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Mechanical Damage Workshop & Study Phase 1 Workshop Executive Summary

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*Mechanical Damage Workshop & Study
Phase 1
Workshop Executive Summary*

*Submitted by:
Michael Baker Jr., Inc.
April 2006*

Executive Summary

Mechanical damage from third party intrusion and latent defects caused during pipeline construction remains a leading cause of major pipeline incidents. Historically, mechanical damage is the single largest cause of failures on pipelines (transporting both natural gas and hazardous liquids).

Significant investments have been made by the Pipeline and Hazardous Materials Safety Administration (PHMSA), the pipeline industry and stakeholder organizations to increase public awareness of the risks of excavation in pipeline corridors. Likewise, much has been invested in research regarding detection of mechanical damage using in-line inspection (ILI) technologies, evaluating the severity of mechanical damage, and mitigation measures. However, no single endeavor has adequately addressed each of these considerations or their interrelationships in sufficient detail with adequate industry support for the outcome to receive broad acceptance by all stakeholders as the benchmark for advancing the technology to address mechanical damage issues.

In an effort to collaboratively approach the problem, PHMSA and the National Association of Pipeline Safety Representatives (NAPSR) held a major public workshop on February 28-March 1, 2006, in Houston to discuss issues associated with the role of technology in preventing, detecting, characterizing, and mitigating mechanical damage risks to energy pipelines. The workshop was organized in collaboration with several stakeholder organizations. It drove the scope for a major synthesis study on mechanical damage being conducted by Michael Baker Jr. Inc. (Baker). The study will evaluate the state of technology as well as gaps in the accepted technology necessary to understand, identify, assess, manage, and mitigate mechanical damage of pipelines. The study will also identify any gaps in associated regulations and industry standards. The study will be structured to seek industry and stakeholder input and review as well as to allow public comment period(s). Successful completion and acceptance of the study will require the support and participation of all stakeholders.

This paper serves as an executive summary of the workshop and identifies topics which will be addressed in the study. In summary, the purpose of this paper is to: 1) summarize the key issues presented and discussed at the workshop; 2) provide PHMSA, other regulatory and industry stakeholders, and the public with a sufficiently in-depth understanding of those topics which the study will address; and 3) provide the framework for additional comments by interested stakeholders on the study issues.

Pre-Workshop Efforts

In June, 2005, Baker was commissioned by PHMSA to investigate the mechanical damage issue and provide information about the mechanical damage study including its outline, purpose and how the workshop, the audience, and the study are related and linked.

Concurrently, PHMSA convened a Steering Committee to plan for the Mechanical Damage Workshop. Originally scheduled for the fall of 2005, the workshop was postponed because of PHMSA and industry's need to focus on the effects of Hurricanes Katrina and Rita. Steering Committee participants were PHMSA, the National Association of Pipeline Safety Representatives (NAPSR), American Gas Association (AGA), Association of Oil Pipe Lines (AOPL), American Public Gas Association (APGA), American Petroleum Institute, Common Ground Alliance (CGA), Interstate Natural Gas Association of America (INGAA), Northeast Gas

Association (NGA), In-Line Inspection Association (ILIA) and the Pipeline Research Council International (PRCI).

One pre-study effort was to query interested stakeholders on issues related to mechanical damage. Baker developed a website (www.BakerProjects.com/OPS) which will be used for public comment during the study effort and which was initially used for the query process. Questions on the mechanical damage issue were developed with the support of the Steering Committee and were made available on http://www.BakerProjects.com/OPS/mech_dam_study.asp. In addition, PHMSA/OPS also requested comments on two reports previously completed by Baker, the [Dent Study Final Report](#) and the [Pipe Wrinkle Study Final Report](#), as issues presented in these reports may need to be included in the broader comprehensive study of mechanical damage.

The Steering Committee also provided input on a series of matrices completed for existing technology associated with the areas of prevention, detection and characterization of mechanical damage. A similar series of matrices were completed for technology research covering these same areas. The matrices were used by the workshop panel moderators as a guide in preparing presentations covering relevant existing technology and technology research that is underway. The [matrices](#) are available on PHMSA's Mechanical Damage Meeting web site.

Mechanical Damage Technical Workshop

PHMSA and NAPSRS hosted the February 28-March 1, 2006, workshop to address pipeline safety issues associated with mechanical damage. The results of this workshop and the information shared were intended to: 1) further research on mechanical damage; 2) document the state of current damage prevention, detection and characterization technology; and 3) establish a clear direction for issues to be addressed by Baker in the mechanical damage study. A copy of the workshop [agenda](#) is attached (**Attachment A**). Over 250 people attended the workshop in person or via web cast. The workshop [presentations](#) are available from PHMSA's web site.

The remainder of this report summarizes information presented at the workshop and issue development area for the study.

Definition of Mechanical Damage

Before undertaking a synthesis study of mechanical damage, it is necessary to first define what is meant by *mechanical damage*. A common understanding of what constitutes mechanical damage is necessary to develop a common study frame of reference which recognizes the variations of understanding the phenomena across the industry.

In pre-workshop activity, Baker sought to arrive at a consensus definition of mechanical damage; however, insufficient input was obtained via the web query. The importance of arriving at a consensus definition of mechanical damage was raised by many of the panelists at the workshop as a key component of the study effort.

In general, mechanical damage usually occurs after a pipeline has been constructed and is caused by excavation equipment, which deforms the shape of the pipe, scrapes away metal and coating. The mechanical damage results in changes to the mechanical properties of the pipe near the damage. Mechanical damage defect types are commonly identified as denting, metal loss, metal deformation, and cracking.

The question regarding the inclusion of plain dents, wrinkle bends and buckles, as well as damage caused by movement of the pipe due to outside forces remained unresolved going into the workshop. Because the causation of these phenomena, and hence, their prevention, significantly differ from damage due to physical impact to the pipe caused by equipment impact, the initial scope development must include a consensus definition of mechanical damage.

Baker proposes to present the definition of mechanical damage in the very early phases of the study effort, using email communication with the workshop participants and the study website to communicate with interested stakeholders. Expectations are that a consensus definition will be developed around which the study proceed.

A summary of each workshop presentation is presented below.

Day 1 - Welcome and Introduction

Regulator Perspective

Ted Willke, DOT/PHMSA

Dr. Willke commented on the progress made by PHMSA and the industry with regard to the reduction of serious accidents over the past 20 years, including contributions from pipeline integrity management, major investment in research and development, and significant efforts by the Common Ground Alliance to reduce excavation damage, yet noting that mechanical damage is still the leading cause of pipeline failures. Highlighting some of the challenges, Dr. Willke cited the following issues: susceptibility of the entire pipeline to mechanical damage; finding damage before a failure occurs; finding latent damage; randomness of outside force damage; increased development around pipelines and current inadequate levels of technology to prevent and detect mechanical damage. Dr. Willke called on the attendees to provide the guidance on what should be the focus of the Baker Mechanical Damage Study insofar as it (1) defines a common understanding of mechanical damage across operators; (2) defines the state of technology and the gaps in technology; and (3) assists PHMSA in aligning its strategic goals and approach with regard to reducing incidents caused by mechanical damage.

Industry Perspective

Dave Johnson, Panhandle Energy

Dave Johnson provided an industry introduction to the workshop, noting that the mechanical damage study is vitally important to the industry. Mechanical damage accounts for up to half of all pipeline incidents/accidents, stressing that the vast majority of failures occur at the time of damage. In recent years, there have been few, if any, previously damaged pipe failures. Therefore, while efforts need to focus in damage prevention, a safe and efficient means of assessing existing damage when found is needed. Mr. Johnson encouraged all to support the Baker study and to talk to Baker and provide input to the study.

Mechanical Damage Study Outline & Purpose

Keith Meyer, Michael Baker Jr. Inc.

Dr. Meyer discussed Baker's efforts to date regarding the mechanical damage study. A web site (www.BakerProjects.com/OPS) was created for public comment during the process. Mechanical damage survey questions were posted in an attempt to generate consensus on various issues, including the definition of mechanical damage. Also posted to the site for comments were

previously completed Baker reports on dents and wrinkle bends. The mechanical damage study will focus on data issues that will define the scope of the problem, as well as prevention, detection, assessment and mitigation. With regard to prevention, the report focus will be on technology, not on best practices. In addition to making introductory comments, Dr. Meyer also addressed the workshop at the end of each day, summarizing relevant issues raised by the speakers which merit inclusion in the study.

Mechanical Damage Overview

A panel of speakers was assembled to present on the nature of the mechanical damage issue, focusing on data from a US, Canadian and European perspective.

The Nature of the Problem (U.S)

Jeff Wiese, DOT/PHMSA

Mr. Wiese provided insight on the nature of the mechanical damage problem and on those issues which the study must address to provide a consensus for understanding the problem. The study, first and foremost, must provide a common level of understanding of the mechanical damage problem. Semantics and definitions need to have consistency. Because of inconsistency of accident and incident reporting, the study needs to provide a better analysis of frequency data. Presenting excavation damage incident data vs. corrosion damage incident data, Mr. Wiese noted that while more incidents are reportedly caused by corrosion failure, the consequences of excavation damage failure in terms of death and injuries is significant. In summary, the study and workshop efforts will allow for (1) communicating what is and isn't known about mechanical damage; (2) sharpening PHMSA's data driven strategies; (3) collaborating in focused R&D investments to leverage efforts; (4) accelerating technology and knowledge gains into new standards and regulations; and (5) improving processes and procedures for dealing with mechanical damage issues.

Pipeline Incidents Caused by Mechanical Damage (U.S)

John Kiefner, Kiefner & Associates

Dr. Kiefner spoke on immediate and delayed failure issues associated with mechanical damage. He presented incident information reported to DOT under 49 CFR Parts 191 and 195 for the period 1985-2003, including the ratios of immediate to delayed for both liquid and gas pipelines (5:1 and 9:1, respectively). He presented a discussion of a 1999 study (GRI-99/0050) on how incidents might be prevented by ILI for 5 different types of delayed failures. In summary:

- ILI is of no use in preventing failures that occur hours to days after damage
- If the history and operating conditions of the pipeline justifies it, ILI before an intentional pressure increase in MOP could prevent failures that occur when the pipe is subjected to a $\geq 10\%$ pressure increase
- Delayed failures that result from suspected corrosion, fatigue or SCC at previous damage likely can be prevented by the types and schedules of ILI currently used by operators
- An arbitrary schedule for ILI would prevent some, but certainly not all delayed failures caused by "old" damage
- ILI for delayed failure incidents due to rock dents is not justified; however, ILI for other purposes will eliminate some of these delayed failures from occurring

Mechanical Damage - A Canadian Perspective

Christine van Egmond, NEB

Ms. van Egmond provided an overview of the issue of mechanical damage in Canada, focusing on NEB-regulated lines. In general, mechanical damage is not considered an issue in Canada due to the low population density (around NEB regulated lines) and the implementation in 1998 of Crossing Regulations. (Corrosion and cracking are considered more important incident causes). These regulations provide requirements for third party excavators as well as pipeline companies working within a 30 meter “safety zone” on each side of the pipeline ROW. Crossing violations are a leading indicator for mechanical damage. Proposed Damage Prevention Regulations will replace the Crossing Regulations in the summer of 2006. Three ruptures attributed to mechanical damage were discussed.

Mechanical Damage – A European Perspective

Murès Zarea, Gaz de France

Mr. Zarea presented information from the 6th European Gas Pipeline Incident Group (EGIG) Report 1970-2004, released in December 2005. External interference accounted for 50% of all incidents (defined as an unintentional release of gas). Failure frequency in the report is defined as the number of incidents divided by system exposure (where exposure is length of pipeline x exposed duration). Only 4.1% of the EGIG reported releases ignited. Also presented was information from a 2003 CONCAWE report on 22,632 miles of onshore oil pipelines from 65 European companies and other entities that found that third party actions were the leading cause of spill releases. Mr. Zarea also provided information on the European Pipeline Research Group (EPRG) efforts regarding methods to assess the resistance of pipelines to mechanical damage. Slides on the July 30, 2004, gas pipeline rupture in Ghislenghien, Belgium attributed to mechanical damage were shown and discussed.

Prevention Panel (Existing Technology)

Christina Sames, AGA - Moderator

Christina Sames, standing in for Dr. Erez Allouche of Louisiana Tech, became the moderator of the two panels. The remainder of the first morning of the workshop focused on prevention of mechanical damage. While non-technological items were highlighted, the intent of the panel was to present application of existing technology to prevent mechanical damage. Information presented by the panelists will be captured in the mechanical damage study.

Preventing Mechanical Damage (Liquid)

Gwen Broussard, Shell Pipeline

Ms. Broussard presented a comprehensive overview of existing methods and technologies employed by operators to prevent mechanical damage including: public education and awareness; mapping tools; surveillance methods; one-call systems; locating and marking; excavation monitoring and enforcement.

Public Awareness & Damage Prevention (Gas Transmission)

Jerry Rau, Panhandle Energy

Mr. Rau discussed Panhandle’s procedures and systems using web-based tools for managing public awareness under its integrity management program. Panhandle communicates with its public officials and emergency responders (POER) through an interactive website. Through the POER website, Panhandle is able to obtain information on identified sites that its personnel

investigate for HCA occupancy. Panhandle plans to use the POER site to similarly obtain ROW encroachment information, targeting emergency responders, home owner associations, excavators and the general public. Panhandle's use of the IRTM system for processing dig requests was also presented.

Damage Prevention (Gas Distribution)

Daphne D'Zurko, NYSEARCH

Ms. D'Zurko presented information on existing technologies employed to prevent excavation damage on distribution pipelines, focusing on pipeline location tools (including ground penetrating radar) and real-time sensing technology (including near commercial GasNet). In summary, the need is for reliable, user-friendly and affordable pipe location tools; real-time warning of threatening activity near often congested pipelines; and automated warning systems integrated into construction equipment or other sources of damage.

VA Pilot Project for One-Call Location Technology (Keynote)

Jeff Wiese, DOT/PHMSA

Jeff Wiese, filling in for Massoud Tahamtani, discussed the Virginia pilot for one-call notification technology whose purpose is to identify and test available technology to enhance the communication process using GPS and enhanced geo-coding of maps. The effort is motivated by pipeline operator requests to reduce "over-notification". Project deliverables include cost/benefit analyses of pilot approach; pilot project performance review; best practice recommendations for technologies and processes; and determination of additional pilot for "e.dig" site would be beneficial.

Prevention Panel (Technology Research)

Christina Sames, AGA - Moderator

The afternoon of the first day of the workshop focused on technology research of mechanical damage prevention.

Prevention Technology Research

Jim Merritt, DOT/PHMSA

Jim Merritt presented an overview of DOT/PHMSA funding of damage prevention program elements. Five funded projects were identified. Expected results of the R&D effort include: universal understanding of route cause failure analysis; establishment of goals to reduce or eliminate unnecessary digs; demonstration of cost effective leak detection and encroachment monitoring technologies; and continued support in hosting field deployment of technologies.

Prevention Technology Research

Harvey Haines, PRCI

The focus of Mr. Haines' presentation was on PRCI damage prevention R&D for 2006. Three programs were presented: DP-1-1 – Operator Practices for Damage Prevention; DP-1-4- Incorporation of GPS Devices in One-Call; and ROW – 1 – Technologies for ROW Monitoring. Also discussed was past effort begun in 1995 on real-time contact monitoring and the GE acoustic real time monitoring demonstration. Next generation capabilities in data capture, data interpretation and visualization, response and communications are expected to come from other fields and industries.

Prevention Technology Research

Daphne D'Zurko, NYSEARCH

Damage prevention R&D efforts funded at NYSEARCH are focused on pipeline location technologies using GPR; seismic, acoustic and fiber optic sensing technologies; and analysis of damage resistant pipe materials including reinforced thermoplastic pipe (RTP) and profuse/peelable pipe. An RFP issued in the spring of 2006 for damage prevention will focus on monitoring systems, sensors for placement on construction equipment, and innovative excavation technologies. Challenges include technology transfer and commercialization of R&D.

Prevention Technology Research

Maureen Droessler, Operations Technology Development

Dr. Droessler highlighted seven current damage prevention research efforts being conducted by OTD, a stand-alone 501c (6) not-for-profit, member controlled company where gas utilities work together to develop technology solutions to common operations issues. The areas of research fall into the areas of (1) monitoring and characterizing unauthorized activity near pipelines, including better detection of boring and HDD equipment; (2) developing tougher materials and coatings that resist damage; and (3) improving locating ability. A brief description of current funded efforts includes:

- Underground facility pinpointing – independent, comparative, technical and field evaluation of emerging locator technologies
- Hand-held acoustic pipe locator – use of sonic technology to provide accurate location information on buried metal, plastic or concrete pipes
- Buried pipe imaging by capacitive tomography – development of a compact and inexpensive capacitive tomography imaging sensor prototype in the form of a flat plate or flexible mat that can be placed on the ground to quickly and accurately provide an image of buried objects in the soil below the sensor
- Integration of electromagnetic and acoustic obstacle detection systems for horizontal directional drilling operations – adaptation and integration of radar system with horizontal drilling machine and the evaluation of a the pre-prototype system in the field
- Micro-excavation system – development of tools to make micro (4-6 inches) size excavation to access buried facilities through smaller, less expensive openings
- Maintenance-free pipeline coatings for critical locations – evaluation of thermal spray systems and coating materials for application on pipe in critical locations and difficult-to-access areas to ensure a corrosion-free life of 50-70 years

MD Perspective and Obstacle Detection for HDD

Chris Ziolkowski, GTI

Mr. Ziolkowski's presentation discussed some of the causes of mechanical damage to buried infrastructure and briefly reviewed various approaches to damage prevention pursued by GTI. These approaches include detection of activities with the ROW (including acoustic sensors and fiber optic monitoring), monitoring of plastic pipe during the installation process (including development of tow tension monitors), detection and imaging of plastic pipe from above ground (employing capacitive tomography), and detection of obstacles in front of HDD in time to avoid contact (covering differential impedance sensing technology and its application).

Detection and Characterization Panel (Existing Technology)

Brian Sitterly, Shell Pipeline Moderator

The morning panel on the second day of the workshop focused on existing technology available to detect and characterize/assess mechanical damage. Presentations were given by members of both the liquid and gas transmission industries, as well as by the In-Line Inspection Association (ILIA).

Detection and Characterization – Enbridge Experience

Walter Kresic, Enbridge Pipelines

Mr. Kresic stated that rock dents account for $\frac{3}{4}$ of all mechanical damage on the Enbridge system and stressed the need for flexibility in mechanical damage defect management approach due to the uncertainty of parameters that define damage. Enbridge uses a full range of detection technologies including caliper, MFL and ultrasonic tools. Characterization techniques include use of commercial MFL to provide detail geometric information along with finite element analysis and semi-empirical approaches that utilize improved MFL characterizations. Because the main failure mode on Enbridge's system is environmentally assisted cracking, crack identification is of primary interest. Enbridge is working with PRCI Research on efforts to test dual-field MFL and to examine existing commercial equipment. They are also collaborating on a variety of characterization projects regarding mechanical modeling, full-scale testing, high-level prioritization and field assessment guidance.

Detection and Characterization – Colonial Experience

Chad Zamarin, Colonial Pipeline

Mr. Zamarin's presentation, while highlighting Colonial's experience, was a thorough overview of in-line inspection and direct examination methods of detection and characterization of mechanical damage. While detailed data integration and risk-based dig planning are key, discrimination of indications remains challenging, and efficient and accurate critical assessment of ILI data is difficult, rendering ILI alone insufficient for management of the threat. Stating that there is no single dominant drive for threats due to latent damage, a paradigm was identified:

- Current regulations focus on depth and lead to the excavation of large numbers of excavations; small number of integrity threatening defects are found, resulting in unnecessary excavations and misguided resources; however,
- While only a small number of integrity threatening defects are identified, many potentially threatening defects are also discovered

Magnetic particle inspection is effective at exposing anomaly features, yet by the time an anomaly is exposed, the decision to repair often has relatively low impact. The key is to be able to characterize before excavation. This requires that data feedback be made available to tool vendors to improve ILI detection. Mr. Zamarin's summary conclusions stressed a need to optimize the detection and characterization process, including the use of risk management to focus where the threat is significant; advanced indirect detection, characterization and data integration to dig the "right" indications; and accurate examination and feedback to mitigate damage and improve the entire process. The path forward identified included:

- Continued focus on prevention
- Fit for purpose tool selection based on risk assessment
- Analysis of damage characteristics and line properties/conditions to develop a profile of pipelines susceptible to latent damage growth

- Risk assessment enhancements, data integration guidelines and reliable engineered dig selection methodologies
- Efficient advanced critical assessment of ILI data
- Prioritization of dents with metal loss / stress risers
- Technical definition of stress risers
- Appropriate scheduling or monitoring of other damage
- Standardized strain based criteria for liquid lines that incorporates fatigue consideration
- Regulations that enable and promote an engineered approach versus one size fits all criteria

MD Characterization – Existing Technologies in Gas Trans. Pipelines

Todd Kenzie, El Paso

Mr. Kenzie’s presentation on existing technologies for damage characterization discussed those currently available technologies identified on the characterization matrix compiled in advance of the meeting. Advantages and challenges in the use of each technique and technology were thoroughly reviewed. It is anticipated that this information will be tabularized for inclusion in the mechanical damage study report.

Detection and Characterization - Duke Energy Gas Transmission

Steve Rapp, DEGT

Mr. Rapp provided an overview of DEGT’s 2005 ILI program, during which 1,103 miles were surveyed with HRMFL ILI and 892 miles with caliper tools. The number of identified anomalies requiring immediate response attributed to mechanical damage was 86; 16 due to topside dents with metal loss and 70 with bottom side dents with metal loss, most of which were found to be associated with original construction damage. There was found to be no evidence of time dependent damage to the pipeline. Pressure reductions during the excavation of bottom side rock damage should be employed due to subtle safety risk, particularly for bottom side dents with high strain profiles. Technology gaps identified for mechanical damage include better prediction models to define failure pressures for dents with gouges, and more reliable metal loss measurement and characterization using high resolution MFL tools. Improved characterization in these areas would allow for “immediate” and “scheduled” response criteria, and therefore, excavation, evaluation and repair of “immediate” anomalies, to be reclassified under IMP programs. Mr. Rapp’s presentation included flowcharts of DEGT’s response protocols for HRMFL identified deformation, as well as flowcharts for remediation of dent features and dents with mechanical damage identified during field investigation. These flowcharts have merit for inclusion in the mechanical damage study report.

Detection and Characterization – ILIA

Bryce Brown, Rosen Inspection Services

Mr. Brown, representing ILIA, presented an overview of the B31.8 S integrity threats that can be detected with ILI as well as summarizing existing ILI technologies. Stating that new regulations have changed the demand placed on ILI products and services, ILI tools and technologies are currently available to address identified integrity threats and continued tool and service development will be based on the input and needs of the operators and industry.

Detection and Characterization Panel (Technology Research) *Brian Sitterly, Shell Pipeline Moderator*

The afternoon panel on the second day of the workshop focused on technology research in the areas of detection and assessment of mechanical damage.

PHMSA Detection and Characterization Technology Research *Robert Smith, DOT/PHMSA*

MR. Smith highlighted the detection and characterization program elements and goals of PHMSA's R&D efforts. Detection technologies expected to develop from the efforts include tools and sensors for unpiggable natural gas pipelines; improvements to MFL sensors; ILI sensors for coating damage; improvements to GUT sensors; and through-coating external inspection of pipelines. Characterization technologies expected to emerge include improvements in both MFL and GUT data characterization; technologies to reduce unnecessary digs; and improvements to severity criteria for wrinkles, SCC and other types of mechanical damage.

Technology Research – Issues and Opportunities *David Batte, Consultant to PRCI*

David Batte's presented a synthesis of PRCI research efforts focused on mechanical damage detection and characterization highlighting current technology status, technology gaps, path forward, current PRCI project portfolio and issues remaining to be addressed.

Detection status issues focus on how reliably and accurately ILI commercial technology can detect damage. More robust models with supporting data to assess damage are needed. Assessment based on dent depth alone is insufficient to characterize cracking, strain and stress distributions and other features of the dent profile. Fundamental knowledge of the underlying failure process is limited, necessitating the use of a fracture- mechanics-based algorithm yet to be developed. Broader validation of assessment modeling is needed. Identified prioritized needs for inspection and characterization include:

- Created database of dent/gouge features for model development
- ILI technology that can discriminate between plain dents and dents with other features
- Tools to integrate geometry and metal loss information
- ILI technology to better characterize and size critical damage features
- Quantify resolution, accuracy and reliability of ILI and in-ditch inspection methods

Identified prioritized needs regarding severity assessments include:

- A validated method for ranking the severity of dents with and without corrosion, gouges, welds, etc.
- A validated method for assessing the safety margin on burst pressure for dents with gouges
- A validated method for assessing the remaining life of gouges and dents with gouges

Mr. Batte discussed PRCI's five year plan for addressing mechanical damage funded projects for 2006. Desired outcomes were listed as follows:

- A quantitative understanding of the types, extent and distributions of mechanical damage experienced by pipelines
- ILI technology capable of identifying and measuring the features that discriminate between critical and benign anomalies in an operating pipeline

- A model for ranking the severity of damage (rupture, leak, non-penetrating dent+/-gouge +/-cracks) based on damage features, pipeline attributes and aggressor characteristics
- Validated state-of-the-art models for determining the burst and delayed failure behavior of damaged pipe
- New recommendations for determining safe pressure reductions and working practices during repair
- An industry guidance document, based on these deliverables, to aid decisions on the characterization, severity assessment, and safe excavation and repair of damaged pipe

Detection and Characterization – Technology Research

Maureen Droessler, OTD

Dr. Droessler discussed OTD funded research focused on damage detection and characterization efforts that specifically related to distribution pipelines. Technology challenges for non-piggable lines include the need for improved inspection capabilities from the surface to minimize the cost of excavations and the ability to detect specific points of coating disbondment and shielding. Also identified was the development of increased “smartness” of the pipe in the way of internal coatings and wraps with the ability to relay information on the conditions that lead to damage.

A brief description of current funded efforts includes:

- Keyhole excavation programs – development of tools to externally and internally inspect and repair buried facilities through smaller less expensive openings
- Flaw acceptance criteria and repair options for low-stress gas pipelines – demonstrate that flaw acceptance criteria and repair options that apply to highly stressed pipelines are overly conservative and may need to be relaxed for low stress pipelines
- Reduce inspection costs through remote field eddy current inspection of unpiggable lines – development of remote field eddy current inspection techniques using relatively small components as a solution for inspecting pipelines with multiple diameters, valve and bore restrictions, and tight or miter bends
- Inspection sensor and platform for unpiggable pipelines – design, construct and test an MFL sensor and a robotic platform that when integrated are able to negotiate all obstacles in a pipeline when performing an inspection on unpiggable systems
- Internal inspection using laser-based ultrasonic technology – development of laser-based ultrasonics as an internal inspection tool under live conditions for cast iron and steel distribution systems

Development of an Inspection Technology for Mechanical Damage

Bruce Nestleroth, Battelle

Mr. Nestleroth discussed research for mechanical damage that included effort by Battelle from 1994 to date. Projects include:

- An electronic method for detecting small area surface stress/strain patterns using non-linear harmonics (NLH)
- An ultrasonic sensor system for detecting and characterizing pipeline stress and strain caused by denting and other deformation which ranks the severity of smooth dents based on ultrasonic measurements of the mechanical properties and the presence of plastic strain, rather than dent dimensions or wall thickness
- Efforts on dual magnetization MFL inspection technology which uses a decoupled signal to expose a region of cold work where the ductility of the steel has been exhausted and the re-rounding of the dent applies a tensile load to the anomaly.

Challenges and Barriers to Industry Acceptance of Technology

Alan Dean, Tuboscope

Mr. Dean, representing the ILIA, discussed the challenges and barriers that exist in getting ILI technology developed, validated and commercialized. While significant research is conducted privately by members of the ILIA, due to the competitive nature of the business, nothing is discussed until commercialization. Using the dual magnetization technology tool being developed with Battelle through PRCI and GTI as an example, Mr. Dean discussed the efforts and lengthy time necessary to bring ILI technology to commercialization, stressing that the most critical steps of the process involve data validation.

MD Characterization (Technology Research)

Chris Alexander, Stress Engineering Services

Mr. Alexander presented a keynote address on the issues of technology research in the area of damage characterization. Defect characterization often involves developing an appropriate priority level to rank the severity of defects. The assessment process consists of the following steps:

- Detection – finding the defect using inspection technology
- Characterization – assessing the severity using experience, operating history, testing, analysis and research
- Determination – defining acceptability and ranking defects if required using evaluation relative to codes, standards and government agencies
- Repair/Replacement – repairing the damage using available technology to determine the best repair options or replacing the pipe segment if warranted
- Restoration of Service – restoring service following the re-establishment of integrity

Mr. Alexander also stressed the need for results-oriented solutions to operators in assessing and characterizing damage and the use of technology when appropriate, but not as a substitute for experience or at the expense of safety.

Question and Answer Sessions

Panelists

General discussion and Q&A followed the presentations by each panel; at the end of Day 1 and at the end of both the morning and afternoon panels of Day 2. The following list of items was identified during these sessions, as well as by speakers during their presentations. Inclusion of some or all of these issues in the mechanical damage study is anticipated.

Status and Overview Issues

- Study needs to clearly define mechanical damage; the definition of mechanical damage is a key study scope item.
- Study needs to address data analysis as presented by John Kiefner.
- Study needs to focus on frequency and consequence issues associated with MD.
- A terminology list needs to be incorporated in the report, and should be issued before a first draft.

- How should incident databases from various countries be compared?
- Are statistics available for distribution pipelines? Comment was made that time dependent defects are not an issue with distribution pipelines due to low stresses and that the distribution focus needs to stay on prevention.
- Study needs to address non-metallic pipe. This is a prevention issue; issues associated with detection of damage in non-metallic pipe should be addressed.
- A question was asked regarding latent damage in distribution pipeline. The study needs to explore whether the growth of defects is unique to conditions of transmission pipelines (i.e., higher stress).
- Study is to develop a common level of understanding of mechanical damage, realizing that PHMSA speaks to many stakeholders with different perceptions of the problem and what needs to be done to address it.
- Technology issues of the study also need to look at issues associated with human interface of the technology.
- How should geo-forces be considered? (This goes to the definition of MD)

Prevention Issues

- The prevention focus needs to be on technology, while still acknowledging issues such as one-call best practices have an important place in damage prevention.
- Study needs to address the issue of over-notification and how technology helps to drive improvements in information from impacted groups.
- What should prevention R&D focus on? What kinds of results do we want and expect?
- Focus R&D of prevention should be on the three areas of 1) technologies, 2)practices, 3) human factors.
- Should more R&D resources be placed on prevention than on detection and characterization?
- How much effort should be focused on prevention technology vs. communication (i.e., with excavators, etc.)?

Detection and Characterization

- Detection needs to focus on identifying injurious conditions; need to screen out those defects that present an integrity issue.

- There was a comment from the audience that the SCC report section on what to when SCC was found was helpful. Study needs to incorporate a similar procedure for mechanical damage (e.g., flow charts presented by Todd Kenzie of El Paso)
- Are operators faced with a dilemma regarding R&D if at the end of the day, the regulations, as they exist, require them to dig up anomalies?
- What is the step-change required in R&D to make the changes before reassessment needs to be done?
- Should definition of mechanical damage be based on capability of the tools and abilities for detecting mechanical damage? Coming up with a better definition might drive tool development; development of tools might better define mechanical damage.
- Canadians and US are drawing from the same R&D efforts; but how this translates to regulation is more based on social aspects (populations, etc.) Europe is less prescriptive than US or Canada.
- Brian Lees asked: Is the decision to excavate being documented for collation and sharing? Walter Kresic thinks that will happen in the future.
- John Jacoby – PHMSA – data for comparison needs to be consistent. Report should cover what needs to be collected in the field for comparing data. Like SCC report – what needs to be documented? How will data be compared and stored?
- Question on accuracy/confidence levels of ILI tools – suggestion to incorporate accuracy of ILI tools info into study.
- A suggestion was made to have the study examine the requirement for reassessment at 5 year intervals. Reassessment intervals for dents and time dependent threats should be dealt with separately, but current regulations do not allow for this.
- Use of dent depth alone is insufficient; need to look at other characterization of the dent including metal loss in dents.
- How do we shift focus to smaller defects; most of large top side defects should be found within the next few years; after that time, it's reassessment. Are R&D efforts geared to this?
- As not all pipelines are piggable, we need to make sure report covers detection methods for non-piggable lines.

Other

- There was a comment concerning an error in the ASMA B31.8 equation in the Dent Report that needs to be addressed. This will be addressed.

Mechanical Damage Technical Workshop

February 28 – March 1, 2006

Marriott Westchase

Houston, Texas

Day 1 – February 28, 2006

7:30 A.M.	Registration	
8:00 A.M.	Welcome & Introduction	
<i>U.S. Government</i>	Theodore Willke	DOT/PHMSA
<i>U.S. Industry</i>	Dave Johnson	Panhandle Energy
8:15 A.M.	Mechanical Damage Study Outline & Purpose	
	Keith Meyer	Michael Baker Jr., Inc.
8:30 A.M.	Mechanical Damage Overview (How big is the problem?)	
<i>U.S.</i>	Jeff Wiese	DOT/PHMSA
<i>U.S.</i>	John Kiefner	Kiefner and Associates, Inc.
<i>Canada</i>	Chris van Egmond	National Energy Board
<i>Europe</i>	Mures Zarea	Gaz de France
10:00 A.M.	Break	
10:15 A.M.	Prevention Panel (Existing Technology)	
<i>Moderator</i>	Dr. Erez Allouche	Louisiana Tech
<i>Liquid</i>	C. Gweneyette Broussard	Shell Pipeline Company LP
<i>Gas Trans</i>	Jerry Rau	Panhandle Energy
<i>Gas Dist (s)</i>	Daphne D'Zurko	NYSEARCH/Northeast Gas Association
<i>Gas Dist (n)</i>		
<i>Keynote</i>	Jeff Wiese	DOT/PHMSA
12:00 P.M.	Lunch	
1:30 P.M.	Prevention Panel (Technology Research)	
<i>Moderator</i>	Dr. Erez Allouche	Louisiana Tech
<i>Overview</i>	Jim Merritt	DOT/PHMSA
<i>Overview</i>	Harvey Haines	Pipeline Research Council International
<i>Overview</i>	Daphne D'Zurko	NYSEARCH/ Northeast Gas Association
<i>Overview</i>	Dr. Maureen Droessler	Operations Technology Development
<i>Keynote</i>	Chris Ziolkowski	Gas Technology Institute
3:00 P.M.	Break	
3:15 P.M.	General Discussion and Q&A (All Speakers)	
4:15 P.M.	Summary and Next Steps	
4:30 P.M.	Adjourn	

Day 2 – March 1, 2006

8:00 A.M.	Detection & Characterization Panel (Existing Technology)	
<i>Moderator</i>	Brian Sitterly	Shell Pipeline Company LP
<i>Liquid</i>	Walter Kresic	Enbridge
<i>Liquid</i>	Chad Zamarin	Colonial Pipeline Company
<i>Gas Trans</i>	Todd Kedzie	El Paso Corporation
<i>Gas Trans</i>	Steve Rapp	DEGT Transmission and Storage Operations
<i>ILLA</i>	Bryce Brown	ROSEN Inspection Services
10:00 A.M.	Break	
10:15 A.M.	Detection & Characterization Panel (Existing Technology) - Cont.	
11:00 A.M.	General Discussion and Q&A (All Speakers)	
11:45 A.M.	Summary and Next Steps	
12:00 P.M.	Lunch	
1:30 P.M.	Detection & Characterization Panel (Technology Research)	
<i>Moderator</i>	Brian Sitterly	Shell Pipeline Company LP
<i>Overview</i>	Robert Smith	DOT/PHMSA
<i>Overview</i>	David Batte	Pipeline Research Council International
<i>Overview</i>	Dr. Maureen Droessler	Operations Technology Development
<i>Keynote</i>	Bruce Nestleroth	Battelle
<i>Overview</i>	Alan Dean	Tuboscope
<i>Keynote</i>	Chris Alexander	Stress Engineering Services, Inc.
3:00 P.M.	Break	
3:15 P.M.	General Discussion and Q&A (All Speakers)	
4:15 P.M.	Summary and Next Steps	
4:30 P.M.	Closing Statement/Adjourn	