Session 4 – Defect Detection/Characterization

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Defect Detection/Characterization

Session Chairs
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Facilitator
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### Session 4 – Defect Detection/Characterization

## Attendance Breakdown

<table>
<thead>
<tr>
<th>Category</th>
<th>Attendance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Approximate total attendance</td>
<td>60 persons at peak</td>
</tr>
<tr>
<td>PHMSA, Federal Regulators</td>
<td>2</td>
</tr>
<tr>
<td>National standards</td>
<td>1</td>
</tr>
<tr>
<td>International standards</td>
<td>1</td>
</tr>
<tr>
<td>Pipeline operators</td>
<td>20</td>
</tr>
<tr>
<td>Service providers</td>
<td>20</td>
</tr>
<tr>
<td>Researchers</td>
<td>20</td>
</tr>
</tbody>
</table>

Note: only 30 (5 pipeline operators) present when priorities were voted
### GAP Analysis – Summary of Capabilities

<table>
<thead>
<tr>
<th>Industry Needs – Threats</th>
<th>MECHANICAL DAMAGE</th>
<th>CORROSION</th>
<th>SCC</th>
<th>CONSTRUCTION DEFECTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical Areas - Activities</td>
<td>Dent, gouge, dent+gouge</td>
<td>Ext (int)</td>
<td>Ext (int)</td>
<td>Girth Weld, Seam Weld, Body</td>
</tr>
<tr>
<td>DETECTION DISCRIMINATION</td>
<td>✓</td>
<td>✓</td>
<td>?</td>
<td>✓</td>
</tr>
<tr>
<td>SIZE / DEPTH</td>
<td>×</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
</tr>
<tr>
<td>ILI</td>
<td>×</td>
<td>?</td>
<td>×</td>
<td>?</td>
</tr>
<tr>
<td>IN-DITCH</td>
<td>×</td>
<td>?</td>
<td>×</td>
<td>?</td>
</tr>
<tr>
<td>ASSESS</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FAILURE PRESSURE</td>
<td>×</td>
<td>✓</td>
<td>?</td>
<td>✓</td>
</tr>
<tr>
<td>GROWTH RATE</td>
<td>×</td>
<td>×</td>
<td>×</td>
<td>? (BENIGN VS. ACTIVE)</td>
</tr>
<tr>
<td>UNDERSTANDING MECHANISMS</td>
<td>×</td>
<td>?</td>
<td>?</td>
<td>✓</td>
</tr>
<tr>
<td>Inc WHERE TO LOOK</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EFFECTIVE CODES</td>
<td>×</td>
<td>✓</td>
<td>×</td>
<td>✓</td>
</tr>
<tr>
<td>Inc VALIDATION, QUALIFICATION, TRAINING</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

✓ = largely OK, × = needs improvement
Phase 1 – Identified Gaps and Issues

DETECTION & DISCRIMINATION

- Discriminate MD secondary features… cracks, corrosion
- Benign vs. active construction defects
- ILI for SCC in gas pipelines
- Other in-ditch inspection technologies
- Guided wave performance: Influence of coatings, applicability to cased crossings, range extension, reproducibility, size thresholds etc
- Inspection through coating, internal scale
- Quantified Probability of Detection
- *Note … leak detection …. not discussed!*

SIZE MEASUREMENT

- Sizing MD features, including secondary features
- Size accuracy… depth is critical, then length, width …
  \[ \rightarrow \] ILI performance specifications (MD & SCC, corrosion)
- Interacting cracks

SIZE CHANGE – GROWTH & DEGRADATION

- Growth rates for corrosion, SCC & MD
- Growth monitoring (online, real time)
Phase 1 – Identified Gaps and Issues (cont’d)

ASSESSMENT

• Failure Pressure of MD
• Screening Assessment for MD; discriminating secondary features
• Effects of residual stress, secondary loading, (ground movement, frost heave)
• Defects are more critical for high strength steels, high design factors
• Assessment of SCC & corrosion at MD
• Toughness vs. Charpy correlation
• Uncertainty of other properties, dimensions
• Delayed Failure: Assessment of MD
  Influence of changing operation, load,
  Influence of changing environment
• SCC crack coalescence
• Collate & review damage experience and learn from it
• Validation of Models….pool of ex-service samples for testing (MD, SCC)
  → code improvements
Phase 1 – Identified Gaps and Issues (cont’d)

UNDERSTANDING THE MECHANISMS, KNOWING WHERE TO LOOK

• Microbial corrosion
• SCC, corrosion: site selectivity
• Distinguishing between rock dents and impact damage
• Coating degradation and disbond: when does corrosion/SCC start?
• Influence of toughness / ductility on delayed failure of MD

CODES, STANDARDS AND INDUSTRY GUIDANCE

• Field testing & demonstration of prototype vehicles, technologies
  → building confidence in capabilities, performance
• ILI performance specifications (corrosion, then SCC, MD)
• Use of complementary techniques to improve POD
• Independent loop test facilities; learning & training, calibration, certification
• Technology packages to support code improvements
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Top 4 Identified R&D Gaps

Defect **Sizing from Outside the Pipe**  
(New / Improved Technology)

Defect **Sizing using ILI**  
(New / Improved Technology)

**Validation, Testing & Qualification**  
(Consensus Standard)

**Severity Assessment of Mechanical Damage,**  
[SCC, Corrosion]  
(New / Improved Technology)
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Defect Sizing from Outside the Pipe

- New or improved technology, relevant to onshore (and offshore) gas and liquids lines, low (and high) pressure applications
- Addresses corrosion, mechanical damage and SCC defects
- Technology needs:
  - Improved sizing and location accuracy
  - Requirement for improved range
  - Focus on depth as opposed to cross-sectional area
  - Address influence of external condition of pipe – coating, soil etc
  - Address internal pipe condition (as necessary)

- Implementation and deployment issues:
  - Certain coatings may be show-stoppers
  - Property variations of material
  - Availability of performance criteria, standard calibration
  - Knowledge, qualification and operator skill
  - Cost

- Timescale to complete research:
  - Guided wave: 1 – 3 yrs
  - Laser mapping, high resolution eddy current methods 1-3 Yrs
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Defect Sizing using ILI

- New or improved technology, relevant to onshore and offshore gas and liquids lines, high and low pressure applications
- Addresses corrosion, mechanical damage and SCC defects
- Technology needs (ILI for ‘piggable’ systems):
  - Improved sizing accuracy (depth, then length, width), resolution
  - Crack detection in gas pipelines (esp SCC)
  - Discrimination of secondary features (esp mechanical damage)
  - Requirement to increase range for low-pressure-system vehicles
- Technology needs (vehicles for ‘unpiggable’ systems):
  - Improved location and sizing reliability
  - Focus on depth as opposed to cross-sectional area
  - Address influence of external condition of pipe – coating, soil etc
  - Address internal pipe condition (as necessary)
  - Range

- Implementation and deployment issues:
  - Piggability
  - Availability of standard calibration and facility to examine calibration
  - Uneven coating for ultrasound

- Timescale to complete research: 1 – 3 yrs – accelerate if possible

*Government/Industry Pipeline R&D Forum - New Orleans, Louisiana, February 7-8, 2007*
Validation, Testing & Qualification

- Revised standards, guidelines and recommended practices, relevant to onshore and offshore gas and liquids lines, high and low pressure applications
- Addresses corrosion, mechanical damage and SCC defects
- Impacts on a wide range of existing industry standards (ASME, API, NACE etc) and government regulations
- Needs:
  - Validation of new inspection/detection technologies and analysis methods for defect detection and characterization, using
    - Full-scale laboratory-based testing – pipe failure tests, vehicle pull-through tests; this requires a pool of ex-service pipe samples
    - Field trials/demonstrations to establish capabilities and build confidence
    - Quantification of performance specifications
    - Independent calibration/certification of accuracy and reliability (detection, identification, false calls, dimensions)
    - A ‘learning test loop’ for capability assessment, training and qualifying operators
  - Technology packages to support improvements in codes and regulations
- Timescale for completion: 2-5 years
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Assessment of Mechanical Damage, (and SCC, Corrosion)

• New or improved technology, relevant to onshore and offshore gas and liquids lines, high and low pressure applications
• Addresses mainly mechanical damage, but also SCC and corrosion defects
• Technology needs:
  • Improved screening assessment (Level 1), including discrimination of secondary features affecting damage severity
  • Improved methods for detailed assessment (Level 2, 3)
  • Methods for assessing immediate failure and delayed failure of mechanical damage (including the effects of changed loading, environmental conditions)
  • Growth rate data (esp depth) for time-dependent failure of corrosion, SCC
  • Defect criticality in higher strength steels and at higher design factors
• Implementation and deployment issues:
  • Critical to maximize collaboration between inspection companies and pipeline operators in order to learn from trials, early operational experience etc
  • Damage + corrosion/SCC is an additional complication, requiring assessment methods
  • Impact of new fuels on internal corrosion/SCC

• Timescale to complete research:
  • Screening assessment: 1-3 years; accelerate if possible
  • Detailed methods for all situations: 3-10 years
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Additional Gaps

See the earlier slides on

Detection and discrimination
Size measurement
Size change – growth and degradation
Assessment
Understanding the mechanism – knowing where to look
Codes, standards and industry guidance