilities by Primary Threat Category</th>
<th>CORROSION</th>
<th>NATURAL FORCES</th>
<th>EXCAVATION DAMAGE</th>
<th>OTHER OUTSIDE FORCE DAMAGE</th>
<th>MATERIAL OR WELDS</th>
<th>EQUIPMENT</th>
<th>INCORRECT OPERATIONS</th>
<th>OTHER</th>
<th>Total Risk Score</th>
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</thead>
<tbody>
<tr>
<td>Operating District D</td>
<td>23</td>
<td>12</td>
<td>89</td>
<td>89</td>
<td>45</td>
<td>3</td>
<td>1</td>
<td>77</td>
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<td>Operating District I</td>
<td>45</td>
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<td>82</td>
<td>35</td>
<td>5</td>
<td>2</td>
<td>69</td>
<td>331</td>
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<tr>
<td>Operating District A</td>
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<td>9</td>
<td>87</td>
<td>88</td>
<td>19</td>
<td>2</td>
<td>1</td>
<td>81</td>
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<tr>
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<td>21</td>
<td>50</td>
<td>45</td>
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<td>1</td>
<td>87</td>
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<td>8</td>
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<td>88</td>
<td>20</td>
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<tr>
<td>Operating District H</td>
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<td>3</td>
<td>68</td>
<td>67</td>
<td>20</td>
<td>3</td>
<td>1</td>
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<tr>
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<td>7</td>
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<tr>
<td>Operating District J</td>
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<td>50</td>
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<td>20</td>
<td>6</td>
<td>4</td>
<td>1</td>
<td>15</td>
<td>80</td>
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</tbody>
</table>
Evaluate and rank Risk

### Threat specific model

<table>
<thead>
<tr>
<th>Corrosion</th>
<th>Total Risk Score (likelihood x consequence)</th>
<th>Natural Forces</th>
<th>Total Risk Score (likelihood x consequence)</th>
<th>Excavation Damage</th>
<th>Total Risk Score (likelihood x consequence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bare steel pipe VA</td>
<td>9</td>
<td>DC Cast Iron - water main breaks</td>
<td>78</td>
<td>Mapping omissions &amp; inaccuracies</td>
<td>85</td>
</tr>
<tr>
<td>Bare steel pipe MD</td>
<td>4</td>
<td>Washouts Montgomery</td>
<td>54</td>
<td>Fiber optic planning district</td>
<td>77</td>
</tr>
<tr>
<td>Cast Iron DC</td>
<td>3</td>
<td>Downtown Alexandria Flood district</td>
<td>12</td>
<td>Blasting Leesburg</td>
<td>58</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Outside Forces</th>
<th>Total Risk Score (likelihood x consequence)</th>
<th>Material or Weld</th>
<th>Total Risk Score (likelihood x consequence)</th>
<th>Equipment Failure</th>
<th>Total Risk Score (likelihood x consequence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Meter sets in Parking Garages Without protection</td>
<td>78</td>
<td>Mechanical coupled services from 1950 - 1970</td>
<td>75</td>
<td>Obsolete rectifiers</td>
<td>1</td>
</tr>
<tr>
<td>Aboveground regulator stations near road widenings - VDOT</td>
<td>65</td>
<td>Kerotest valves - thoroughout system</td>
<td>12</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Incorrect Operation</th>
<th>Total Risk Score (likelihood x consequence)</th>
<th>Other</th>
<th>Total Risk Score (likelihood x consequence)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overpressure System</td>
<td>65</td>
<td>Pipe on building rooftops</td>
<td>34</td>
</tr>
</tbody>
</table>

### Relative Risk Ranking of groups

<table>
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<th>Total Risk Score</th>
</tr>
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<tr>
<td>Bare steel pipe VA</td>
</tr>
<tr>
<td>Pre 1970 plastic pipe - uprated in '90s</td>
</tr>
<tr>
<td>Bare steel pipe MD</td>
</tr>
<tr>
<td>Cast Iron DC</td>
</tr>
<tr>
<td>Obsolete rectifiers</td>
</tr>
</tbody>
</table>
Evaluate and Rank Risks

- System subdivision for the evaluation and ranking of risks must be sufficient to appropriately analyze risk(s) present in the Operator’s unique operating environment.
- System subdivisions may be predicated on threats (materials, construction, etc.) and consequences (wall-to-wall pavement, high density population areas, etc.)
- Geographical segmentation may be appropriate when systems are separated by space or a specific, predominate threat exists (e.g., where flooding can be expected, earthquake prone area). However, different materials may be a predominate threat in a region, and segmentation may need to be refined to accommodate different failure rates.
Evaluate and Rank Risks (cont.)

- Plan must provide explanation of the process used to validate the data used in the risk ranking and to review the output of the risk ranking model for “reasonableness”.
- The Plan (or Model used such as Opti-main) must address risks specific to services as well as mains.
- When changes are made to a risk model, the risk ranking should be re-run and results incorporated into DIMP promptly.
QUESTIONS?