

CELEBRATING 60 YEARS

2012

year in review

PIPELINE RESEARCH COUNCIL INTERNATIONAL



MISSION

To be the global leader in collaborative energy pipeline research that provides safe, reliable, environmentally conscious and efficient means of delivery.



OUR MEMBERS

Pipeline Members

Alliance Pipeline Limited (Canada)
Boardwalk Pipeline
BP
Buckeye Partners, LP
CenterPoint Energy
Chevron Pipe Line Company
Colonial Pipeline Company
Dominion Transmission, Inc.
Enbridge Pipelines Inc. (Canada) &
Enbridge Energy Partners, LP
Energy Transfer
Eni S.p.A. (Italy)
Enterprise Products
Explorer Pipeline Company
ExxonMobil Pipeline Company
Gassco A.S. (Norway)
GDF Suez (France)
Kinder Morgan
Marathon Pipe Line LLC
N.V. Nederlandse Gasunie (Netherlands)
National Fuel Gas Supply Corporation
National Grid (U.K.)

NiSource Gas Transmission & Storage
Pacific Gas & Electric Company
Petrobras (Brazil)
PetroChina Pipeline Company (China)
Phillips 66 Pipeline LLC
Plains All American Pipeline, LP
Sasol Gas Limited (South Africa)
Saudi Aramco (Saudi Arabia)
Shell Pipeline Company LP
Southern California Gas Company
Spectra Energy Transmission, LLC
Total S.A. (France)
TransCanada Pipelines, Ltd. (Canada)
TransGas Limited (Canada)
Transwestern Pipeline Company
Williams Companies, Inc.

PRCI'S VALUE PROPOSITION

PRCI leverages our members' resources to create a research forum of ideas and results producing solutions that assure the safe, reliable, environmentally sound, and cost-effective pipeline transportation of energy to consumers worldwide.



Technical Program Associate Members

Australian Pipeline Industry Association, Ltd.
Baker Hughes, Pipeline Inspection
Cameron Compression
CNPC Tubular Goods Research Institute (China)
Dresser-Rand Corporation
Elster-Instromet N.V. (Belgium)
Emerson Process Management
Emerson Therm-O-Disc, Inc.
Evraz Inc. NA (Canada)
KROHNE Oil & Gas B.V. (Germany)
Mears Group, Inc.
NDT Systems & Services LLC
Nippon Steel Corporation (Japan)
ROSEN USA, Inc.
ShawCor Ltd. (Canada)
SICK Process Automation (Germany)
Solar Turbines, Inc.
Stupp Corporation
Subsea Integrity Group (U.K.)
Sumitomo Metal Industries, Ltd. (Japan)
T.D. Williamson, Inc.

Tubos de Acero de Mexico, S.A. (Mexico)
Welspun Tubular LLC

Pipeline Industry Organizations

Association of Oil Pipe Lines
Electric Power Research Institute
Operations Technology Development

Associate Members

Applus RTD
Baoshan Iron & Steel Co., Ltd. (China)
China Petroleum Pipeline Bureau (China)
GE Oil & Gas
Lincoln Electric Company

CONTENTS

01 Statements from the President and Chairman.....4

02 A New Industry Research Paradigm.....8

03 Membership Growth.....12

“It is rewarding to witness the growth of the industry as we continue to establish PRCI as the premier organization for the oil and gas pipeline industry.”



04 Accomplishments & Important Findings in Research.....**14**

05 Current Research.....**22**

06 Initiatives for the 2013 Research Portfolio.....**28**

**growth in our membership as we
become a ‘go to’ research organization
in the industry.**

— CLIFFORD M. JOHNSON, PRESIDENT, PRCI



Statements from the
President and Chairman



Eric J. Amundsen

Welcome and I am pleased to offer my perspective as we take a look back in this 2012 PRCI Year in Review. The year 2012 marked the 60th anniversary of the founding of PRCI, originally established as the Pipeline Research Committee of the American Gas Association in 1952. The initial accomplishments of the organization, as well as those during the past year, serve to advance the state of knowledge and technology for our vitally important industry. While our industry is considered mature by just about any measure, we continue to thirst for advanced knowledge, understanding, and technology solutions that enable our ability to operate the world's energy pipelines safely, reliably, efficiently, and in an environmentally safe manner.

Whether you are a member of PRCI, a prospective member, or an interested stakeholder, I believe you will find this look-back informative as we highlight the major accomplishments of 2012 and also offer a glimpse into the future. A major focus of the organization's leaders over the past year has been to continue the execution of the Strategic Plan for PRCI. The Plan was developed in late 2010 and initiated in 2011, and at its core are four goals upon which we guide our behavior and decision making processes. These goals are central to the organization's mission and are embodied in everything we do:

Goal 1 – PRCI will execute and deliver innovative technical solutions using a nimble and flexible R&D process model.

This is the core mission of the organization. PRCI continues to improve upon the execution of its R&D program in a timely and complete manner. The organization has key performance indicators in place to monitor progress of all of its projects and programs and has demonstrated significant improvement in the timely completion of its work. The development of a consortium based model for large, aggressive programs such as subsea technology development is underway as well as a focus on quick reaction projects to address acute industry needs.

Goal 2 - PRCI research is viewed as direction setting by stakeholders through the communication of technology needs, ongoing R&D, and innovative solutions for the pipeline industry.

This goal drives us to communicate openly with all our stakeholders on both R&D needs and solutions that have been generated and deployed. Over the past year, PRCI's reputation and visibility have prompted the Government Accountability Office and National Transportation Safety Board to reach out to our organization in the area of pipeline safety. This goal is a key to new member recruitment where we continue to enjoy year-over-year net increases in members and total miles of energy pipelines within PRCI. Internal and external stakeholders continue to recognize the value proposition that PRCI offers.

Goal 3 - PRCI will compel participation by fostering a collaborative culture that enables quality research, networking opportunities, professional development, and industry leadership.

The PRCI R&D model is built upon the concept of collaboration (none of us is a smart as all of us) at all levels within the organization. This notion is externally evident by efforts with the Australian Pipeline Industry Association (APIA) and the European Pipeline Research Group (EPRG) to develop the Joint Technical Meeting – Young Engineers Program, and with the Southern Gas Association (SGA) to offer a co-branded ILI course in 2013. The 2012 Research Exchange was the most well attended meeting in history

01 Chairman’s Statement & President’s Statement

with over 250 attendees and 80 technical papers presented. During the past year, PRCI has successfully established the PRCI Technology Development and Deployment Center in Houston to enable collection and analysis of pipeline integrity samples.

Goal 4 - Develop & maintain the worldwide collaborative pipeline industry R&D “roadmap.”

PRCI has been central to the discussion, development, and communication of the comprehensive R&D Roadmap for pipeline integrity technology for the past year. This effort has included three major planning meetings around the globe, involving over 200 individuals and organizations such as CEPA, INGAA, OTD, NYSEARCH, AGA, API, AOPL, PHMSA, and others to facilitate the development of the Roadmap. PRCI staff and several industry leaders have worked tirelessly to accomplish the initial effort in the area of pipeline integrity; so the stage is set and model developed for continued effort in the other technology areas for our industry.

As you can see from the brief recap above, considerable progress is being made every day against the PRCI Plan. In closing I am compelled to repeat the words I offered last year as I firmly believe them to be true. The true strength and overall value of PRCI is sourced in its members. If you are reading this and are not a current member of PRCI, I encourage you to reach out to Cliff Johnson, myself, or any of our Board members to learn more about what might cause your company or organization to join us, as many have done this past year. The value we realize is multifaceted and is returned as a function of input and effort. So if you are a current member, we challenge you to participate at a higher level and realize the enhanced benefits of that effort. I look forward to the challenges, excitement and rewards that I know 2013 will bring and am honored to be entrusted with the position of Chairman.



Eric J. Amundsen
Chairman

////////////////////////////////////



Clifford M. Johnson

As we bring a close to our 60th year and prepare to embark on 2013, it is important that we take a look back and acknowledge the growth and progress that we have made in PRCI. In 2012, membership has expanded to 68 companies including the addition of Kinder Morgan - the largest pipeline operating company in North America, Energy Transfer Partners, and Sasol Gas Limited of South Africa. It is rewarding to witness the growth in our membership as we continue to establish PRCI as the “go to” research organization for the oil and gas pipeline industry.

Our growth is due in large part to the quality work produced by PRCI’s Technical Committees as they address the key asset management and operational challenges facing the industry. In May 2012, the president of Colonial Pipeline, Tim Felt, challenged the industry to address the need to develop enhanced in-line inspection (ILI) capabilities. Through the support of PRCI members, we were able to raise over \$1 million to launch the effort before the end of June. The additional

funding provided to this initiative by members and stakeholders for 2013 demonstrates the commitment of PRCI's membership to improve this essential capability. In July, PRCI received a recommendation from the National Transportation Safety Board (NTSB) in the U.S., asking that we conduct a review of various ILI tools and technologies—including tool tolerance, the probability of defect detection and defect identification, and that we provide a model with detailed step-by-step procedures to pipeline operators for evaluating the effect of interacting corrosion and crack threats. We will be meeting with the NTSB to discuss the current state-of-the-art for ILI and our future efforts in this area. Throughout this endeavor, we have been working closely with the pipeline trade associations in North America to ensure our collective efforts in assuring pipeline safety and integrity are coordinated and efficient.

To continue to strengthen our programs and to ensure that we are able to achieve successful deployment of research results, PRCI has established the PRCI Technology Development and Deployment Center in Houston, Texas. This is a repository containing a large array of linepipe samples containing a variety of defects that will allow us to demonstrate the functionality of various inspection technologies and facilitate their further development. The Center will be a focal point for ILI technology advancements and will enable service providers to assess their equipment on unique and complex pipe anomalies that would otherwise not be available. In these controlled conditions, pipeline operators will be able to better understand the performance of advanced options and be able to more rapidly employ them in the field.

In 2012, PRCI hosted a series of summits bringing together the leaders in the pipeline R&D community to establish a consensus on the direction and focus for pipeline R&D, with emphasis on a unified definition of the top priorities and developing a process by which these can be addressed in an efficient and collaborative manner. This important initiative is further described on the next few pages and we encourage our members and the industry to review the roadmap documents and provide ongoing input to ensure it remains an accurate representation of industry R&D needs and activities.

Building on these successes, 2013 promises to be an exciting year as we continue to support our members' efforts to improve pipeline safety, increase operating efficiencies, ensure environmental stewardship and provide reliable service. The 2013 R&D portfolio represents another year of continued growth, with over \$10 million to be invested in over 60 projects and a number of key programs including: Mechanical Damage, Leak Detection, Right of Way Automated Monitoring, ILI Technology Improvements, Compressor Engine Environmental Compliance and Operating Reliability, Strain Based Design, Measurement Reliability, and the expansion of our Subsea program. In February 2013, we will hold our annual Research Exchange Meeting, which is a great opportunity for members to learn about the PRCI research programs and to begin to understand how to utilize the results in their daily operations. We will also develop a Young Engineers Program at the Joint Technical Meeting on Pipeline Research in conjunction with our partners, the European Pipeline Research Group (EPRG) and the Australian Pipeline Industry Association (APIA) that will enable us to assist the next generation of engineers by introducing them to operations facilities around the world. If you would like more information about becoming a part of PRCI or if you have any questions please contact me or visit our website at www.prci.org.



Clifford M. Johnson
President



02

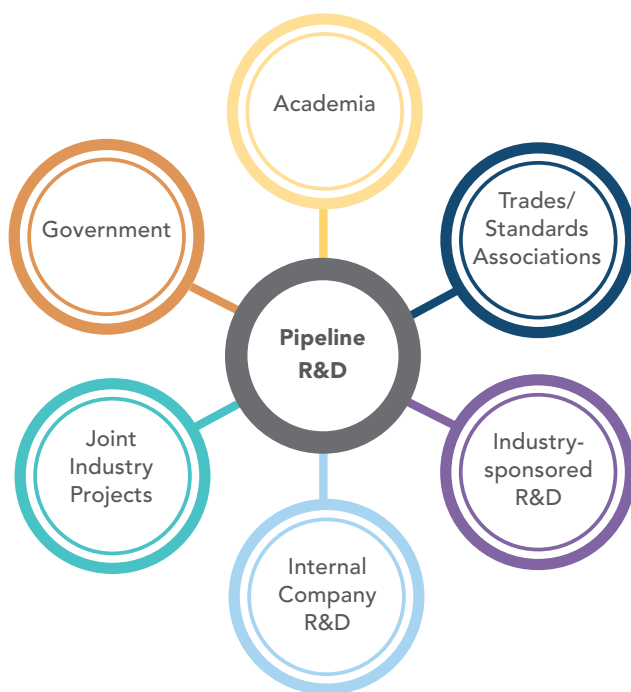
A New Industry
Research Paradigm

One of PRCI's most important initiatives in 2012 was leading the industry in an effort to unify and promote convergence of the pipeline integrity R&D agenda by developing an industry R&D roadmap. By hosting a series of R&D summits throughout the year, PRCI brought together the leaders in the pipeline R&D community to establish a consensus on the direction and focus for pipeline R&D, with emphasis on a unified definition of the top priorities and developing a process by which the top priorities can be addressed in a more efficient and collaborative manner. While the pipeline industry had established the fundamental elements of an effective R&D structure, there was a need to better define and coordinate the pipeline integrity R&D program across the various organizations and key stakeholders, which was the primary goal of this exercise.

A HISTORY OF LEADING PIPELINE RESEARCH

Since 1952, PRCI has been the leading collaborative technology development organization in the energy pipeline industry, conducting a research program valued at over \$50 million in the last five years alone. PRCI's success as the primary R&D platform for the pipeline industry is a result of the unique forum we provide for identifying the research needs of the energy pipeline industry. The R&D programs are developed to respond to the drivers that define the industry, including business drivers, operations drivers, and legislative and regulatory drivers. PRCI's collaborative model and broad membership provide significant depth, diversification, and knowledge base across a range of operating parameters and system configurations, geographic regions, and economic and regulatory models.

The energy pipeline industry is facing significant challenges – the series of high profile pipeline incidents over the past several years has heightened the awareness of regulators, pipeline operators, and the public to the significance of the pipeline infrastructure and has led to a renewed emphasis and focused attention on pipeline safety. PRCI and a number of organizations have established initiatives and made a commitment to further improving pipeline safety with the goal of zero incidents. Regardless of the party or organization that has established a program or made a commitment, pipeline research has been identified as a core component of meeting the challenges confronting the industry.



Inputs to Develop Industry R&D Roadmap

SETTING THE R&D AGENDA

There was a series of R&D Summits held in December 2011, February 2012, and May 2012. The summits addressed the processes and procedures for establishing the priorities, defining the resource requirements to address those priorities, and distributing the R&D work. Roadmaps have been/are being developed in the following areas (not in order of priority):

- » Unpiggable Pipelines
- » ERW/Longitudinal Seam Welds
- » Leak Detection
- » Data Integration & Decision-making Processes/Tools
- » SCC & Cracking – welds and pipe body
- » Anomaly Assessment
- » Mechanical Damage
- » Damage Prevention
- » Improvements in ILI Capabilities
- » Facility Integrity
- » Risk Assessment

Notably, the May 2012 R&D Summit was held in Barcelona, Spain to provide the opportunity for inputs and perspective from European and other non-North American pipeline operators that were not able to attend and participate in the two prior R&D Summits, which were held in North American venues. It placed specific emphasis on obtaining input and concurrence by non-North American pipeline operators, research contractors, and subject matter experts (SMEs) to confirm the direction and primary topics addressed in the collaborative pipeline industry R&D roadmap were truly addressing the pipeline integrity R&D needs on a global basis.

R&D ROADMAP INTEGRATION

In July 2012, PRCI had a strong presence at the Joint Government & Industry Pipeline R&D Forum which brought together an international group of over 200 representatives from government agencies, natural gas and hazardous liquid pipeline operating companies, trade organizations, and academia. The forum’s goals included: identifying key challenges facing industry and government, sharing information on current research

ROADMAP ELEMENTS BY PIPELINE LIFE CYCLE | QMI Process: Cradle to Grave

Design	Manufacture	Build/Construct
» Strain-Based Design » Harsh Environments » Geohazards » RBDA » Siting & Environmental Impact » Design for Inspection » CO₂ Pipelines	» Manufacturing Processes » Mill QA/QC » Materials - High Strength Steels/High Performance	» Modernizing Contruction Practices » HDD » Line Lowering » Line Transport » Welding and Weld Inspecting » Field Applied Coatings

efforts, and identifying research needed to meet the challenges. PRCI staff and member companies were key in leading the meeting sessions and setting the industry research agenda by identifying challenges and technical gaps, reducing duplication of research, leveraging resources, and broadening synergy within the industry. As a result of the forum, the Pipeline and Hazardous Materials Safety Administration (PHMSA) of the U.S. Department of Transportation (DOT) issued a Research Announcement in October 2012 identifying 20 topics for which the government sought research proposals and will provide funding to implement. Working with our R&D partners, PRCI developed and submitted White Papers for three of the topics listed in the Research Announcement and is supporting six as a member of the Project Team and project sponsor.

Through its staff and member company contributions, PRCI also played a leading role in promoting the importance and value of pipeline research and technology development at the 2012 International Pipeline Conference (IPC), held in September in Calgary, Alberta. One of the most substantial contributions was PRCI's leadership role in organizing and moderating the panel session on collaborative pipeline R&D. The session capitalized on the assembly of a worldwide, world-class group of technical experts attending the IPC to confirm consensus on the direction and focus of the pipeline industry R&D roadmap being developed by PRCI. The panel provided an analysis of the gaps and needs in the North American and international pipeline research framework, and reviewed emerging conditions and trends in the industry that impact the R&D programs. The panel also addressed the role of government in the collaborative R&D environment (as identified in the PHMSA Research Announcement described above), coordination of pipeline industry trade organization efforts and initiatives, and cross-over opportunities with other industries. It provided a wide range of perspectives on pipeline research and technology development and identified key areas where the pipeline industry needs and gaps are well-suited to a collaborative approach among industry stakeholders. During the session, the audience was able to address the panelists and to provide input on the R&D roadmap and best practices for collaborative R&D. These inputs and the information provided will be incorporated into the PRCI R&D Roadmap Report for the Pipeline Industry.

With a wide and diverse range of interests represented at the R&D Summits and the input from our members now fully available, PRCI is now proceeding with two primary activities: coordinating with external stakeholders to address the top priorities and development of the final report for the R&D Roadmap. The R&D Roadmap report, and the associated detailed documents included in the report for each of the Roadmap elements, will be monitored and updated as needed to ensure that the industry accomplishments and new gaps identified are included as the R&D program implementation process proceeds and advancements are made in pipeline R&D and technology development.

All threats managed across asset life cycle

Operations & Integrity Management	Repair & Remediate	Decommission & Abandonment
» Damage Prevention » Pipeline Inspection » ILI » In Ditch/NDE » Above Pipe » Difficult to Inspect » DA » Re-inspection » CP » Coatings » Leak Detection » Emission Reductions » Data Integration	» Anomaly Assessment/FFS » Corrosion Growth » Crack Growth » Composite Materials » Safe Practices for Inspection In Ditch	



Membership Growth

In the past year, PRCI was pleased to continue diversifying its membership and enhancing worldwide collaboration in the pipeline research industry. In 2012, PRCI welcomed a new pipeline member from South Africa, Sasol Gas Limited, as well as Kinder Morgan and Energy Transfer based in North America.



The **Sasol Gas** business markets both natural and methane rich gas, which are transported via a pipeline network to the end users.

Sasol Gas operates and maintains a gas supply network through 2,500 km of pipeline, including the 865 km cross-border pipeline linking the gas fields in Mozambique to the Sasol Gas network in South Africa.



In the summer of 2012, **Kinder Morgan** assumed El Paso's membership in PRCI. Kinder Morgan is the largest midstream and the fourth largest energy company (based on combined enterprise value) in North America. They own an interest in or operate approximately 75,000 miles of pipelines and 180 terminals. Their pipelines transport natural gas, refined petroleum products, crude oil, carbon dioxide (CO₂) and more. Kinder Morgan also stores or handles a variety of products and materials at their terminals such as gasoline, jet fuel, ethanol, coal, petroleum coke and steel.



Energy Transfer assumed Panhandle's membership in PRCI in 2012. Energy Transfer owns and operates a diversified portfolio

of energy assets. Their operations include the gathering, treating, processing, marketing and transportation of natural gas and natural gas liquids. In 2013, Energy Transfer will declare nearly 19,000 miles consisting of Panhandle Energy, Transwestern, Tiger, and Fayetteville Express.

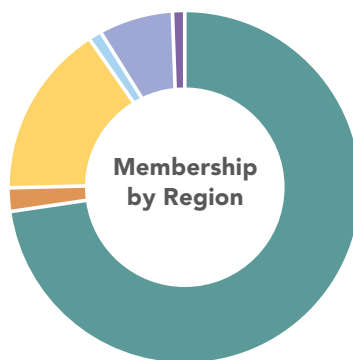
PRCI was also fortunate to further expand its Pipeline Industry Organization membership in 2012 by welcoming the Electric Power Research Institute (EPRI).



The **Electric Power Research Institute (EPRI)** is an independent, non-profit company performing research, development and

demonstration in the electricity sector for the benefit of the public. EPRI's broad array of collaborative RD&D programs focuses on the many specific technology challenges of helping its members provide society with reliable, affordable, and environmentally responsible electricity. EPRI is funded by membership participation in its research activities. Members represent more than 90% of the electricity generated and delivered in the U.S.. International participation extends to 40 countries. EPRI's Nuclear Power Sector participates in PRCI which includes the Nuclear Plant Technologies Group and Non-Destructive Evaluation Group.

Further augmenting PRCI's membership in 2012 is the addition of one full Associate Member and three Technical Program Associate Members (TPAM). Associate Members are the industry service providers, vendors, and manufacturers of equipment whose capabilities enable PRCI research to be deployed in the industry and the marketplace. TPAMs are members of one or more of the six technical committees through which PRCI conducts its research. We are pleased to welcome Baoshan Iron & Steel Co., Ltd. as a full Associate member based in China, and CNPC Tubular Goods Research Institute (China), KROHNE Oil & Gas B.V. (Germany) and Mears Group, Inc. (USA) as Technical Program Associate Members.



72% North America
3% South & Central America
13% Europe
2% Middle East
9% Asia
1% Australia



Accomplishments & Important
Findings in Research

With its technical leadership and expertise, funding and material contributions, and time and resources, the PRCI membership is able to deliver knowledge and technology that addresses the needs of the worldwide pipeline industry and global energy consumers. PRCI focuses on projects that:

- » Assure system safety and environmental performance
- » Assure the productivity and reliability of pipeline assets
- » Anticipate change and adapt existing systems
- » Allow our members to build new pipelines where and when they are needed
- » Continue to reduce risks from and to pipelines

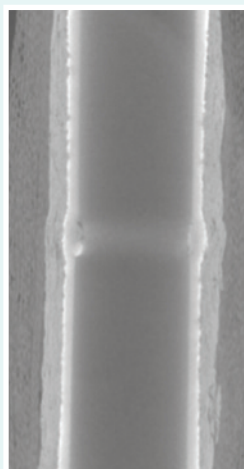
PRCI's research projects have produced numerous important findings and technology developments that our members are able to put into practice resulting in cost efficiencies, and operational improvements. Some of the most recent are as follows:

OPERATIONS & INTEGRITY

- » In 2012, we established the Pipeline Industry NDE Repository, where PRCI is progressively establishing a unique, world class repository of pipeline damage samples to support technology development and educational opportunities. The benefits of having such an establishment available to the industry have already been realized, as the NDE Repository has been utilized for an NDE Open House, enabling new technology development, supporting industry-sponsored workshops, and providing a location for accumulation of former in-service pipe materials that are invaluable to the industry and PRCI's NDE R&D program. The NDE Repository has over 250 test specimens available for advancing pipeline research and is a key enabler to understanding and improving current inspection technologies, and promoting the development of new technologies for pipeline integrity management. The NDE Repository will progressively develop into PRCI's Center for Technology Transfer and Deployment.
- » A comprehensive study and technical review on Non-Destructive Examination (NDE) & Inspection Techniques Applied to Composite Wrap Repairs was completed that built on prior work by the Design, Materials, and Construction (DMC) Technical Committee on the performance of composite materials for pipeline repair and reinforcement. The project assessed a wide range of NDE technologies to monitor changes in the feature beneath the composite repair, the integrity/condition of the composite material itself, i.e., delaminations and adherence to the pipe wall. The report provides pipeline operators with a guidance document to reference when evaluating the appropriate type of NDE technology to apply for inspection of



Test specimen at NDE Repository undergoing inspection study for detection and sizing of fatigue cracks in girth welds



Digital radiography image showing pipe wall outline and composite material delamination

04 Accomplishments & Important Findings in Research

composite wrap repairs, and can be updated as the industry continues to expand its use of composite materials.

- » PRCI is seeing an increasing interest and expansion of its research programs that address Subsea Pipeline Integrity Management and assessment. In 2012, PRCI completed several projects and other activities related to subsea pipelines, including sponsoring workshops and becoming a member of Deepstar to promote coordination with other stakeholders with subsea interests. A cornerstone of PRCI's 2012 subsea program was the completion of Industry Guidelines for Subsea Pipeline Integrity Management (SPIM). The guidelines provide operators with a comprehensive, systematic, and integrated management approach for subsea pipeline systems for any stage of field life, and the tools and information needed to support effective allocation of resources and improve the integrity and safety of subsea pipeline systems. Subsea pipeline operators now have a consistent, structured approach and one complete guidance document that addresses integrity and considers risk across an entire subsea field system. The final report includes graphics that diagram the components that are included in the program and those that are outside the limits of the study.
- » PRCI completed several field studies of leak detection technology in 2012, including evaluation of technologies for detecting small leaks in liquid pipelines and leaks in natural gas systems. Significant progress was made regarding leak detection for natural gas pipelines. A key outcome of PRCI's 2012 program was the development of an automated ground-based sensing solution for detecting and locating leaks from pipelines using automobiles. Studies completed by PRCI led to the development of a commercialized system for automated leak detection using natural gas sensors mounted in cars with integrated data management and reporting capabilities.



Gas sensor and related equipment installed in an automobile for ground-based monitoring and surveillance of pipelines.

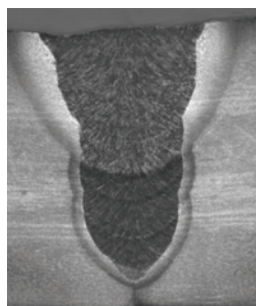
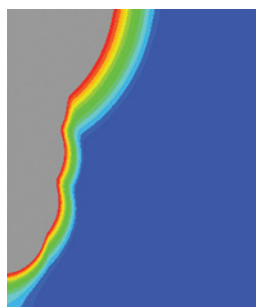
- » Significant results pertaining to pipeline damage prevention research were achieved in 2012 including studies completed on evaluating the impact of human factors on damage prevention. The research included two separate phases of work which centered on interviews and workshops with representatives of pipeline operating companies from five separate countries to establish intervention strategies for the top 25 human factors related to pipeline damage prevention. A key outcome of the study was the development of a “User’s Guide” that identifies practical human factors interventions and best practices.
- » Remote sensing technologies were also evaluated through field studies to assess the performance of sensing technologies on both satellite and fixed wing aircraft platforms for damage prevention. For each of the platforms, field testing consisted of placing potential threats to pipeline integrity (i.e., construction machinery) on or near the pipeline ROW corridor and collecting and analyzing data to determine the sensing technology performance capabilities for detecting unauthorized encroachments. Testing showed that current remote sensing technologies are capable of performing at levels similar to standard pipeline

patrol methods and are mature with regard to the technology development scale and commercial readiness level.

- » Operators that manage liquids pipeline facilities with aboveground storage tanks (ASTs) are continually seeking technology innovations that allow for in-service inspection of tank integrity to minimize interruptions in-service, environmental impacts, and confined space entry, each of which affects costs associated with the inspections. Research was completed for two separate in-service inspection projects, including one providing a comprehensive analysis of suitable remote or robotic techniques that could replace current standard technologies (out-of-service) and still comply with the requirements of API 653, and a separate project on developing an innovative emission monitor to replace current manual measurements made for tank roof seals. The studies completed have concluded that 1) Current robotic platforms provide inspection data that meets the requirements of API 653 for thinning and corrosion of the tank floor, with the only limitation being high levels of sludge/residue; and 2) Automated monitoring of tank roof seals (internal floating roof tanks) can be achieved using emissions sensing technologies and regulatory analysis concludes that most jurisdictions allow the use of alternatives to manual seal gap measurements.

DESIGN, MATERIALS & CONSTRUCTION

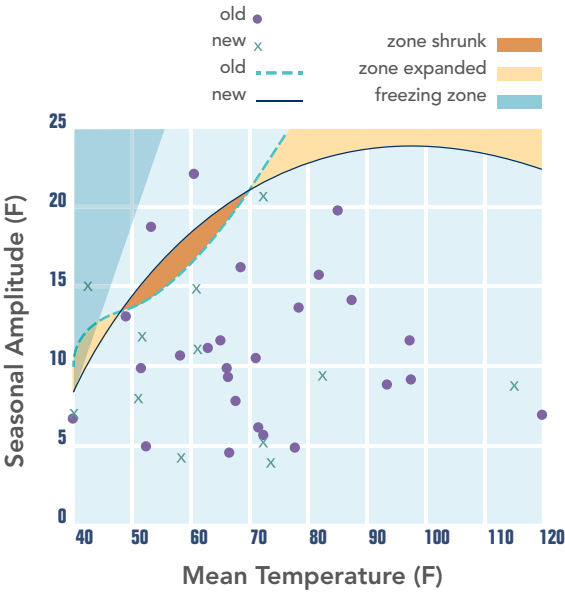
- » In 2012, research was completed and final reports were published on the use of composite systems for the repair of mechanically damaged pipelines and for the use of composite systems for the reinforcement of vintage girth welds. These efforts provide important data on alternative materials and methods available to industry for addressing these important concerns and maintaining the integrity of energy transmission pipelines.
- » The Strain Based Design & Analysis Program completed a key project in 2012 and released a report for industry use. This report addresses pipe material effect on strain demand, which is a key aspect of the program. High strength pipe can exhibit significant levels of anisotropy in the shapes of the stress-strain relationships in the longitudinal and hoop tension/compression directions, which can play an important role in pipeline strain demand evaluations. The research was aimed at evaluating the effects of anisotropy and the shape of pipe steel stress-strain relationships on pipeline strain demand for X80 and X100 pipe. The research included: a literature review; an analysis of pipe steel plasticity concepts; characterization of the anisotropy and stress-strain curve shapes for both conventional and high strain pipe steels; development of representative analytical X80 and X100 stress-strain relationships; and evaluating a large matrix of ground-movement induced pipeline deformation scenarios to evaluate key pipe stress-strain relationship shape and anisotropy parameters. The conclusion from this work is that specifications for high strength UOE pipe for strain-based design applications should be supplemented to consider shape-characterizing parameters such as the plastic complementary energy.



- » Welding of High Strength Steel Pipelines was the focus of a collaboratively funded, multi-year research effort that resulted in the approval this year for public release of 22 individual final reports. These reports provide a comprehensive state-of-the-art assessment of all aspects of welding high strength steel pipe including testing, microstructure and hardness characterization, and the effects of mechanical and thermal properties. Although focused primarily on the welding and performance high strength steels, the methods and results can be applied to other grades of steel as well. These reports are providing a foundation for 21st century research and development in the welding arena.

CORROSION

- » Over the past several years, substantial energies have gone into examining the cathodic protection (CP) criteria spelled out in the NACE standard for CP applied to steel pipelines (RP0169-2002) and addressing whether the criterion should be applied with the CP current on (on-potential criterion) or as a polarized potential, which is typically measured upon interruption of the CP current (off-potential criterion). PRCI implemented an evaluation of the effectiveness and applicability of the -850mV on-potential cathodic protection (CP) criterion for the protection of buried pipelines from external corrosion, and investigated complementary methodologies that can be utilized in conjunction with the criterion to improve pipeline integrity. The study revealed several conditions where active corrosion may be present on buried pipe that otherwise meets either the -850mV on- or off-potential criteria, including: shielding of CP current, microbiological influenced corrosion activity, high temperatures, DC stray current, AC induced corrosion, and seasonal variations. This study also illustrated how consecutive in-line inspections (ILI) can be used to evaluate the effectiveness of the -850mV on- or off-potential criteria. Multiple ILI runs taken over time allow for a calculated corrosion growth rate estimate, which provides a basis for an assessment of active corrosion on the pipeline and an indication of the effectiveness of CP. Future work will consider the complexities of corrosion growth rate and CP in various soil environments and operating conditions.
- » PRCI assessed the performance of conventional Above Ground Coating Evaluation Surveys (AGCES), such as ACVG & DCVG, by proposing methods to improve the probability of detection (POD) of coating holidays, and implementing reliability-based survey methods for Pipeline Corrosion Integrity Management (PCIM). The findings are extremely valuable since current AGCES are known to be highly variable with respect to several influencing factors such as environmental (soil resistivity, soil moisture content, pipe DOC), survey specifications (electrical signal input, probe spacing), survey instrumentation used, and operator experience. Experiments were done



using a controlled and isolated soil environment with a buried pipeline to establish detection threshold for minimum coating fault size at various depths of cover & probe spacing, current levels, sizes of pipe, and soil resistance. Further validation of the observed lab results will be accomplished using a comprehensive field data from PRCI members, which will commence in 2013.

- » We further enhanced a probabilistic model and related tools developed in prior PRCI research for predicting conditions where the threat of internal corrosion in dry gas pipelines is extremely unlikely (equates to no more than 20 percent loss of wall thickness within 50 years). Building on the initial data sets, the enhancements were made based on the availability of additional operating data that were collected to target regions of pipeline operation where the internal corrosion threat is predicted to be higher than in dry gas pipelines. The enhancements resulted in updated operating charts that can be used to more accurately evaluate whether under a nominal operating condition the internal corrosion threat due to water condensation is extremely unlikely. A new Excel tool for analyzing internal corrosion threat based on pipeline operating conditions was also developed. This new tool allows assessment of internal corrosion threat in either case, depending on whether time-series operating data or only operating condition summary statistics are available.

MEASUREMENT

- » A study to assess the impact of meter accuracy shifts on ultrasonic meters from grime on the meter body and acoustic transducers was completed. The study showed that significant shifts in accuracy can be created and that the expected shift differs by make and model of the meter.
- » A meter station design tool has been completed that can be used to assess the uncertainty expected from different meter station designs. This aids the designer in determining the most cost effective method of reducing uncertainty for measurement facilities. The software can be downloaded by member companies from PRCI's member website, PRIME.
- » Meter stations often encounter two phase flow (gas and liquid flow) for facilities intended to operate in a gas only phase. A study has been completed to assess the impact on meter accuracy when two phase flow occurs on ultrasonic meters. The study showed that the presence of liquids causes a measurement error and that error may persist when the liquids no longer exist. Some acoustic transducers are more susceptible to errors than others under two phase flow conditions.
- » Calibration methods for differential pressure transmitters can differ significantly. A study evaluating the different calibration techniques concluded that alternate calibration methods are more accurate than the commonly used method of zeroing the transmitter at atmospheric conditions.



**Three Traversing
Pitot Tubes Installed
Downstream of an 8" Flow
Conditioner**

COMPRESSOR & PUMP STATION

- » Research has been completed on the Mechanical Seal Auxiliary Systems Guideline. Pump seals are the largest source of leaks at pump stations. The report recommends specific design considerations when purchasing, modifying, and operating pumps to reduce the potential for seal leaks. Operating practices are described that can be used to identify degrading seals before they fail. In the future use of seal auxiliary systems, it is this monitoring and trending of

04 Accomplishments & Important Findings in Research

operating data that is becoming more critical. Much of the required technology to perform this trending is already in existence; but it is only slowly being adopted, with some possible advances in technology adding to the accuracy and reliability of the trended predictions and detections.

- » The second phase of a waste heat recovery project was completed. The study focused on using waste heat to pre-cool pipeline gas prior to compression, the use of heat storage, and an evaluation of a stacked Rankine cycle heat recovery system on reciprocating compressor engines. Methods for evaluating the economics of waste heat recovery systems are included in the report.
- » With proposed emission regulations, it is likely that a large number of reciprocating gas engines used at compressor stations will require modifications. A project was completed that evaluated the best practices from previous engine modification efforts to reduce NO_x emissions. Design guidelines and project execution recommendations were developed including a design check list that can double as a specification guideline.
- » A method to evaluate the remaining life of gas turbine rotor disks was developed. The research showed that existing OEM standards are very conservative and the adoption of the developed methods can significantly extend the time between overhaul for rotor disks with a corresponding savings in overhaul costs.
- » Work was completed in developing emission factors for greenhouse gases. Adoption of this method will significantly reduce the workload required of operators when reporting these emissions. This work was done in conjunction with the Gas Machinery Research Council.
- » Work was completed on assessing alternatives to gas expansion starters for gas turbines. Alternatives included drives that eliminated expansion starters as well as alternatives that used more efficient expansion starters.



Starter Gas Throttle Valve

Completed Research Reports

Operations & Integrity

- » Characterization of Detection and Measurement Uncertainties Associated with In-Line Inspection Crack Detection Tools
- » Compilation of Technical Reports on Full-Scale Testing of Mechanical Damage – Defect Creation, Materials Characterization, and Experimental Testing and Results (25 Reports)
- » Development of Dual Field Magnetic Flux Leakage (MFL) Inspection Technology to Detect Mechanical Damage
- » Flaw Characterization Using Guided Waves
- » Industry Guidelines and Best Practices for Subsea Pipeline Integrity Management
- » Influence of Human Factors on Pipeline Damage Prevention
- » Inspection of Mechanical Damage Test Samples
- » Modeling of Magnetic Flux Leakage Sensor Dynamics on In Line Inspection Tools
- » NDE & Inspection Techniques Applied to Composite Wrap Repairs
- » Satellite Based Integrity Management
- » Subsea Pipeline Damage Inspection Guideline

Design, Materials & Construction

- » Assessment of Geosynthetic Fabrics to Reduce Soil Loads on Buried Pipelines
- » Composite Repair of Mechanically-Damaged Pipes
- » Improve Weld Quality by Use of Commercially Available Real-Time Welding Monitors
- » Reinforcing Vintage Girth Welds with Composite Materials
- » Understanding the Effect of Pipe Material Properties including the Shape of the Stress-Strain Curve on Strain Demand
- » Welding of High Strength Steel Pipelines: 21st Century Welding (A comprehensive program leading to 22 Final Reports addressing all aspects Interpretation and Guidelines for Application of API 1104)

Corrosion

- » Enhancement and Validation of Internal Corrosion Threat Guidelines for Dry Natural Gas Pipelines – Phase I: Enhancement
- » Investigate Cost Effective Methods for Addressing and Mitigating Corrosion Effects Under Failed Shrink Sleeves and Other Disbonded Coatings

- » Leak vs. Rupture Boundary for Pipes with a Focus on Low Toughness and/or Ductility
- » Performance of Above Ground Coating Evaluation Survey Method

Measurement

- » Assessment of Orifice Meter Flow Measurements with Low Differential Pressures
- » Characterization of Clamp-On Meters for Broader Application
- » Development of Clamp-On Ultrasonic Meter Installation Guidelines
- » Investigation into High Pressure Deferential Pressure Transmitter Calibration
- » Meter Station Design Tool System User Manual V7 - Upstream Piping Effects
- » New Interface Multi-Run Uncertainty Tool - V2.02

Compressor & Pump Station

- » A Survey of Diagnostics Techniques for Compressor Engines
- » Characterization of Lubricating Oil Carry Over in a 2-Stroke LB NG Engine
- » Characterization of Oxidation Catalyst Performance: VOCs and Temperature Variation
- » Development of an Active Air Control System
- » Development of Digital Turbocharger Performance Monitoring System
- » Engine Cooling Performance Optimization
- » Exhaust Manifold Design Guidelines
- » Field Testing of Ion Sense and Pressure Ratio Technology on a TLA-6
- » Gas Turbine Driven Compressor Station Efficiency Improvement Study
- » Long Term Field Test of In-Situ NOx Sensors in Typical Pipeline Lean Burn Engines and Gas Turbines
- » Non Destructive Evaluation of RR RB211 High Pressure Turbine Blades
- » NOx Reduction through Selective Catalytic Reduction (SCR) Exhaust After-Treatment
- » The One-Half Gram Legacy Pipeline Engine: Configurations and Costs and Integration

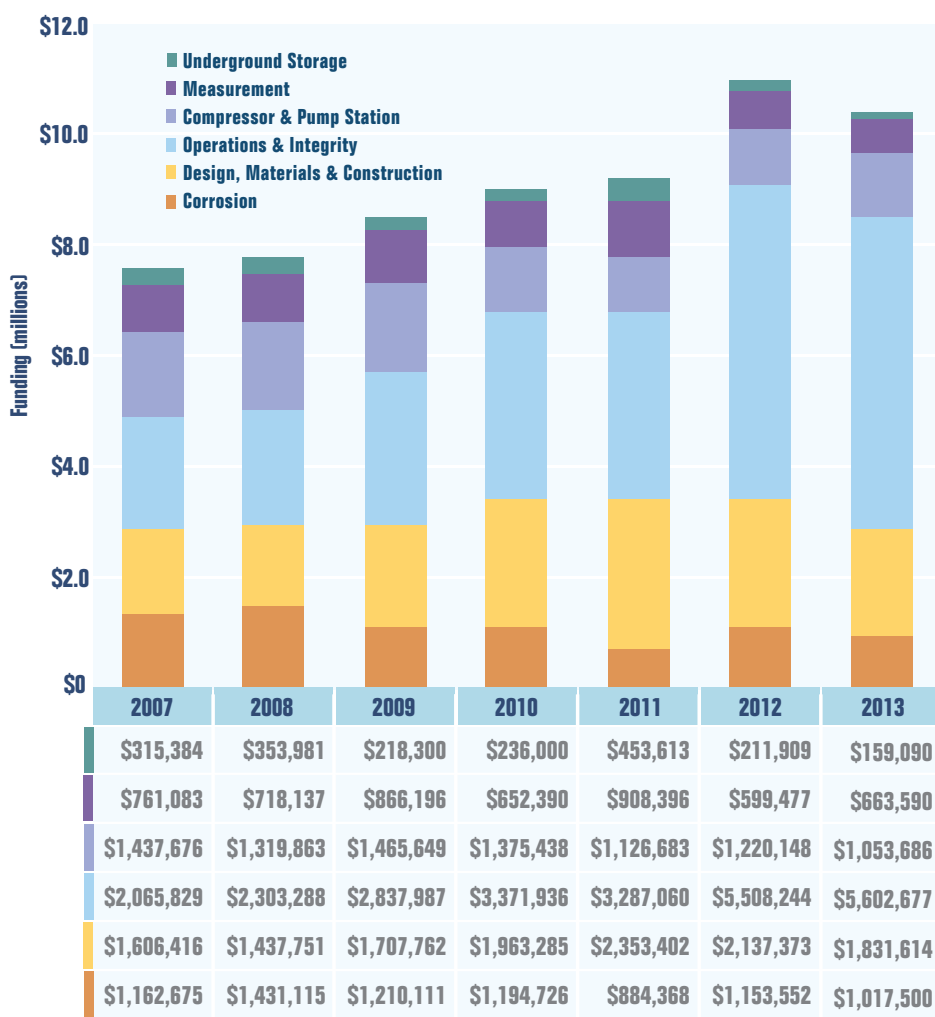
Underground Storage

- » Testing for the Dilation Strength of Salt



Current Research

Every year, PRCI produces a collaborative research program aligning with the industry's priorities by means of an annual voting ballot. Members allocate funds directly to programs of importance to their operations and business drivers. The funding for this research is further augmented by member company supplemental monetary and in-kind contributions, and cofunding from non-member companies. Following are some highlights of PRCI's current program focus, and related projects.



OPERATIONS & INTEGRITY

- » Enhancing current in-line inspection (ILI) tools and developing the next generation of technology to ensure pipeline safety, integrity, and reliability including improvements to sensors and sensor delivery platforms and data processing methods and techniques. PRCI has begun the first focused project within the larger program to evaluate the ability of current ILI technology to determine the pipeline metallurgical “fingerprint.” These data will help operators target areas where there may be discrepancies in their knowledge of the as-built system details and ensure that operators are meeting the requirements for confirming traceable, verifiable, and complete records and establishing an MAOP. Continuing research for subsea pipeline integrity management, with studies including evaluation of alternative materials and coatings for offshore riser pipe, effective methods for monitoring subsea systems, and engineering analysis to support the development of a process for extending the design life of subsea systems.
- » Conducting a baseline workload study for control room management operations. The results of this data-driven study will lead to the development

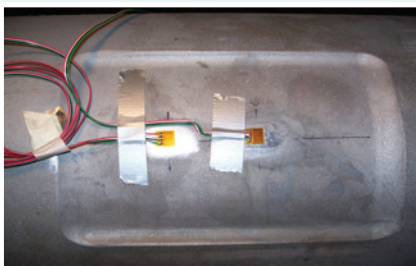
05 Current Research

of guidelines for pipeline operators to establish a control room work load management plan. The project will also establish the format and content for the database to be maintained for the pipeline industry.

- » Implementing a comprehensive, multi-year and multi-phased study to support revisions to API 1149 and improvements to Computational Pipeline Monitoring (CPM) systems. The studies will address a range of operating parameters and uncertainties in evaluating CPM system performance. This work is expected to produce “family of curves” estimations based on the other fluid properties mentioned above, operational affects, and instrumentation analysis / guideline.
- » Developing an integrated, engineered solution and approach to automating pipeline right of way monitoring and surveillance. This work is a continuation of the PRCI multi-year RAM Program, and will focus on the performance of continued field testing to evaluate and validate remote sensing technologies for detecting machinery threats and leaks on pipeline ROWs. Sensing technologies will be evaluated for potential application using ground-based, fixed wing, unmanned systems, and satellites as the delivery platform. An integral part of this work is the parallel development of advanced data processing systems and algorithms for identifying threats to pipeline integrity using the sensing data collected. Validating the application of satellite technology and remote sensing for monitoring ground movement in geologically active or other locations that are subjected to ground movements. Data is being collected to confirm the technology applicability and sensitivity for both lateral and vertical ground movement using radar satellite data.

DESIGN, MATERIALS & CONSTRUCTION

- » PRCI is implementing the on-shore construction modernization research plan. This continuing work is supported by the IPLOCA (the International Pipeline & Offshore Contractors Association) and the INGAA Foundation. The focus is identifying new technologies, or new applications of existing technologies, with the potential to reduce significantly the time and/or cost of construction, while maintaining or enhancing construction quality. Current work is focused on developing improved industry guidelines for calculating lowering-in stresses during pipeline construction and on the route selection process and development of industry guidance for route selection in varying terrains, soil and route conditions.
- » PRCI continues research to evaluate composite repair systems, which began in 2008 and includes a long-term testing program (up to 10 years) to assess the actual performance of several commercially-available composite systems to repair simulated corrosion damage in buried, fully-pressurized pipelines. The photo below shows



The current work is evaluating composite repair systems for subsea applications. Testing began this year with composite repairs being installed under conditions that simulate that environment.

strain gauge installation in the simulated corrosion defect that was covered by the composite repair before the pipe was buried and tested for the long-term project.

CORROSION

- » Development of practical corrosion growth rate model for reliability-based assessment which accounts for time and location dependencies as well as sizing and classification errors. The approach is taking into account both probabilistic and deterministic methods of calculating corrosion growth rates.
- » Assess the effectiveness of cathodic protection criteria for a variety of soil and coating combinations through the evaluation of active corrosion features in in-line inspection data. This research is a continuation to prior year's research which has examined the effectiveness and applicability of current -850mV on- and off-potential criteria for the protection of buried pipelines.
- » Establish correlations between stress-corrosion cracking severity and operational and geotechnical characteristics of a gas pipeline through the examination of ILI data. Prior work has focused on natural gas pipelines, while current research is developing and validating correlation models using data from liquids pipeline.
- » Investigate the consequence model for the four population density classes of gas pipelines to properly address both mechanical damage as well as corrosion risk factors, and update both societal and individual risk targets as necessary with explicit clarification whether the reliability targets can be interpreted in an absolute/historical sense.
- » Further validate the grinding limits for repair of stress-corrosion cracking on operating pipelines through full-scale testing to provide confidence for those who perform the repair. Phase I is experimenting with machined fatigue cracks, while phase II will focus on SCC colonies and complex features, such as: cracks in gouges, cracks in dents, and cracks interacting with welds.
- » Development of a self-healing coating for pipelines to prevent external corrosion damage at equal to or improved performance level compared to current practices. A survey of the membership's current practices and experiences has been conducted and the findings will be used to pursue solutions with the highest potential for broad applications.
- » Investigate how glycol and water enter a dry gas pipelines and determine the corrosive potential of glycol-water mixtures as they react with varying degrees of contaminants in the gas stream.
- » Development of a set of guidelines to optimize digs and re-inspection intervals for stress-corrosion cracking based on electromagnetic acoustic transducer (EMAT) ILI data using reliability principles developed in prior PRCI research.

MEASUREMENT

- » Work is being performed to assess the low flow performance of new generation ultrasonic gas meters. In separate studies, additional work is being performed to assess the upstream piping effects on ultrasonic gas meters and to assess the ability of ultrasonic gas meters to read through pulsations.
- » Work is being performed to evaluate the diagnostic capabilities of Coriolis and turbine meters.
- » A study is underway to evaluate the response time and accuracy of chemical energy (BTU) sensors. This project is being performed jointly with the Compressor and Pump Station Technical Committee to address their common issues.
- » Work is finishing on an effort to assess the effects of liquid contamination on ultrasonic gas flow meters.

- » A project has been initiated to assess the accuracy and reliability of hydrogen sulfide analyzers.
- » An investigation is underway to assess ultrasonic gas meter accuracy shifts and potential measurement bias resulting from operation at pressures and temperatures that are substantially different than those used for calibration.

COMPRESSOR & PUMP STATION

- » Engine exhaust catalysts are often fouled by ash produced by combusting power cylinder lubricating oil. Research is underway to evaluate the potential for timed lubricating oil injection to reduce oil carryover and the associated catalyst fouling.
- » Likely air regulation changes could eliminate the current exemption for formaldehyde controls on gas turbines. Additional research is being performed to compare the likely control limits to current ambient background levels.
- » Research is underway to collect emissions data from a Solar Titan 130 SoLoNO_x gas turbine to assist in modifying engine control methods to reduce NO_x emissions. The likely outcome is a guarantee of emission performance at ambient temperatures below 0° F.
- » Additional research is being performed to assess the impact of ethanol on pump and terminal facilities.
- » Additional research is being performed to determine the optimum compressor lubricating oil injection and materials to minimize the amount of compressor lubricating that enters the pipeline system.
- » Software tools are being developed to aid operators in efficiently configuring air/fuel Ratio controls on legacy pipeline engines.
- » Work is nearing its completion to assess the technology challenges for liquid carbon dioxide pump stations and the development of a mechanical seal auxiliary system guideline.
- » An evaluation is being performed on the NO₂ model (AERMOD) that EPA requires for compressor station NO₂ permitting. This will support the industry's technical discussions with EPA to either initiate a program to improve the AERMOD performance or relieve the industry of this modeling requirement.
- » Research continues to evaluate advanced engine diagnostics to ensure continuous emission compliance.



Catalyst Slipstream System

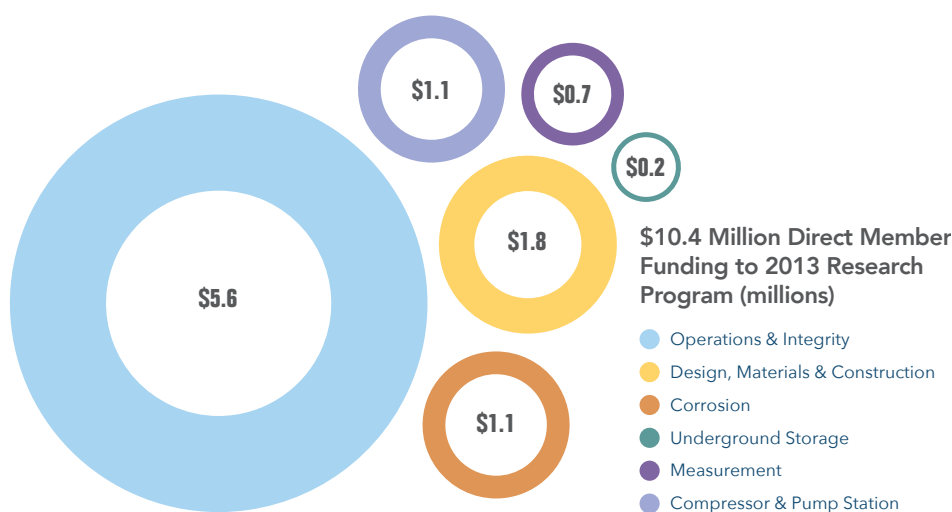
UNDERGROUND STORAGE

- » Storage well casings used for gas reservoir storage and for salt cavern storage of either gas or liquids can encounter significantly different mechanical loading conditions than do typical pipeline segments. However, the magnetic flux leakage tools typically run in these wells draw their design basis from the pipeline application, and the effect on downhole MFL performance and precision under severe mechanical loadings is not well understood. A project is ongoing to evaluate the effects of these loadings and determine the extent to which MFL algorithms need to incorporate these conditions.
- » The condition of the cement sheath surrounding each storage well is a critical element in overall storage integrity. A new EMATs-based cement bond log tool will be evaluated on a set of operating storage wells that have well-documented cement logs. This tool is designed to operate in a gas-filled wellbore to assess whether there is any disbondment at the casing/cement interface that might require remedial action. Current ultrasonic-based cement logging requires the well be filled with fluid and thus taken out of service and incur fluid disposal costs.



Initiatives for the
2013 Research Portfolio

At the Board of Directors meeting in September, PRCI members allocated funding and in-kind support to a research portfolio valued at nearly \$10.4 million. It features programs and projects that will continue to deliver on the organization's core mission of technology development in support of safer and more environmentally friendly approaches to operating and maintaining the energy pipeline infrastructure around the world.



The following highlights a number of specific initiatives in 2013 that will advance the energy pipeline industry:

OPERATIONS & INTEGRITY

The Operations & Integrity Technical Committee has a number of substantial programs will be addressed in 2013 including:

- » Research will focus on the critical link between inspection and assessment, linking experimental full-scale testing data and related models to inspection data on real-world mechanical damage samples from former in-service operating pipelines. Pipes with mechanical damage that are subjected to full-scale testing will also be included in ILI and in ditch technology evaluations, with the objective of providing a direct comparison of the inspection technologies capabilities to measure the critical parameters that are relevant to the assessment models. The inspections include emerging NDE and ILI technologies for characterizing residual stresses, strains, and magnetic permeability changes in the pipe steel structure in the damaged region.
- » Prior studies and gap analyses have shown that technology improvements for leak detection measures are needed including computational and control room systems, in-field sensing, and monitoring technologies that achieve limits of detection that confirm releases from pipeline systems at very low volumetric loss percentages. Field testing will be performed on actual pipeline ROWs to evaluate the performance of sensing systems for both in-ground and above ground applications and platforms, and work will continue on advancing computational methods and models. Additional testing is planned in 2013 to evaluate a wider range of operating conditions, sensitivity of the sensing systems, and other technologies that may also have application for monitoring and detection of leaks in liquids pipelines. Leak detection for liquid service will also include the use of ground-based and aerial platforms to complement the in-ground sensors tested in 2012.

06 Initiatives for the 2013 Research Portfolio

- » Damage prevention remains a top priority for the industry, with the need for persistent, near real-time surveillance and monitoring to identify and stop any unauthorized activity in the immediate vicinity of pipelines before damages occur. Addressing this challenge requires multiple tiers and approaches as reflected in PRCI's R&D program, with projects focusing on threat prevention and detecting unauthorized encroachment using sensors on ROW patrol aircraft and satellite technologies and sensors, and the social media for more effective and measureable communication and engagement with the public.
- » Work will continue to evaluate and develop new sensors and platforms for in-line inspection (ILI) technologies and other non-destructive evaluation (NDE) technologies and methods, using the PRCI NDE Repository as the base of operations. Work in the NDE Program will include the ongoing efforts to improve existing ILI technologies, develop new technologies, and the development of reference standards for qualifying and quantifying performance of technologies. The NDE program will also develop standardized methods and processes for validation of inspection technologies.

DESIGN, MATERIALS & CONSTRUCTION

- » PRCI continues research to improve construction efficiency while maintaining quality standards. The top research priorities in this area are being addressed by two projects. One focuses on identifying and documenting current best practices in the area of energy pipeline route selection, then continuing research to identify and assess 21st century technologies and methods for improving this key aspect of pipeline construction. The other project examines the pipeline placement process; first seeking current best practices, then improvements. These projects are unique in that they are benefitting from the input, participation and support of the International Pipeline and Offshore Contractors Association (IPLOCA) and the Interstate Natural Gas Association of America Foundation (INGAA Foundation). These organizations along with PRCI member companies bring exceptional understanding and insights on pipeline construction modernization possibilities.
- » In the materials and welding arena, research continues on key weld fracture toughness test procedures to increase the comparability and therefore the value of test data from multiple sources, worldwide. Test methodologies will be validated for double jointing, and high-low misalignment will be incorporated into girth weld acceptance criteria. In the pipe materials area, research will continue to evaluate CRA weld overlay pipe for subsea applications.
- » Rapid, effective, in-service pipeline repair remains a high research priority for PRCI. In 2013, the extensive composite program continues with projects focused on the long-term performance evaluation of composite repair systems for corrosion defects, for maintaining rated pipeline service, and for the repair of subsea pipelines.
- » Structural integrity assessment research continues with the development of sleeve end fillet weld stress intensity factor solutions, and an improved understanding of factors affecting the reliability of HFI/ERW pipe seam welds.

CORROSION

- » Evaluation of current practices and equipment used for assessing the integrity of the coating system as the pipe comes out of a horizontal or micro-tunneled thrust bored pipelines road crossings.
- » Development of pipeline coating fault excavation and inspection documentation procedures to increase the accuracy of external pipeline inspection technologies.

- » Improving the performance of the External Corrosion Direct Assessment (ECDA) methodology by generating an integrated ECDA “report card” and provide a benchmark for operators to compare individual ECDA metrics.
- » Investigation of an alternative method for potential measurement to assess the level of cathodic protection to a buried or submerged metallic pipeline.
- » Development of an optimized set of safety factors or response criteria for use with ILI results by examining the different levels of safety embodied in the current safety factors.
- » Internal corrosion sample collection guidelines to help pipeline operators manage internal corrosion threats through better knowledge of the effects of time on the composition of liquid and solid samples.

MEASUREMENT

- » Evaluate the sampling techniques for shale gas supplies, especially where gas composition changes frequently and/or the gas composition is operating near the phase equilibrium line.
- » Develop meter station design procedures that minimize flow-induced pulsations that can adversely impact measurement performance.
- » Evaluate ultrasonic gas meter performance during transient conditions when pipeline liquids are present.
- » Evaluate the performance of new generation ultrasonic gas meters in compact installations as an alternative to or an upgrade from turbine meters.
- » Assist in the development of a miniaturized gas chromatography or gas quality sensor that significantly reduces the carrier gas and sample gas requirements. In addition, the miniaturized system should significantly reduce the installation costs due to simplified sampling systems and associated sample lines.

COMPRESSOR & PUMP STATION

- » Investigate the feasibility of using sensors, rather than gas analysis, to detect changes in fuel composition that could change air fuel ratio (Trapped Equivalence Ratio) and NO_x emissions. The project will demonstrate that the sensor from the signal can be used to adjust trapped equivalence ratio back to the desired set point and maintain desired NO_x emissions.
- » Oxidation catalysts have proven to be effective at reducing CO, CH₂O, and some VOCs. Evaluation of species specific reduction efficiencies on different catalysts is the focus of current efforts. Oxidation catalyst degradation on 2-stroke lean-burn engines has not been adequately studied. Degradation is expected to be problematic on 2-stroke lean-burn engines due to power cylinder lube oil carry over and low exhaust temperatures. New lube oil formulations have been emerged for operation with oxidation catalysts. However, they still contain additives that, over time, poison oxidation catalysts. This project will evaluate oxidation catalyst performance under field operating conditions.
- » The successfully completed Emissions Reduction for Legacy Engines (ERLE) program focused on NO_x emissions reductions for pipeline engines with the mandate of “doing no harm” with regard to all other aspects of engine operation and performance. However, if oriented towards different optimizations, those same ERLE technologies could improve efficiency, improve reliability, or increase the operational flexibility of pipeline engines while maintaining their current emissions levels. A project will demonstrate the benefits of applying these technologies to more problematic pipeline engines.

06 Initiatives for the 2013 Research Portfolio

- » Performance of current NO_x sensors is problematic, in particular drift and cross-sensitivity to other species. A project will demonstrate a prototype laser emissions sensor for pipeline engines.
- » Many booster pumps at pipeline stations are built with ANSI 150 flanges and are running near the limit of these flange ratings. During pipeline system operation, there are often flow transients that occur due to start-up, shut down, and valve closures which can cause large spikes in pressure that could exceed the flange pressure ratings. A project will develop strategies for bringing the pressure spikes to acceptable levels.
- » A project will improve greenhouse emission performance measures and estimation with the objective of reducing the cost of compliance for greenhouse gas reporting.

UNDERGROUND STORAGE

- » A full scale test of an improved brine string stiffener is tentatively planned for 2013, contingent on host site availability and incremental funding support. This test will employ a previously-developed novel sensor package to determine the precise location of the brine string as it swings within the salt cavern, thus enabling its movement to be monitored as a function of fluid injection and withdrawal rates; critical information for ensuring the brine string is not in danger of failure.

Pipeline Research Council International is the preeminent global collaborative research development organization **of, by, and for** the energy pipeline industry.

OF WORLDWIDE PIPELINE INDUSTRY ORGANIZATIONS:

Since 1952, PRCI has been recognized around the world as a unique forum within the energy pipeline industry delivering great value to its members and the industry — both quantitative and qualitative — through the development and deployment of research solutions to the operational, maintenance, and regulatory challenges that face it.

BY MEMBERS WORKING TOGETHER THROUGH PRCI:

The collaboration achieved through members' resource/expertise contributions and funding results in the development of pipeline industry research and technological advances that benefit member organizations and all energy users.

FOR THE GLOBAL PIPELINE INDUSTRY AND THOSE WHO HAVE AN INTEREST IN IT:

Members vote for research projects most relevant to their organizations, so projects truly reflect the industry's priorities. The results provide intelligence allowing the industry to continue reducing risks from and to pipelines.



Pipeline Research Council International, Inc.

3141 Fairview Park Drive • Suite 525 • Falls Church, VA 22042 • USA

Main 703-205-1600 • Fax 703-205-1607 • www.prci.org