Pipeline Research Council International, Inc.

Anomaly Detection and Characterization R&D for In-Line Inspection

Successes, Challenges, & Opportunities

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Presentation Topics

- Summary of PRCI Programs and Approaches Related to In-Line Inspection – Drivers and Challenges

- Building on the Successes and Addressing the Next Series of Challenges for the R&D Community
PRCI Membership Drives Research

- **38 Energy Pipeline Operating Companies**
  - 25 Natural Gas Transmission; 11 Liquid
  - 2 Operators - both Liquid and Natural Gas Transmission

- **World-wide Research Organization**
  - 26 U.S. Companies
  - 12 Non-U.S. (Brazil, Canada, Europe, Saudi Arabia)

- **14 Associate Members**
  - U.S.; Canada; Mexico; Japan

- Total mileage represented ~355,000 miles
Anomaly Characterization:
Sensors
Deployment
Data Analysis & Integration

Primary Types of Defects:
Volumetric Anomalies
Planar anomalies
Deformation anomalies
Complex defects
NDE Roadmap – Program Structure
Overall Objectives of Roadmap

To develop and validate improved tools and inspection procedures for locating, sizing and characterizing:

- Corrosion and metal/wall loss
- Stress corrosion cracking
- Non-penetrating mechanical damage defects due to impact
- Other features/defects (e.g., Vintage girth welds)
Defect Populations – NDE Program

- Corrosion – Internal & External
- Coating damage, removal
- Dent (re-rounded), pipe ovalization
- Stress, strain concentration
- Metal removal, ploughing, gouge
- Surface & sub-surface cracking
- Time-dependent cracking
- MD with Nearby weld, corrosion
- Leak vs. Rupture
  - Tracks 2, 3 & 4
Focus on managing threats and integrity management

- MD-1; Tools to Detect and Discriminate Mechanical Damage
- NDE 1; NDE Inside the Pipe
- SCC-3; Sensor Technology for Sizing and Characterizing SCC Cracks
- EC-4; Accuracy of tools for corrosion mapping
- EC-5; Location and Characterization of Corrosion in Difficult to Inspect Areas
- SPIM -1; Subsea Pipeline Integrity Management and inspection
Technical Approach – Current Projects

- **Benchmarking and Applying Existing Technology**
  - Performance of existing technologies – MD-1-2
  - Vintage Girth Weld Defect Detection and Characterization Using ILI Technology – NDE 1-1
  - ILI Performance Characteristics (corrosion based) – EC 4-1
  - Related in-the-ditch projects – MD 1-4, MD 1-5, NDE 2-2
  - Understanding signals from MD – MD-1-3

- **Next-generation Technology**
  - Dual-field MFL – MD 1-1
  - Ultrasonic measurement of strain – MD-1-6
  - Detection, Sizing and Characterization of SCC and Other Cracks in Dents – SCC 3-4
  - SCC crack mapping using a Flexible Eddy Current Array Probe (SCC 3-5)
  - Monitoring advances/developments for EMAT tools – SCC 3-7

- **PRCI 2010 Ballot**
Detecting and Characterizing Damage
Assessing Damage Severity
NDE Focus Areas for ILI

- Improved quantitative understanding of the ability of ILI technologies to detect and discriminate features
- Determination of the performance characteristics of existing ILI techniques
- Exploration and validation of new ILI tools/technologies
- Establishment of techniques and protocols for in-the-ditch measurements to improve understanding of ILI capabilities
- Improve (or develop new) industry guidance and best practice for characterization and measurement of anomalies
Gaps in Understanding & Capability

- Quantitative understanding of the performance of existing ILI for discriminating between significant and benign anomalies

- Ability to interpret MFL signals for accurate characterization of defect features

- Additional field experience to validate dual-field MFL and other emerging ILI technologies

- Industry guidance on feature characterization and measurement for damage severity assessment (linked to “Outside the Pipe”)

- Severity-ranking and decision-making algorithms enabling timely and proportionate responses when damage is discovered
  - Link to Track 4
Future Directions & Developments

- Reliability Based Integrity Management
  - Key Elements of the approach are directly linked to improvements in ILI technology or development of standards and/or knowledge documents; establishing reliability targets linked to ILI/ECDA
    - ILI tool tolerances and uncertainty - Effect of ILI POD and sizing uncertainties on these predictions
    - Corrosion growth rates and variability
    - Re-inspection intervals – will rely substantially on understanding and degree of confidence in ILI readings; improved accuracy improves RB IMP
  - Defect population and growth rates: generally comes from NDE and comparison with similar lines (databases)
    - Several PRCI projects in this area
  - Impact of ILI data on computational models – e.g., accuracy of prediction of limit state models (RSTRENG, ASME B31.8G)
    - The capabilities and limitations of models used needs to be carefully assessed and understood
    - Recent work in this area by both PRCI and DOT

- Advance combo tools/technologies – “Super Pig”
Roadmap Outcomes & Industry Benefits

- **Improved tools** for locating, characterizing and sizing the features that discriminate damage severity, forming the basis for reliable, quantitative assessment of structural significance (immediate/delayed failure)

- **An effective suite of assessment methods** to quantify damage severity, enabling sound decision-making and safe, timely repairs (screening, case-by-case, ECA)

- **New recommendations** for determining safe pressure reductions and working practices during repair

- **Recommended practices** for using composite materials to repair mechanical damage

- **An Industry Guidance document** to aid decisions on the characterization, severity assessment and safe excavation/repair of damaged pipe
Key Industry Challenges and R&D Needs

- New/emerging technologies - sensors, platforms, data mgmt
- Better accuracy and certainty for the sizing of corrosion and estimating corrosion growth rates
  - Improve understanding of the effects of ‘very deep defects’ and the statistical distribution assumptions on their occurrence and the predicted risk
  - Study time-dependent effects - better assess corrosion rates/variability
  - Location dependence of corrosion and statistical dependence of corrosion rates on ‘neighboring’ defects
- Improved tools for crack/cracking detection
- A different approach to MFL - supplements to MFL technology or step changes in tool application or advancement
- EMAT – monitoring performance and modeling to advance understanding of EMAT signals
- Eddy current – A combination of MFL and Eddy Current could improve identification capabilities, e.g., deep defects
Key Industry Challenges and R&D Needs

- Developing databases of defects for testing and validation with real features/defects

- Effective and routine communication between ILI vendors and operators

- Reducing ‘Historical’ Population of Defects
  - assessment → monitoring
  - repeat inspections – technology capabilities will need to improve on the ±10% or 15% tolerance with an 80% certainty

- Improving Methods for Correlating ILI Signals to In-the-Ditch Assessment
  - Algorithms and protocols

- Continued validation of Reliability-Based approaches