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2003 Joint Government and Industry Pipeline R&D Forum

Washington D.C

December 2003

Report

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Executive Summary

The U.S. Department of Transportation's Office of Pipeline Safety (OPS) in conjunction with the energy pipeline industry's collaborative R&D program administered jointly by Pipeline Research Council International, Inc (PRCI) and the Gas Technology Institute (GTI) hosted the *Joint Government and Industry Pipeline R&D Forum*. The Forum brought together over 130 representatives from State, Federal and foreign government offices along with domestic and foreign natural gas and hazardous liquid pipeline operators. The Forum's goals included identifying key challenges facing industry and government, sharing information on current research efforts, and identifying research that can help to meet the challenges.

The Forum was successful in identifying key challenges facing industry and government. The OPS, National Institute for Standards and Technology (NIST), Association for Oil Pipelines, Interstate Natural Gas Association of America, American Gas Association, PRCI, and GTI identified the following as a few of the key technical challenges facing their organizations: ageing pipelines and facilities, limitations in the strength of pipe materials and their resistance to mechanical and chemical damage, limitations in existing techniques to locate steel and plastic pipe to avoid excavation damage, absence of proven techniques to remotely monitor right-of-ways, assessment of pipe segments that cannot be pigged, ability to detect small leaks, acceptability of in-service repair techniques, and limitations in the ability to evaluate the integrity of prime movers (e.g., pumps, compressors) to support preventive maintenance decisions. In addition to these technical challenges, speakers described several other institutional and communication-related challenges, including: the need for R&D expenditures to be viewed as useful by the full range of operator constituents, better communication of the value and impact of investments in pipeline R&D, managing the continuity of supply while maintaining predictable prices, and preserving and expanding the pool of experienced and expert people in the industry. Forum participants identified additional challenges in the technical track sessions. A list of these challenges is located in the Appendix.

The Forum also allowed participants to share information on current research efforts. The OPS, Department of Energy, Department of Interior's Minerals Management Service, NIST, PRCI, GTI, NYSEARCH/Northeast Gas Association, Solution Mining Research Institute, Gas Machinery Research Center, Interstate Natural Gas Association of America Foundation, and In-Line Inspection Association all provided an overview of current research efforts. Their presentations can be found on the PRCI and OPS websites

OPS: <http://primis.rspa.dot.gov/rd> and <http://ops.dot.gov>
PRCI: <http://www.prci.org>

Additional research needs were also identified in five general areas: new construction, materials and welding; accident prevention; detection and assessment; mitigation and repair; and facilities. These include research on higher strength steels and composites, innovative/faster/cheaper joining procedures, refined anomaly detection and

assessment tools and procedures, internal repair procedures, and technologies to eliminate fugitive emissions as just a few of these research needs. The full list can be found in the Appendix. A brief summary is included below.

Track 1: New Construction, Materials, and Welding

This session focused on the issues and R&D needs for New Construction, Materials, and Welding of pipelines. The workshop participants identified needed and high value research and development including: fracture initiation and propagation on newer high-strength pipe steels, construction of pipelines in arctic regions and the deep offshore, composite pipe development, improved technology for plastic pipe, and new technology to reduce the cost of pipeline construction.

Track 2: Prevention

Discussion in the prevention track dealt largely with improving the practical ability to protect pipelines against third-party damage. Many tools already exist, but their use is limited by their cost. Practical (*i.e.*, affordable) means of accurately locating pipelines are needed. This includes ability to determine depth of cover and specific spatial location in the field, as well as to improve the overall ability to map pipelines accurately in relation to their surrounding environment. Similarly, the group commented that communication of available information that could improve third-party damage protection has not always been effective. The group felt that improved dissemination of historical record of coating disruption and best practices on damage prevention would result in improved protection of pipelines from damage.

Track 3: Detection and Assessment

Participants in discussions in this Track considered the range of threats to pipeline integrity and the spectrum of pipeline conditions requiring assessment. Some considerations given special attention were off-shore pipelines and pipelines that cannot be assessed using in-line devices - especially those that are shielded. Areas considered worthy of near-term focus included improved leak detection, damage prevention techniques, assessment techniques for seam-related threats, and improved remaining strength evaluation techniques.

Track 4: Mitigation and Repair

The major area of interest among participants in the Track on Mitigation and Repair was developing innovative techniques to improve the cost-effectiveness of pipeline repairs. The mantra was "excavation and repair techniques that are cheap, efficient, safe and quick". Other developmental areas in which the participants believed added focus was appropriate included improved coatings and coating application techniques for use in repairs, and means of mitigating stress corrosion cracking. The participants also expressed interest in the concept of developing small footprint repair approaches to expedite permitting of excavations.

Track 5: Facilities

This Track focused on research and development needs associated with prime movers (e.g., compressors, pumps), storage and metering. Participants agreed that these facilities are typically the orphans when R&D needs and opportunities are considered, and that the separate focus provided by discussions at the Forum will help address this concern. Projects were explored addressing lower emissions and greater efficiency for compressors, improved metering technology and metering standardization, and enhanced deliverability from existing storage and new storage options.

While one purpose of this Forum was to take note of key technology challenges and research needs, the Forum also provided an opportunity for individuals from government and industry to discuss the reasons why research in certain areas was needed and how that research could impact the safety and reliability of the Nation's pipeline infrastructure.

Numerous participants noted that as available Research & Development dollars shrink in today's economy both Government and Industry will have to work together to meet the challenge of developing energy pipeline technology.

Background

Forum Objectives and Approach

What was the Forum designed to achieve?

Our nation, and indeed the world, is strongly dependent on pipelines to deliver the energy needed to sustain economic well being and to promote economic growth. As the current pipeline infrastructure continues to age and as increasing energy demand necessitates new pipelines, we must redouble our efforts to assure pipeline safety, integrity and reliability. Research and development represents a critical component in increasing that level of assurance.

Presently the limited resources available to support R&D are managed by a diverse group of government agencies and private institutions. Each of these groups has its own unique focus and priorities. An effective mechanism is needed to assure that the aggregate set of projects undertaken in response to these priorities addresses all the significant issues and avoids needless overlap. The Pipeline Research and Development Forum, held on December 11 and 12, 2003 and jointly sponsored by the Office of Pipeline Safety (OPS) and the Pipeline Research Council International, Inc. (PRCI), was designed to be the first in a series of broad-based efforts to bring together knowledgeable stakeholders from government, industry and the public to increase this assurance.

How did the Forum approach attainment of its objectives?

To achieve its objectives, the Forum was structured to explore the challenges facing the pipeline industry, to share information on recently completed and ongoing activity to address these challenges, and to identify potential gaps and overlaps in the set of projects currently underway or in planning. The result was intended to be an information resource to help the various sponsors of research and development in defining their priorities and in selecting related projects by developing a clearer picture of the ongoing and planned efforts of other sponsors.

OPS Mission and Focus

The Mission of the OPS is **“To ensure the safe, reliable & environmentally sound operation of the nation’s pipeline transportation system.”**

The OPS safety jurisdiction over pipelines covers more than 3,000 gathering, transmission, and distribution operators as well as some 52,000 master meter and liquefied natural gas (LNG) operators who own and/or operate approximately 1.6 million miles of gas pipelines, in addition to over 200 operators and an estimated 155,000 miles of hazardous liquid pipelines. OPS currently has over 100 employees: half work at Headquarters in Washington, DC, and the other half work in the five OPS regional offices located in Washington, DC; Atlanta, GA; Kansas City, MO; Houston, TX; and Lakewood, CO.

OPS sponsors and conducts research to provide the technical and analytical foundation necessary for planning, evaluating, and implementing the pipeline safety program and to provide the technical basis for regulatory and enforcement activities. OPS is sponsoring research and development projects focused on providing near-term solutions that will increase the safety and reliability of the Nation's pipeline system.

Recent R&D projects are focused on: leak detection; detection of mechanical damage; damage prevention; improved pipeline system controls, monitoring, and operations; and, improvements in pipeline materials. These projects are addressing technological solutions that can be implemented in the near-term to improve pipeline safety.

In 2003, a study by the General Accounting Office (GAO) found that OPS' R&D program is aligned with OPS' mission and pipeline safety goals.

PRCI Mission and Focus

Pipeline Research Council International, Inc. (PRCI) is a not-for-profit corporation comprised of leading energy pipeline companies in North America, Europe, and the Middle East. PRCI's focus is on collaborative, industry-wide research and development that enables its members and the industry at large to improve safety, reliability, environmental performance and cost-effectiveness.

At present, PRCI's 32 member companies represent nearly 75% of North America's transmission pipeline mileage and 40,000 miles of domestic hazardous liquid pipeline mileage. PRCI member companies bring together more than 200 professionals with a wide range of engineering and technical skills to guide pipeline research. PRCI and GTI cooperatively fund this research through six technical committees. These six committees plan and manage R&D activities in the following areas:

- Design, Construction and Operations
- Corrosion and Inspection
- Materials
- Compressor and Pump Station
- Underground Storage
- Metering and Measurement

The PRCI/GTI research budget for 2003 and 2004 totals over \$23 million dollars with an additional \$14 million dollars in co-funding. Its technology program is focused on the business drivers of the industry, from assuring system integrity and reliability to reduction in capital and operating costs. Building on this foundation will be a critical success factor in the industry's ability to forge and deliver on the commitments it will have to make.

Forum Overview

The Joint Government Industry Pipeline R&D Forum was held in Washington D.C. on December 11 and 12, 2003. The event was sponsored by OPS and PRCI and included over 130 representatives from Federal, State and international government agencies, public representatives, research funding organizations, standards organizations, and pipeline operators from the U.S. and overseas. A list of attendees can be found in the Appendix.

The Forum's goals included identifying key challenges facing industry and government, sharing information on current research efforts, and identifying research that can help to meet the challenges. It was envisioned that the results of the Forum could be used by the participating organizations to help guide and focus their independent programs.

Opening Session

The opening session focused on the key challenges facing government and industry and on overview of existing R&D programs.

The OPS, NIST, Association for Oil Pipelines, Interstate Natural Gas Association of America, American Gas Association, PRCI, and GTI each provided their perspective on the key challenges facing government and industry. Stacey Gerard, Associate Administrator for OPS, stated the key challenges facing OPS were identifying technological gaps before they lead to accidents, expediting deployment of the results of research and development, and identifying promising technologies from outside the traditional pipeline community. Ben Cooper, Executive Director, AOPL summarized the

major challenges as locating and understanding the significance of existing defects, monitoring an extended right-of-way to deter mechanical damage, detecting small slow leaks, and seeing underground to avoid digging into buried utilities. James Hill, Acting Director, Building and Fire Research Program, NIST summarized NIST expertise in materials research, fire safety and standards development. Don Field, president of Peoples Energy, speaking for the American Gas Association, stated that the major challenge is how to improve the gas system security, reliability and integrity while improving delivery efficiency.

Winston Johnson, Chairman of PRCI, noted that the major challenges relate to managing the impact of industry mergers and acquisitions while preserving and expanding the pipeline knowledge base, demonstrating the cost-benefit of R&D, making the government-industry technology collaboration on R&D work, and communicating the effectiveness of R&D efforts within the industry. Robert Stokes, Vice President of R&D for GTI stated that the major challenges are maintaining an adequate domestic gas supply, reducing price volatility, assuring predictable prices in line with the industrial market, and assuring the security of the pipeline infrastructure.

The R&D funding organizations next provided an overview of their R&D programs. The OPS program focuses on near term research that will help to prevent, identify, or mitigate pipeline integrity threats. The NIST program focuses on fire safety, materials research, and standards development. The DOE program focuses on developing longer-term higher risk technologies that help ensure integrity, deliverability and reliability of natural gas. The MMS program supports research and development designed to improve operational safety and pollution prevention as well as oil spill response and clean up. PRCI efforts are focused through six technical committees on promoting pipeline safety, reliability and cost minimization for both gas and liquid petroleum pipelines. GTI's pipeline infrastructure R&D program is focused on both gas transmission and distribution operations, in particular on preventing damage from the major threats to the integrity of these lines. The Northeast Gas Association manages R&D through its NYSEARCH committees, focusing on prevention of threats and on detection and assessment of existing damage.

The Solution Mining Research Institute includes software development and development of guidelines to promote safe solution mining. The Gas Machinery Research Council funds and manages a small number of R&D projects designed to improve monitoring, evaluating, control and enhancing the safety and performance of machinery related to production and transport of natural gas. The INGAA Foundation supports work intended to clarify and resolve issues affecting the safety, integrity and regulation of natural gas transmission pipelines. The In-Line Inspection Association supports the improving ILI devices by identifying and promoting practices to improve the effectiveness and acceptability of ILI equipment.

Presentations from the opening session are available on the OPS and PRCI websites:

OPS: <http://primis.rspa.dot.gov/rd> and <http://ops.dot.gov>
PRCI: <http://www.prci.org>

Technical Track Sessions

Five concurrent technical track sessions structured discussion of the key challenges facing industry and government, ongoing research activities, and additional R&D needs in the following areas:

- New Construction, Materials, and Welding
- Prevention
- Detection and Assessment
- Mitigation and Repair
- Facilities

Each technical session began with a review of the challenges identified in the opening session and those identified in the registration survey for that track. Participants then identified additional challenges specifically related to the track session's topic. Below are a few of these identified challenges. A full list can be found in the Appendix. The listing in the Appendix is not intended to represent priorities, but rather simply to summarize the discussions from the Forum. Each participating organization can employ these results in the context of its own mission and needs to formulate its future R&D plans.

Summary of Challenges

New Construction, Materials and Welding:

- Pipeline materials resistant to stress corrosion cracking
- Means to non-destructively test plastic pipe joints
- Improved likelihood of leak-before rupture (e.g., through the use of composite materials)
- Limitations in the strength of pipe materials and their resistance to mechanical and chemical damage

Prevention:

- Improved communications among industry, government and the public
- Ability to cost-effectively measure depth of cover
- Ability to differentiate between “benign” and “real” encroachment events
- Monitoring of off-shore pipe

Detection and Assessment:

- Ability to analyze and characterize defects identified through ILI assessment
- Criteria for mechanical damage severity evaluation
- Ability to determine key pipe mechanical properties in-situ

Mitigation and Repair:

- Cost and efficiency of mitigation and repair actions
- Time required for permitting of needed excavations
- Characterization and mitigation of SCC
- Coating materials and techniques for use in mitigation and repair

Facilities:

- Emissions of equipment
- Net energy efficiency at compressor stations
- Metering technologies
- Storage options

Presentations of Ongoing R&D

Following the identification of challenges, participants heard detailed presentations from industry leaders on the R&D work they were conducting. Below is a listing of the presenters for the track session. These presentations are available on the PRCI and OPS web sites listed above.

Track 1: New Construction, Materials and Welding	PRCI Materials Committee: Brian Rothwell GTI: Daniel Ersoy PRCI Design, Construction & Operations Committee: Joe Zhou MMS: Bob Smith OPS: Bob Smith
Track 2: Prevention	PRCI Design, Construction & Operations Committee: Rick Gailing GTI: James Huebler PRCI Corrosion and Inspection Committee: Jeff Didas OPS: Beth Callsen and Sam Hall
Track 3: Detection and Assessment	MMS: Bob Smith OPS: Jim Merritt PRCI Corrosion and Inspection Committee: Jerry Rau GTI: Albert Teitsma PRCI Design, Construction & Operations Committee: Keith Leewis NYSEARCH/NGA: George Vradis PRCI Materials Committee: Bill Amend
Track 4: Mitigation & Repair	OPS: Jeff Wiese PRCI Corrosion and Inspection Committee: Ron Scrivner
Track 5: Facilities	PRCI Underground Storage Committee: Karen Benson Solution Mining Research Institute: Joe Ratigan PRCI Compressor and Pump Station Committee: Sam Clowney Gas Machinery Research Council: Don Crusan PRCI Measurement Committee: Jeryl Mohn

Following the presentations, participants identified other research opportunities that could help to address the challenges. Below are a few of these opportunities. A full list can be found in the appendix.

Summary of Opportunities

New Construction, Materials and Welding

- Characterization of mechanical properties and performance of high strength steel and welds
- Development and characterization of large diameter plastic pipe materials capable of operating at high pressure
- Techniques to join new plastic pipe materials and inspecting joints
- Weld NDT techniques
- Better fabrication techniques

Prevention

- Improving and making more compact instruments to determine depth of cover
- Proving tools for direct assessment
- Development of integrated systems to coordinate information on potential encroachment
- Improved GPS geospatial characterization

Detection and Assessment

- Develop improved techniques for NDE to characterize pipe materials
- Detection and assessment of pipe that is shielded from CP
- Improved characterization of Defects identified by ILI

Mitigation and Repair

- Enhanced in-service repair techniques
- Standardized techniques for small footprint excavations for ease of permitting
- Improved mitigation and repair practices
- Standardization of decision bases for repair of mechanical damage

Facilities

- Techniques to minimize NO_x emissions over a wide range of operation
- Tools to identify and quantify fugitive emissions
- Innovative gas storage near markets
- Multiphase flow measurements

These final session reports were delivered to the plenary session for review by the entire group.

Follow up Actions

The sponsors intend the Forum to be an annual event. In the interest of designing future Forums to be as useful as possible, OPS solicited feedback from participants on useful changes (additions, deletions or restructuring) and will incorporate this feedback in future designs. Details of the feedback can be found at the sponsor's web sites.

OPS: <http://primis.rspa.dot.gov/rd> and <http://ops.dot.gov>

PRCI: <http://www.prci.org>

Appendices

Technical Track Sessions Challenges and R&D Opportunities

This Appendix presents the results from the five Track Sessions in the form of Challenges and R&D Opportunities. The listings of challenges and opportunities are not intended to represent any priority, but rather are simply compilations of discussions from the Forum. Each organization will assimilate the results of this Forum and address its identified gaps and needs within the context of its own mission and needs. Though priorities among these organizations may vary, the need for this type of collaborative and broad-based approach to gap/need identification was widely recognized as extremely beneficial to all participants.

Track 1 New Construction, Materials, Welding

Challenges

1. Pipeline materials resistant to SCC
2. Flaw tolerance /determine critical flaw size – fracture initiation models for high strength steels
3. Local buckling (high strength steel)
4. Quality control of materials
5. Keeping costs down while meeting requirements of new materials
6. Yield strength versus tensile strength. uniform elongation
7. Standardized tensile tests applicable to high strength pipe
8. Non-destructive equipment for testing plastic pipe joining
9. X-rays – improved imaging and interpretation of film (films or other automated processes, ultrasonics)
10. Field construction practices including welding consumables
11. How to inspect CRA clad pipe
12. Large/thick walled plastic – testing with different temperatures instead of just room temperature fracture susceptibility.
13. Standards and tests
14. Composite materials, and composite over steel for a safer pipe (leak before rupture)
15. Education and communication to public, press and state regulators regarding new sitings
16. Focus on safety by examining all new projects and informing the public
17. Better data collection for communication of risk to the public
18. Deep water technology, light weight materials for pipe systems
19. Design procedures for SCR systems
20. Consideration of pipelines as an integrated engineering system
21. Hydrogen economy
22. Cross-industry R&D information sharing (intra-company – offshore vs. onshore & liquid vs. gas)
23. Welding issues in high strength steel
24. Materials that are resistant to outside force
25. CP in high strength steel
26. Hydrogen embrittlement in high strength pipe
27. Mechanical properties of heat affected zone & how to measure
28. Residual magnetization from pipe making and coatings (affects ILI)
29. Alternative-based design
30. Trenching in artic regions
31. External loads – frost heave

32. Restoration, one-step pavement, etc
33. Alternatives to pressure testing (when water not available or cold, water disposal issues)
34. Locating plastic pipe without tracer wire
35. Issues of re-grind material in extrusions in plastic pipe
36. HDD in permafrost or protected marsh, protected inland areas

R&D Opportunities

1. Research in mechanical properties and performance of high strength steels and welds
2. Research on high pressure large diameter plastic pipe (joining and non-uniform materials)
3. Research on alternative design methodology
4. Fraction mechanics of composites (performance, inspection)
5. Technology assessment of high strength steel and composites
6. Construction and operations of composites (field bending or alternatives, joining, cp, inspection, repair, degradation over time)
7. Technology assessment of SCC
8. Crack growth model for SCC and remediation
9. HTHP service, design, fabrication, testing
10. NDT for welds and inspection
11. NDT for inspection of plastic pipe fusions
12. Evaluation of high productivity welding technologies
13. High pressure liners for cross-country (assess off-shore approaches)
14. Innovative approaches in pipe joining
15. New approaches for cheaper, faster, better construction and fabrication of pipe
16. New techniques to lessen costs of wetland crossings and erosion during construction
17. New methods of transporting LNG and CNG other than pipelines (off-shore regasification)
18. New approaches to communicating risk (communication with public and local officials) proactive vs. reactive
19. New approaches to communicating the value and merit of pipeline systems to local and regional officials and public
20. Approaches to dealing with encroachment issues
21. Cross-industry research regarding materials

Track 2 Prevention

Challenges

1. Effective communication between Industry/Government and the public.
2. Cost effective depth of cover measurement.
3. Understanding of currently available Direct Assessment Tools and what they provide.
4. Discrimination between benign and real encroachment threats.
5. Cheaper satellite communications for ROW data.
6. Avoid duplication of effort & resources
7. Need for decision making tools -corrosion growth
8. R&D/documentation on coating failure
9. Best practices compendium current and emerging technologies to prevent mechanical damage
10. Effective methods for monitoring offshore pipelines

R&D Opportunities

1. Downsizing of existing depth of cover measurement, GPS and coating quality tools
2. Proving of DA tools
3. Integrated system for coordinated encroachment efforts to increase threat discrimination
4. Improve use of satellites for encroachment detection
5. Document what we know about older coatings & failure data
6. Develop R&D Partnerships
7. Better mapping of geospatial environment (<10ft)
8. Preventing dragging anchors across pipelines

Track 3 Detection and Assessment

Challenges

1. Develop safe, environmentally responsible, cost-effective and reliable solutions for the design, construction, and operation of energy pipelines
2. Improved techniques for defect analysis and characterization (ILI and NDE)
3. Mechanical damage assessment criteria (e.g., for dents, gouges and for wrinkle bends)
4. Improved methods of in-situ, non-destructive assessment of pipeline properties, particularly low toughness or other characteristics that influence the selection of appropriate flaw evaluation methods
5. Programs to maintain pipeline integrity, influence regulatory requirements associated with safety & integrity and reduce capital costs of new pipelines

R&D Opportunities

1. Damage prevention, detection, assessment & notification
2. Non-destructive assessment of pipeline properties: knowing material properties
3. Integrity practice standards based on science and knowledge
4. Detection and assessment of shielded (areas not receiving appropriate cathodic protection) pipe
5. Improved characterization of anomalies detected via ILI

Track 4 Mitigation & Repair

Challenges

1. Cost efficiency of Mitigation & Repair.
2. Decision basis, acceptance criteria.
3. Mitigation or repair concerns requiring innovative technology solutions
4. Improved mitigation and repair practices
5. Techniques to facilitate permitting

R&D Opportunities

1. On-line (in-service) repair techniques
2. Internal pipeline repair
3. CESQ bell hole techniques
4. Repair practices for low stress pipe
5. Internal repair robots
6. Improved recoating techniques
7. Repair of small leaks
8. Repair of pipeline with numerous defects
9. Repair criteria for small diameter pipes or unusual materials
10. Engineering basis for reassessment intervals
11. Life prediction with SCC
12. Repair/remediation of cased crossings
13. Solutions to disbanded coatings
14. Identification and location of repairs
15. Effectiveness of storage tank bottoms
16. Degaussing tool
17. Improved O&M (noteworthy practices)
18. Measuring cp effectiveness
19. Non disruptive asphalt repair
20. SCC mitigation
21. Characterization of "appurtenances"
22. Repair of acetylene girth welds
23. Low disruptive repair for advanced permitting

Track 5 Facilities

Challenges

1. Lower Emissions (meeting compliance)
2. Quantifying fugitive emissions of CO₂, methane
3. Increase net energy efficiency at compressor stations
4. Energy conservation & efficiency of site in its entirety, including auxiliaries & hydraulic efficiencies
5. With increasing cost of gas, need to improve economics (bottom line effect)
6. Blow downs, operational leaks (intended/non-intended), loss of gas from wellhead to burner
7. System optimization
8. Maintain measurement/ other standards
9. Development of new metering technology
10. Enhanced deliverability from current infrastructure (compression, storage, metering, etc).
11. Exploration of new storage options.

R&D Opportunities

1. NO_x Research that will allow us to get to 15gNO_x for engines and 15ppm NO_x for turbines over entire range of operations.
2. HAPs: Lower formaldehyde 93ppb (turbines), engines 100ppb
3. Inexpensive monitoring technologies (industry need).

4. Research that will increase the net energy efficiency at the prime mover, compressor and all of the plumbing
5. Tools to accurately identify and quantify fugitive emissions
6. Technologies to eliminate fugitive emissions
7. Research that will optimize system performance through integration of modeling and sensor technologies.
8. Research to evaluate existing and evolving metering technology as basis for new standards or to revise existing standards (industry need).
9. Technical justification for international standardization (industry need).
10. Continued R&D into ultrasonic, coriolis, and other evolving technologies.
11. Complete the development of energy meter and transfer technology (industry need).
12. ID ways to measure fluid quality more cost effectively and in real time (industry need).
13. Multiphase measurement.
14. Opportunity map to define priorities – across the board assessment of entire infrastructure (planning groups to work with the R&D groups).
15. Continue to support existing programs that improve deliverability through compression, storage and metering efficiencies.
16. Innovative market area storage (industry need).
17. Efficiencies in LNG development for peak shaving applications (industry need).
18. R&D that will reduce the cost of building peak shaving facilities (hydrates, etc).

Forum Participants

GOVERNMENT / ASSOCIATIONS	
American Gas Association	Traweek, Lori
American Gas Association	Williams, Ted
American Petroleum Institute	Matheson, Marty
ASME	Dietz, Francis
Association of Oil Pipe Lines	Cooper, Benjamin S.
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GMRC	Short, Marsha
GTI	Irby, Rick
GTI	Willer, Jay
INGAA	Boss, Terry D.
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In-line Inspection Association	Brown, Bryce
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NACE International	Johnson, Cliff
NAPSR - California State Fire Marshal's Office	Tong, Glenn
NAPSR-Rhode Island	Ledversis, Don
National Association of State Fire Marshals	McGarry, Frank
National Energy Board - Canada	Jeglic, Franci
National Energy Board of Canada	Kopec, Josef Jan
National Transportation Safety Board	Kushner, Alan S.
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NIST	Handwerker, Carol
NIST	Ricker, Richard
NIST	Whetstone, James
NIST Building and Fire Research Laboratory	Hill, James E.
Northeast Gas Association	D'Zurko, Daphne

Northeast Gas Association/NYSEARCH OMB	Vradis, George
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PRCI	Johnson, Winston A., II
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	Estes, Deborah

<p>Natural Resources US. Dept of Energy, Office of Fossil Energy Western Governors' Association</p>	<p>Freitas, Christopher Brown, Shanna</p>
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Advantica	Ward, Clive R
Avistar, Inc.	Rhodes, George W.
Battelle Pipeline Technology Center	Colwell, Jeff
BJ Pipeline Inspection Services	Leedham, Robert J
Buckeye Pipe Line Company	Shelton, Larry
Buckeye Pipeline Company	Phelps, John
C-CORE	Kenny, Shawn
Colonial Pipeline Company	Didas, Jeffrey L.
Colonial Pipeline Company	Stewart, Richard
Columbia Gas Transmission	Crusan, Don
El Paso Pipeline Group	Lucido, Jack
El Paso Pipeline Group	Clowney, Sam
Southern Natural Gas/ El Paso	Thomas, Eric
Enbridge Pipelines	Adams, Richard
Enbridge Pipelines	Meyer, Art
EWI Microalloying	Gordon, Robin
ExxonMobil Pipeline Company	Sprick, Dennis
GASSCO	Herloee, Egil
GE Oil & Gas, PII Pipeline Solutions	Holden, Ernie

GE Oil & Gas, PII Pipeline Solutions	Llerma, Carlos
GE Oil & Gas, PII Pipeline Solutions	Marquez, Mario
GE Oil & Gas, PII Pipeline Solutions	Thetford, Scott
GE Oil & Gas, PII Pipeline Solutions	Wiggins, Ian
GE Oil & Gas, PII Pipeline Solutions	Walker, James
Gulf South Pipeline	Lytle, David A.
Longview Inspection	White, Gary R.
Panhandle Energy	Benson, Karen
Panhandle Energy	Mohn, Jeryl L.
Panhandle Energy	Rau, Jerry F.
Peoples Energy	Field, Donald
Petrobras Transporte S.A.	Moreira, Lino F. R.
Pipeline Safety Trust	Winter, Greg
Pipeline World	Tiratsoo, John
Radiodetection	Walton, Jim
SMRI/PB Energy Storage Services Inc.	Ratigan, Joe
Southern California Gas Company	Amend, Bill
Southern California Gas Company	Gailing, Rick
Southern California Gas Company	Stewart, Lee M.
Technical Toolboxes Ltd.	Kainer, Ed
Technical Toolboxes, Inc.	Summa, Joseph
Todo Trading Company LLC	Freberg, Douglas

TransCanada PipeLines Limited	Aker, Gordon
TransCanada PipeLines Limited	Rothwell, Brian
TransCanada PipeLines Limited	Zhou, Joe
TWI (The Welding Institute)	Hadley, Isabel
Williams Gas Pipeline	Scrivner, Ron W.
Williams Gas Pipeline	Katz, David