Assessment and Management of Pipeline Cracking

API RP 1176 Status and Implementation Plan
Pipeline Safety Trust

November 20, 2015
Industry Integrity Efforts Have Reduced Incidents in Key Areas

- Corrosion incidents are down 76%
  - Enhanced “smart pig” ILIs
  - Strengthened corrosion management programs

- Third-party damage incidents are down 78%
  - Improved public awareness campaigns

- Opportunity now to address need for better crack detection, analysis and response
  - Especially for seam-related cracks

Source: 2015 API-AOPL Annual Liquids Pipeline Safety Performance Report & Strategic Plan
RP 1176 Incorporated Expertise from Across the Industry

- A Task Group within API's Pipeline Integrity Work Group (PIWG) led the RP development process
  - Integrity managers from 20+ companies
  - Five subcommittees

- Retained counsel from some of the leading pipeline experts
  - Kiefner & Associates served as technical consultants

- Incorporated work from
  - AOPL, INGAA and CEPA
  - R&D by industry and regulators
  - Existing standards and documents

- Sought review and input from state and federal regulators
RP 1176 Scope

- applicable to any pipeline system used to transport hazardous liquid or natural gas
  - including those defined in U.S. Title 49 CFR Part 195 and 192.

- provides the operator with a description of industry-proven practices in the integrity management of cracks
  - and threats that give rise to cracking mechanisms

- largely targeted to the line pipe along the right-of-way
  - some of the processes and approaches can be applied to pipeline facilities
Crack Management RP Philosophy

- Augments operators existing IMP
- Address all types of crack failure mechanisms
- Flexible
- Requires an in-depth knowledge of each system’s characteristics
- Requires the integration of data
Mike Stackhouse – Plains - Overall RP Leader
Five Subcommittees Focused on Key Topics

- Bruce Dupuis – TransCanada
  - Mechanical Damage
  - SCC

- Jake Haase – Enterprise Products
  - ILI Assessment
  - Response Criteria
  - Assessment Selection

- Ken Bagnoli – Exxon Mobil
  - Manufacturing defects
  - ERW Seams

- Benny Mumme – Koch Pipeline
  - Remediation
  - Performance Metrics
  - Reassessment

- Rich Dalasio – Sunoco Logistics
  - Consistency across RP and with other standards
  - Coordination and Alignment
  - Research

- Kiefner & Associates
  - SMEs
1. Understanding the threat mechanisms associated with pipeline cracking
   A. SCC and other environmental cracking
   B. Long-seam defects: ERW & EFW, DSAW
   C. Mechanical damage

2. Applying the most appropriate integrity assessment technology and modeling
   A. Integrity assessment method selection
   B. ILI technology review
   C. Hydrostatic testing
   D. In-the-ditch NDE
   E. Defect growth and re-assessment

3. Employing the appropriate repair strategies

4. Establishing preventative and mitigative practices

5. Evaluating program performance
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“provide general guidelines for application of inspection technology”

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11.4 Capabilities of In-Line Inspection Tools for Axial Cracks
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11.7 Crack ILI Response Criteria
Crack response

Requires balance between:

- Prioritized response similar to corrosion
- Avoiding onerous excavation program that provides little risk reduction and large negative impact on all stakeholders
Current Crack Response

Current (and proposed version) of 49 CFR Part 195 stipulates a 180 day (270 day) response for the criteria:

A potential crack indication that when excavated is determined to be a crack.

Similarly, current version of API 1160 stipulates a 365 day response for the criteria:

A potential crack indication that when excavated is determined to be a crack.

Issues:

- Provides no assessment/prioritization guidance
- Implies no crack merits an immediate response
Crack Response: RP Immediate Conditions

a) A Likely Crack whose predicted depth is greater than 70% of nominal pipe wall.

b) A Likely Crack with an FPR less than 1.1.

c) A Likely Crack or Possible Crack indication predicted to interact with a dent.

action required by an operator regardless of whether they are found within a segment of pipeline that could potentially impact an HCA or not
Crack Response Approach

Create a flexible framework provides for operators to develop a crack response criteria in which different operators can leverage their experience and understanding of:

- Inspection technology
  - Detection
  - Characterization
  - Sizing
- Susceptibility
- Growth mechanism
Section 11.6 Crack Tool Response Methodology

- Map ILI features into a common frame of reference - integrity relevance:
  - Likely Crack
  - Possible Crack
  - Unlikely Crack

- Valid cracking mechanism (susceptibility), to account for the presence of the ILI anomaly.

- “Likely Crack” directly proceeds to remediation per the prescribed timeline.

- “Possible” and “Unlikely” reflect the potential of an iterative field correlation program with a protracted timeline.
Crack Response: 365-day Conditions

(a) A crack ILI indication whose predicted depth is greater than 50 % of nominal pipe wall that has been determined to be one of the following:
   1) A Likely Crack that is time-dependent or potentially time-dependent
   2) A Possible Crack that is time-dependent

(b) A crack ILI indication with an FPR less than 1.25 that has been determined to be one of the following:
   1) A Likely Crack that is time-dependent or potentially time-dependent
   2) A Possible Crack that is time-dependent

(c) If not already available through previous correlation data or required excavations, a representative sample of the crack ILI indications that considers both the likelihood and time-dependency characterizations identified by the operator.
Crack Response: Scheduled Conditions

- When a time-to-failure analysis of a crack ILI indication that DOES include tool tolerances reaches an FPR less than 1.1, is determined to be time-dependent, and is a Likely Crack or Possible Crack.

OR

- When the half-life of a time-to-failure analysis of a crack ILI indication that DOES include tool tolerances that reaches an FPR of 1.0, is determined to be time-dependent, and is a Likely Crack or Possible Crack.
Crack Response

Crack Length

- isolated cracks (river bottom): \( L = \) length of crack tip to crack tip
- isolated cracks (elliptical profile): \( L = \) length of the effective area
- colony or field of cracks: \( L = \) interlinking crack length
  - In many cases, the interlinked length is shorter than the length of the crack colony or field.

- Annex C - Assessment Methods for Crack-like Flaws
- Annex E - Toughness
- Annex G - Fatigue C and n Values
Fatigue Growth

\[ \frac{da}{dN} = C(\Delta K)^n \]

- **Paris Law**

### Table G.1. Survey Sampling of Line Pipe Fatigue Crack Growth Parameters

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<th>Source</th>
<th>Application</th>
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<th>C, Pa(m)^{0.5}</th>
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<td>Keller, et al (DOE)</td>
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<td>Lambert, et al</td>
<td>X60, fatigue component of SCC lab testing with SCC crack growth rate of 0.0927 mm/yr (0.00365 in./yr)</td>
<td>1.53e-14</td>
<td>1.68E-08</td>
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</table>
Stress Corrosion Cracking

- 6 Threat Mechanisms Associated with Cracking
  - 6.2 Environmentally Assisted Cracking
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- 13 SCC Direct Assessment

- Annex A - SCC Additional Information

- Annex H - Prediction of Crack Growth with Consideration of Variable Loading Conditions on Oil and Gas Pipelines in Near-Neutral pH Environments
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- **14 In-the-Ditch Assessment**
  - 14.1 General
  - 14.2 Assessment of SCC and Other Pipe Body Cracks
  - 14.3 Assessment of Longitudinal Seam Cracks

- **Annex K - In-the-Ditch Technology**
API RP 1176’s Development Timeline

- Work teams began in 2/2014

- Version 5 sent to API PIWG, API OTG, PHMSA, and INGAA on 11/3/14 for review

- Version 5 comments were resolved by 12/31/14

- Version 6 was balloted 5/2015
  - Extensive engagement across industry generated hundreds of comments and proposed edits

- Version 7 (edits to version 6) will be balloted in 12/2015
  - Anticipating late Q1/16 to early Q2/16 final release
RP 1176 Implementation Plan Objectives and Tactics

- **Create awareness of relevance of RP 1176**
  - Align industry around importance of implementing RP 1176
  - Panel sessions at API Conf, Enbridge Cracking Forum, Banff Pipeline Integrity Workshop, Rosen Roundtable
  - Publishing information in technical journals
  - Finalizing communication materials for external audiences: taking points, pamphlet etc

- **Improve understanding**
  - Provide additional API Conf. sessions to communicate content
  - Hold technical sessions to support implementation effectiveness

- **Assist institutionalizing**
  - Developing a abridged companion document to support operator implementation
  - Communicate leadership roles

- **Leverage external communications**
  - Increase appreciation of industry’s proactive approach to mitigate cracking-related integrity concerns