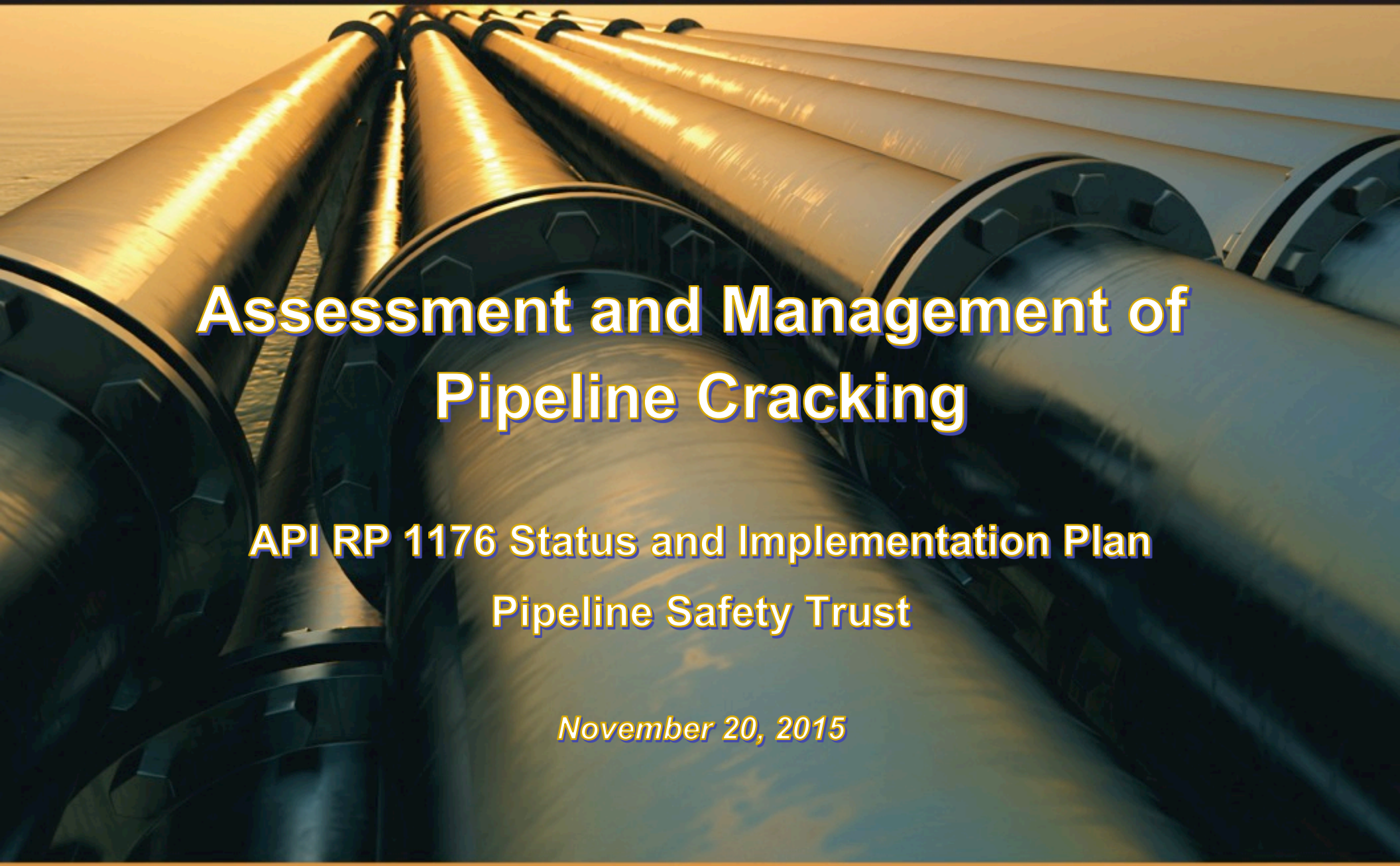


# Assessment and Management of Pipeline Cracking

## API RP 1176 Status and Implementation Plan

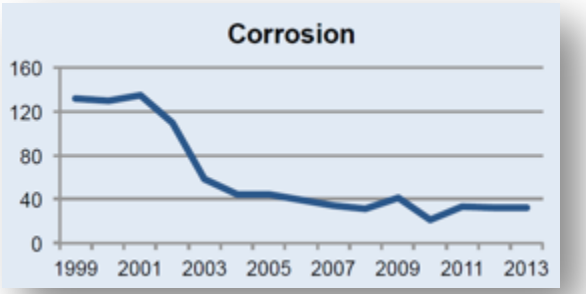
## Pipeline Safety Trust

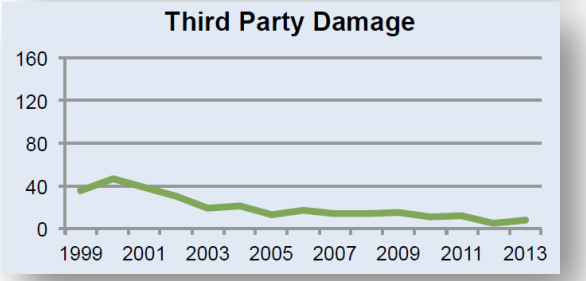
*November 20, 2015*

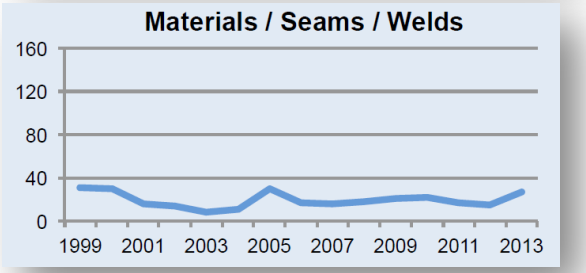
# Industry Integrity Efforts Have Reduced Incidents in Key Areas

- **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

## Right of Way Incidents




*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
- **Benny Mumme – Koch Pipeline**
  - Remediation
  - Performance Metrics
  - Reassessment
- **Jake Haase – Enterprise Products**
  - ILI Assessment
  - Response Criteria
  - Assessment Selection
- **Rich Dalasio – Sunoco Logistics**
  - Consistency across RP and with other standards
  - Coordination and Alignment
  - Research
- **Ken Bagnoli – Exxon Mobil**
  - Manufacturing defects
  - ERW Seams
- **Kiefner & Associates**
  - SMEs

# RP 1176 Outlines the Core Disciplines of Crack Management Programs

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**

# Table of Contents - Sections



**Over 160 pages in length**

# Table of Contents - Annexes

# Section 11 In-Line Inspection for Integrity Assessment

**"provide general guidelines for application of inspection technology"**

11.1 General
11.2 In-Line Inspection Tool Types
11.3 ILI Tool Utilization Considerations
11.4 Capabilities of In-Line Inspection Tools for Axial Cracks
11.5 Verification of ILI Results
11.6 Crack Tool Response Methodology
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**

| Source | Application | C, ksi(in.)$^{0.5}$ | C, Pa(m)$^{0.5}$ | n |
|---|---|---|---|---|
| API 579 | Welds | 8.16E-10 | 8.97E-04 | 3.00 |
| Barsom & Rolfe | "Typical," ferrite-pearlite steels | 3.60E-10 | 3.96E-04 | 3.00 |
| Vosikovsky | X65, in aqueous environments | 5.20E-10 | 5.71E-04 | 2.82 |
| Vosikovsky | X65, in sour crude oil | 7.24E-10 | 7.96E-04 | 2.90 |
| Andreason & Vitovec | Grade B | 1.32E-20 | 1.45E-14 | 5.40 |
| Keller, et al (DOE) | X52 | 1.41E-13 | 1.55E-07 | 3.77 |
| San Marchi et al/Stalhheim et al | TMCP | 4.90E-12 | 5.38E-06 | 3.50 |
| Vintage line pipe, early 1950s | Youngstown dc-ERW | 1.12E-10 | 1.23E-04 | 3.31 |
| | Kaiser SSAW | 1.51E-11 | 1.66E-05 | 4.01 |
| | A.O. Smith EFW | 2.33E-11 | 2.56E-05 | 3.89 |
| Lambert, et al | X60, fatigue component of SCC lab testing with SCC crack growth rate of 0.0927 mm/yr (0.00365 in./yr) | 1.53e-14 | 1.68E-08 | 3.97 |

# Stress Corrosion Cracking

- **6 Threat Mechanisms Associated with Cracking**
  - 6.2 Environmentally Assisted Cracking
    - 6.2.1 Stress Corrosion Cracking
- **8 Crack Growth**
  - 8.3 Stress Corrosion Cracking and Corrosion Fatigue Growth
- **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**

# Section 14 In-the-Ditch Assessment

- **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