Pipeline Research Council International, Inc.

Collaborative Research to ensure safer pipeline systems

Cliff Johnson, President

September 11, 2014
CRUG Conference
Houston, Texas
PRCI OVERVIEW
### Pipeline Research Council International

<table>
<thead>
<tr>
<th>PIPELINE</th>
<th>RESEARCH</th>
</tr>
</thead>
<tbody>
<tr>
<td>▪ Natural Gas</td>
<td>▪ Knowledge (e.g., Best Practices)</td>
</tr>
<tr>
<td>▪ Crude Oil &amp; Petroleum Products</td>
<td>▪ Technology (sensors and tools)</td>
</tr>
<tr>
<td>▪ Biofuels</td>
<td>▪ Innovation</td>
</tr>
<tr>
<td>▪ CO₂</td>
<td>▪ Deployment &amp; Transfer</td>
</tr>
<tr>
<td>▪ Related Facilities (includes Storage)</td>
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<table>
<thead>
<tr>
<th>COUNCIL</th>
<th>INTERNATIONAL</th>
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<tbody>
<tr>
<td>▪ Forum for Ideas &amp; Opportunities</td>
<td>▪ North America</td>
</tr>
<tr>
<td>▪ Peer-based</td>
<td>▪ Europe</td>
</tr>
<tr>
<td>▪ Industry-driven</td>
<td>▪ South America</td>
</tr>
<tr>
<td>▪ Source of Research Inventory</td>
<td>▪ Middle East</td>
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<tr>
<td></td>
<td>▪ Asia</td>
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<tr>
<td></td>
<td>▪ Australia</td>
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<tr>
<td></td>
<td>▪ Africa</td>
</tr>
<tr>
<td>Year</td>
<td>Event</td>
</tr>
<tr>
<td>------</td>
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</tr>
<tr>
<td>1952</td>
<td>Established in AGA to Solve Long-running Brittle Fractures</td>
</tr>
<tr>
<td>1975</td>
<td>First Biennial Joint Technical Meeting with EPRG</td>
</tr>
<tr>
<td>1980</td>
<td>Holland’s Gasunie First Non-North American Member</td>
</tr>
<tr>
<td>1999</td>
<td>Incorporated as a Not-for-Profit Corporation</td>
</tr>
<tr>
<td>2000</td>
<td>Separated from AGA</td>
</tr>
<tr>
<td>2001</td>
<td>Agreement with GTI to Consolidate Programs</td>
</tr>
<tr>
<td>2002</td>
<td>Business Plan Adopted by PRCI, INGAA, and AOPL Boards</td>
</tr>
<tr>
<td>2003</td>
<td>AOPL &amp; 8 Liquid Pipelines Join; PRCI becomes the “Energy Pipelines” Organization</td>
</tr>
<tr>
<td>2003</td>
<td>Research Engagement with DOT/OPS Begins</td>
</tr>
<tr>
<td>2004</td>
<td>PRCI Terminates Relationship with GTI; Now Wholly Independent</td>
</tr>
<tr>
<td>2004</td>
<td>Membership Expanded to Include Associate Members</td>
</tr>
<tr>
<td>2005</td>
<td>“Vote Your Dollars” Adopted for Setting the Annual Program</td>
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<tr>
<td>2007</td>
<td>Tripartite MOU Between PRCI, EPRG, APIA</td>
</tr>
<tr>
<td>2010</td>
<td>Developed Strategic Plan for 2012 – 2017</td>
</tr>
<tr>
<td>2012</td>
<td>Established NDE Technology Development &amp; Deployment Center</td>
</tr>
<tr>
<td>2013</td>
<td>Completed the Pipeline Industry Global R&amp;D Roadmap</td>
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<tr>
<td>2014</td>
<td>Approved the Development of the PRCI Technology Development Center</td>
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</table>
PRCI Membership

- **39 Energy Pipeline Operating Companies**
  - 21 Natural Gas Transmission; 10 Liquid
  - 8 Liquid/Natural Gas

- **3 Pipeline Industry Organization (PIO) Members**
  - Association of Oil Pipe Lines (AOPL)
  - Electric Power Research Institute (EPRI)
  - Operations Technology Development (OTD)

- **38 Associate Members & Technical Program Associate Members**
  - Australia, Canada, China, Europe, Japan, Mexico, U.S.
  - Special Membership – Australian Pipeline Industry Association (APIA)

- **Worldwide Research Organization**
  - 46 U.S. Companies
  - 34 Non-U.S. (Australia, Brazil, Canada, China, Europe, Japan, Mexico, Saudi Arabia, South Africa)
ASSOCIATE MEMBERS (6)

TECHNICAL PROGRAM ASSOCIATE MEMBERS (32)
Membership Growth Over Last Ten Years

- 2004: 43
- 2005: 40
- 2006: 49
- 2007: 52
- 2008: 53
- 2009: 54
- 2010: 55
- 2011: 63
- 2012: 68
- 2013: 70
Pipeline Technical Committees & Focus

- **Design, Materials & Construction**
  - Materials & Metallurgy (line pipe materials)
  - Welding & Weld Inspection
  - Design & Construction (geo-hazards, offshore, extreme environments)
  - Structural Integrity Assessment

- **Corrosion**
  - Detection, Assessment, Prevention, & Management of Corrosion & SCC
  - Coatings
  - Improvement & Enhancement of Cathodic Protection; Design & Operations
  - Quantitative Risk Risk Assessment

- **Operations & Integrity**
  - NDE Technology Development & Inspection Methods
  - Operating Efficiencies and Improvements
  - Integrity Management Programs
  - ROW Management – Environmental & Third-party Interference/DP
  - Leak Detection
Facilities Technical Committees & Focus

- **Compressor & Pump Station**
  - Cost-effective Emissions Reduction and Emissions Monitoring
  - All Equipment in Stations – Engines, Turbines & Drives
  - Equipment Reliability, Availability & Life Extension
  - Improve Fuel Efficiency and Greenhouse Gas Emissions Mitigation & Reporting

- **Measurement**
  - Improve Custody Transfer Accuracy and Reduce Metering Errors and Bias
  - Support the Technical Underpinnings of Measurement Standards
  - Reduce Lost & Unaccounted For Gas
  - Expand the Operating Range of Existing Equipment

- **Underground Storage**
  - Salt Cavern Operation
  - Wellbore and Cavern Integrity and Inspection
# The Last Five Years

<table>
<thead>
<tr>
<th></th>
<th>2013</th>
<th>2012</th>
<th>2011</th>
<th>2010</th>
<th>2009</th>
<th>TOTAL</th>
</tr>
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<tbody>
<tr>
<td>CORR</td>
<td>$1,018K</td>
<td>$1,154K</td>
<td>$884K</td>
<td>$1,195K</td>
<td>$1,210K</td>
<td>$5.460M</td>
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<tr>
<td>DMC</td>
<td>$1,832K</td>
<td>$2,137K</td>
<td>$2,353K</td>
<td>$1,963K</td>
<td>$1,708K</td>
<td>$9.993M</td>
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<tr>
<td>O&amp;I</td>
<td>$5,603K</td>
<td>$5,360K</td>
<td>$3,287K</td>
<td>$3,363K</td>
<td>$2,838K</td>
<td>$20.452M</td>
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<tr>
<td>CPS</td>
<td>$1,054K</td>
<td>$1,220K</td>
<td>$1,127K</td>
<td>$1,375K</td>
<td>$1,466K</td>
<td>$6.242M</td>
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<tr>
<td>MEAS</td>
<td>$664K</td>
<td>$599K</td>
<td>$908K</td>
<td>$652K</td>
<td>$866K</td>
<td>$3.690M</td>
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<tr>
<td>US</td>
<td>$159K</td>
<td>$212K</td>
<td>$454K</td>
<td>$236K</td>
<td>$218K</td>
<td>$1.279M</td>
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<tr>
<td>TOTAL</td>
<td>$10.238M</td>
<td>$10.683M</td>
<td>$9.014M</td>
<td>$8.785M</td>
<td>$8.306M</td>
<td>$47.116M</td>
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</table>
The PRCI Record of Success - Pipelines

- RSTRENG for Determining the Remaining Life of Corroded Pipe
- Horizontal Directional Drilling Design Guide
- AC Prediction & Mitigation in High-voltage ROWs
- Hydrostatic Testing Alternatives
- On-bottom Stability Model & Guidelines
- Long-range Guided Ultrasonics to Assess Pipeline Condition
- Reliability-based & Strain-based Alternative Design Methodologies
- Automated Welding Methods & AUT Inspection Techniques
- High-strength Steels, X-65 Above & Associated Welding Techniques
- Decision Tools for Repair & Remediation of Materials Defect & Damage
The PRCI Record of Success - Facilities

- High-pressure Fuel Injection for Retrofit NOx Controls
- Turbocharger Condition Monitoring System
- Catalyst-based Formaldehyde Controls on ~5000 HP Engines
- Expanded Solar SoLoNOx Operating Range to Below 50% Load
- Ultrasonic Meter Installation & Operating Standards
- Field Evaluation of Commercial Hydrocarbon Dew Point Analyzers
- Improved Gas Sampling Procedures for Near- dew Point Conditions
- Meter Station Uncertainty Analysis Tool
- Remaining Strength of Corroded Casing (Wells) Under Tensile Loads
Pipeline Industry R&D Puzzle

- Awareness & understanding of the R&D universe
  - Multiple parties and interests
  - R&D funding constantly challenged
  - Instant gratification society
  - Many competing interests
  - Staying the course and managing emerging issues
- Changing role of industry-government relations

Collaborative model is key to achieving success – identify and manage barriers
Critical Elements of the Roadmap

1. Improvements in ILI Capabilities & Re-inspection Intervals
2. ERW/Longitudinal Seam Welds
3. Leak Detection
4. Unpiggable/Difficult to Inspect Pipelines
5. SCC & Cracking – welds and pipe body
6. Anomaly Assessment
7. Mechanical Damage & Damage Prevention
8. Data Integration & Decision-making Processes/Tools
9. Facility Integrity
10. Risk Assessment
Additional Items to be Addressed

- **Design Materials & Construction**
  1. Strain-Based Design
  2. Welding & Inspection of Welds
  3. Reliability Based Design and Assessment
  4. Materials – Composites and others
  5. CO$_2$ Pipelines

- **Corrosion**
  1. Establishing Corrosion Growth Rates
  2. Cathodic Protection Effectiveness and Criteria
  3. Direct Assessment Methods – ECDA, ICDA, SSCDA
  4. SCC Mitigation

- **Subsea Pipelines**
# Roadmap Elements by Pipeline Life Cycle

## QMI Process – Cradle to Grave

### Design
- Strain-Based Design
- Harsh Environments
- Geohazards
- RBDA
- Siting & Environmental Impact
- Design for Inspection
- CO₂ Pipelines

### Manufacture
- Manufacturing Processes
- Mill QA/QC
- Materials - High Strength Steels/ High Performance Pipe

### Build/Construct
- Modernizing Construction Practices
- HDD
- Line Lowering
- Line Transport
- Welding and Weld Inspection
- Field Applied Coatings

### Operations & Integrity Mgmt.
- Damage Prevention
- Pipeline Inspection
- ILI
- In Ditch/NDE
- Above pipe
- Difficult to Inspect
- DA
- Re-inspection
- CP
- Coatings
- Leak Detection
- Emission Reductions
- Data Integration

### Repair & Remediate
- Anomaly Assessment/FFS
- Corrosion growth
- Crack growth
- Composite Materials
- Safe Practices for Inspection In Ditch

### Decommission & Abandonment
- Environmental Impact Cost Benefit
- “Reverse HDD”
- Disintegrating Pipe

### All Threats Managed Across Asset Life Cycle
PRCI RESEARCH ON COMPOSITE REPAIR SYSTEMS FOR ENERGY PIPELINES

Focus of PRCI Research is on the Applicability and Performance of Commercially Available Systems
Overview of PRCI Research Projects

- **Completed Research:**

  - **Assessment of the State-of-the-art of Composite Repair Systems** - MATR-3-3 (2011)
  
  - **Evaluating the Use of Composite Materials in Reinforcing Mechanically-damaged Pipelines** – MATR-3-5 (2012)
    
   - Examined the effectiveness of repair systems for dent repair
   
   - Included several composite repair systems manufacturers and a steel repair sleeve system
Overview of PRCI Research Projects

- **Completed Research:**
  - Reinforcing Vintage Girth Welds with Composite Materials – MATR-3-7 (2012)
    - *Focus on the applicability to vintage (pre-1970) girth welds*
    - *Alternative to replacement or to increase operator confidence in specific welds*

- Reports of these project results are available at no charge to PRCI members and for purchase from PRCI by others
Overview of PRCI Research Projects

- **Ongoing Research:**
  - **Guidelines for Using Composite Systems to Repair High Pressure Gas & Liquid Transmission Pipelines** - MATR-3-10
    - Assess whether composite repairs have achieved a defined target level of performance
    - Establish a unified performance standard
    - Provide guidance on the proper use of composite repair systems - design and validation standpoints
    - Capstone project for other PRCI composite repair systems research
Overview of PRCI Research Projects

- Assuring the Permanency of Composite Systems for the Repair of Corrosion and Mechanical Damage - MATR-3-4
  - Long-term, multi-year, research project focused on the permanence of repairs
  - Includes burial of repaired pipe under pressurized operating conditions
  - Includes periodic burst testing of repaired pipe
  - Multiple systems for durations up to 10 years
Long term testing project – MATR-3-4

- Field test site:
Overview of PRCI Research Projects

- **NDE & Inspection Techniques Applied to the Assessment of Integrity of Composite Wrap Repairs – NDE-2-3**
  - Currently no commercial NDT methods available to validate the integrity of composite repairs
  - Tested the full spectrum of commercially available NDE technologies at PRCI facility in Houston
  - Research has been recently completed and the report is under review.
Overview of PRCI Research Projects

- Consideration of Composite Materials as an Alternative Method for the Determination of MAOP – MATR-3-9
  - Using composites as reinforcement to strengthen rather than replace in-service pipe
  - Drawing upon prior testing, identifying gaps and developing a detailed plan for this new functionality.
  - Research has recently been completed and the Final Report is under review by the project team.
Overview of PRCI Research Projects

- **Evaluation of Composite Repair Systems for Subsea Repairs – MATR-3-6**
  - Full-scale testing of repaired corroded Grade X65 Carbon steel pipe.
  - Repaired underwater & several systems tested.
  - Pipe in a simulated seawater chamber for 10,000 hours under constant pressure with applied cyclic pressures prior to destructive testing.
  - Research complete report under review
Composite Repair Systems for Subsea Repairs – MATR-3-6
PRCI Technology Development Center
O&I - our core is ‘SENSING & MAKING SENSE’ for Pipeline Integrity
  - NOT exclusive, in synergy with other TCs & industry

Need improved TECHNOLOGY to bridge gaps
  - Crossover technologies – LTRC
  - New, emerging Technologies

Need objective Technology Performance Evaluation
  - Common ground for operators & technology + service providers

Need real-life field testing to develop, prove & document Practical Applicability of Solutions => Best Practices
  - Final metrics for delivering the R&D results to operations

Challenges: complex, involvement & team-work pushes it forward
PRCI Repository

- Established a facility in Houston that provides storage and working areas for large samples.
- Co-located with Oceaneering
- Currently has over 600 pipeline damage samples – inventory valued at over $5 million
- Provide a safe accessible working environment to perform and simulate NDE examinations.
- Provide the capability to industry for trial and development as well as performance testing
- Maintain confidentiality of key samples to ensure accuracy
## Key Components of the Program

<table>
<thead>
<tr>
<th>Samples</th>
<th>Availability of samples with real flaws and a wide range of morphologies.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration/Base-lining</td>
<td>Have a fixed reference point or benchmark – what are we comparing performance to.</td>
</tr>
<tr>
<td>Testing &amp; Proctoring</td>
<td>Test a range of tools, types, procedures and the influence of human factors.</td>
</tr>
<tr>
<td>Analysis &amp; Publication</td>
<td>Establish what the data is telling us and get the data out to the industry – make use of the R&amp;D.</td>
</tr>
<tr>
<td>Legacy</td>
<td>Retain the benchmarks for improvement – provide for education, development and measuring, i.e., are we improving?</td>
</tr>
</tbody>
</table>
Current Status - Facilities

- Space for storage
- Space for testing
- Installed interior racks
- Inventory and catalogs being maintained, updated
- Capacity considerations
Pipe Loops

- The PRCI TDC has installed two pipe loops
  - These test loops can be used for further development of ILI equipment
  - 10” pipe loop & 18” pipe loop have been installed
PRCI Repository Open House

- PRCI held its annual Open House on October 22\textsuperscript{nd} 2013

Over 90 people in attendance with 8 live demonstrations
PRCI TDC External Rendering
Thank you! Questions?

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