Gas Storage Technology Consortium

Technical Quarterly Progress Report for
April 1, 2007 – June 30, 2007

By

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DISCLAIMER

ABSTRACT

Gas storage is a critical element in the natural gas industry. Producers, transmission and distribution companies, marketers, and end users all benefit directly from the load balancing function of storage. The unbundling process has fundamentally changed the way storage is used and valued. As an unbundled service, the value of storage is being recovered at rates that reflect its value. Moreover, the marketplace has differentiated between various types of storage services and has increasingly rewarded flexibility, safety, and reliability. The size of the natural gas market has increased and is projected to continue to increase towards 30 trillion cubic feet over the next 10 to 15 years. Much of this increase is projected to come from electric generation, particularly peaking units. Gas storage, particularly the flexible services that are most suited to electric loads, is crucial in meeting the needs of these new markets.

To address the gas storage needs of the natural gas industry, an industry-driven consortium was created – the Gas Storage Technology Consortium (GSTC). The objective of the GSTC is to provide a means to accomplish industry-driven research and development designed to enhance the operational flexibility and deliverability of the nation's gas storage system, and provide a cost-effective, safe, and reliable supply of natural gas to meet domestic demand.

This report addresses the activities for the quarterly period of April 1, 2007 through June 30, 2007. Key activities during this time period included:

- Organizing and hosting the 2007 GSTC Spring Meeting;
- Identifying the 2007 GSTC projects, issuing award or declination letters, and begin drafting subcontracts;
- 2007 project mentoring teams identified;
- New NETL Project Manager;
- Preliminary planning for the 2007 GSTC Fall Meeting;
- Collecting and compiling the 2005 GSTC project final reports; and
- Outreach and communications.

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INTRODUCTION

Gas storage is a critical element in the natural gas industry. Producers, transmission and distribution companies, marketers, and end users all benefit directly from the load balancing function of storage. The unbundling process has fundamentally changed the way storage is used and valued. As an unbundled service, the value of storage is being recovered at rates that reflect its value. Moreover, the marketplace has differentiated between various types of storage services and has increasingly rewarded flexibility, safety, and reliability. The size of the natural gas market has increased and is projected to continue to increase toward 30 trillion cubic feet over the next 10 to 15 years. Much of this increase is projected to come from electric generation, particularly peaking units. Gas storage, particularly the flexible services that are most suited to electric loads, is crucial in meeting the needs of these new markets.

To address the gas storage needs of the natural gas industry, an industry-driven consortium was created – the Gas Storage Technology Consortium. The objective of the GSTC is to provide a means to accomplish industry-driven research and development designed to enhance the operational flexibility and deliverability of the nation's gas storage system, and provide a cost-effective, safe, and reliable supply of natural gas to meet domestic demand. Consortium technology development is conducted in the general areas of well-bore and reservoirs, operations, mechanical, and salt caverns. Consortium members elect an executive council that is charged with reviewing projects for consortium co-funding. Proposals must address improving the production performance of gas storage and provide significant cost sharing. The process of having industry members develop, review, and select projects for funding ensures that the GSTC conducts research that is relevant and timely to the industry. Co-funding of projects using external sources of funding is sought to ensure that GSTC funds are highly leveraged.

EXECUTIVE SUMMARY

This report summarizes the important accomplishments during the period of April 1, 2007 through June 30, 2007. The GSTC was established under contract to The Pennsylvania State University from the U.S. Department of Energy (DOE), National Energy Technology Laboratory (NETL), in June 2004. The agreement provides the Pennsylvania State University with the overarching management responsibilities for the GSTC.

Key activities for this reporting period included the following:

2007 GSTC Spring Meeting

The 2007 GSTC Spring Meeting to hear all requests for funding was held on May 16-17, 2007 at the Buffalo Marriott Niagara, Amherst, NY. Nine proposals were submitted in response to the request for proposals. A strategic planning session was part of the general meeting session. The Executive Council met immediately following the general meeting to select projects to go forward.

2007 GSTC Projects

Four projects were selected for funding beginning August 1, 2007 – July 31, 2008. The projects are:

- Evaluation of Magnetic Pulse Welding (MPW) for Improved Casing Repair: *Edison Welding Company*
- RGD X-ray Technology Well Bore Inspection and Assessment – A Feasibility Study: *Gas Technology Institute*
- Penetration Power of Ultrasonic Guided Waves for Piping and Well Casing Integrity Analysis: *The Pennsylvania State University*
- Smart Gas: Using Chemicals to Improve Gas Deliverability – Phase II: *Correlations Company*

Project Mentoring Teams

Mentoring teams were identified for all 2007 projects. Conference calls for projects will be scheduled and conducted on a monthly basis during the first quarter of the project and quarterly thereafter. The mentoring teams for 2006 projects will continue.

New NETL Project Manger

Mr. Richard Baker has assumed the duties as the NETL Project Manager for the GSTC effective May 14, 2007. He replaces Mr. Timothy Grant who has moved to the Office of Systems, Analysis and Planning where he will be working on climate change issues.

2007 GSTC Fall Meeting

Plans are underway for the fall technology transfer workshop and the hearing of all proposals received in response to the request for proposals. In addition, training for the Gas Storage Field Deliverability and the New Comprehensive Analysis projects is

being considered. The GSTC administration is working to secure a meeting site and drafting preliminary plans.

2005 Project Final Reports

The 2005 projects ended December 31, 2006. To date, six reports have been received, approved, and are posted in the "members only" portion of the GSTC website. A paper copy and a compact disc the final reports will be distributed to all 2005 full members in mid-summer.

Communications

The *GSTC Insider* e-newsletter was released in April 2007. The next *GSTC Insider* e-newsletter is drafted for release in July 2007.

EXPERIMENTAL

A description of experimental methods is required by the DOE for all quarterly technical progress reports. In this program, Penn State is responsible for establishing and managing an industry-driven underground gas storage consortium. Technology development research awards are made on a competitive basis. Technical reports from the individual researchers are required to contain experimental discussion sections and are submitted to consortium members and the DOE for review. Therefore, this section is not applicable to the Penn State contracted activities.

RESULTS & DISCUSSION

This report addresses the activities for the reporting period from April 1, 2007 through June 30, 2007. Key activities during this time period included:

- Organize and host the 2007 GSTC Spring Meeting;
- 2007 GSTC projects selected;
- Project mentoring teams identified;
- New NETL project manager named;
- 2005 project final reports;
- Planning for the 2007 GSTC Fall Meeting; and
- Outreach and Communications.

GSTC ADMINISTRATION

2007 GSTC Spring Meeting

The GSTC received nine proposals in response to the 2007 request for proposals. The 2007 GSTC Spring Meeting to hear all proposal requests was organized and held at the Buffalo Marriott Hotel, Amherst, New York on May 16-17, 2007. All projects were scheduled for a 30-minute presentation followed by a question and answer session. Thirty-three representatives from industry, academia, trade associations and the federal government participated. In addition to project presentations, the new NETL Project Manager for GSTC, Mr. Richard Baker, gave a short presentation, followed by a GSTC

strategic planning session. During the strategic planning session, members offered several suggestions on what the GSTC could do for continued growth and to better serve the industry:

- Technical publications are important
- The research needs applied in the field
- The GSTC website would be a good place to put ideas for a new RFP
- Knowledge dissemination: Look at research that's already been done. Look at state-of-research compared to where we are
- Plan to diversify funding – do not rely solely on DOE funds
- GSTC needs to build more strategic alliances

The Executive Council met following the general meeting to identify projects to go forward. The meeting agenda is attached as Appendix A.

2007 GSTC Projects

The Executive Council recommended four projects of co-funding (Table 1). The funding cycle will be August 1, 2007 to July 31, 2008. Appendix B contains a one page Executive Summaries of these projects.

Table 1: 2007 GSTC Projects

2007 Project Summaries				
Title	**GSTC**	**Applicant**	**Total Costs**	**%**
Evaluation of Magnetic Pulse Welding (MPW) for Improved Casing Repair, *Edison Welding Institute*	$90,000	$60,750	$150,750	40
RGD X-Ray Technology Well Bore Inspection and Assessment-A Feasibility Study, *Gas Technology Institute*	$88,755	$237,257	$318,012	75
Penetration Power of Ultrasonic Guided Waves for Piping and Well Casing Integrity Analysis, *The Pennsylvania State University*	$85,000	$73,281	$158,281	46
Smart Gas: Using Chemicals to Improve Gas Deliverability-Phase II, *Correlations Company*	$75,000	$75,000	$150,000	50
	$338,755	**$446,298**	**$785,053**	57

Project Mentoring Teams

It was the desire of the general members to continue the project mentoring team conference calls that began last year. The Executive Council identified project mentoring teams for all 2007 projects. It was suggested that the mentoring calls be held once per

month during the first quarter for the 2007 projects. Should the mentors be satisfied with the direction of the project, a change to quarterly could be implemented thereafter. During the next quarter, the call schedule will be put in place. The mentoring teams for the 2006 projects will continue through December 31, 2007.

New NETL Project Manager

Mr. Richard Baker assumed the duties as NETL Project Manager for the GSTC, effective May 14, 2007. Mr. Baker replaces Mr. Timothy Grant, who has moved to the Office of Systems, Analysis and Planning where he will be working on climate change issues.

TECHNOLOGY TRANSFER/OUTREACH

2007 GSTC Fall Meeting

Plans are underway for the 2007 GSTC Fall Meeting on November 7-8, 2007 in Portland, OR. The GSTC is working to secure a meeting site and drafting preliminary plans for the meeting. In addition, training for the Gas Storage Field Deliverability and the New Comprehensive Analysis projects is being considered.

2005 Project Final Reports

The 2005 projects ended December 31, 2006. Six of the final project reports are ready for distribution. The two reports still outstanding are:

- New Comprehensive Inventory Analysis Tool, *Schlumberger*. This project was extended until June 30, 2007.
- Scale Remediation Using Sonication: Pre-Commercial Test Project, *TechSavants, Inc*. This project has been delayed in doing the two weeks of field testing on the final four wells. Once flow-prover testing is completed, the results will be analyzed, then it will be integrated into a final report.

All completed reports are now available in the "member's only" section of the GSTC website. A paper copy and a compact disc (CD) of the final reports will be distributed to all 2005 full members.

Communications

The *GSTC Insider* electronic newsletter was drafted for release in July 2007. This newsletter will be distributed to the GSTC list serve as well as being posted to the GSTC website.

PLANNED ACTIVITIES FOR NEXT REPORTING PERIOD

During the next quarter the GSTC will:

- Negotiate subcontracts for the four new GSTC projects;
- Issue a new request for proposals;
- Continue planning for the 2007 GSTC Fall Meeting;
- Initiate the mentoring team conference calls schedule for 2007 projects
- Compile and release the 2005 GSTC project final reports;
- Draft and release another online newsletter; and
- Continue to update the GSTC web site.

CONCLUSIONS

During this reporting period, the GSTC organized and hosted the 2007 GSTC Spring Meeting. Four projects have been identified for 2007. A mentoring team has been identified for the 2007 projects. The mentoring teams for the 2006 projects will continue through December 31, 2007. The 2007 calendar is being finalized. The GSTC is planning for the 2007 GSTC Fall Meeting in Portland, OR. Through these efforts, the GSTC continues to improve and better serve the gas storage industry.

REFERENCES

A listing of referenced materials is required by the DOE for each quarterly technical progress report. However, this technical progress report for the GSTC did not utilize any reference materials during this reporting period.

APPENDICES

Appendix A – 2007 Spring Meeting Agenda

Appendix B – 2005 Project Executive Summaries

APPENDIX A
2007 Spring Meeting Agenda

GSTC SPRING PROPOSAL MEETING

Buffalo Marriott Niagara
1340 Millersport Highway
Amherst, NY 14221

	May 15, 2007
6:00-9:00 pm	Reception – Albright-Knox Art Gallery – transportation provided to/from Marriott
	May 16, 2007
7:30 am	Continental Breakfast and Registration
8:30 – 9:00	Opening Remarks and Introductions
9:00 – 9:30	Evaluation of Magnetic Pulse Welding (MPW) for Improved Casing Repair *Presenter: Edison Welding Institute (EWI)*
9:30 – 10:00	Predicting and Mitigating Salt Precipitation – Phase II *Presenter: Correlations Company*
10:00 – 10:30	Break
10:30 – 11:00	RGD X-Ray Technology Well Bore Inspection and Assessment-A Feasibility Study *Presenter: Gas Technology Institute*
11:00 – 11:30	Design Parameters for Full-Scale Constructed Wetland Treatment Systems for Produced Waters from Underground Gas Storage *Presenter: Clemson University*
11:30 – 12:00	Penetration Power of Ultrasonic Guided Waves for Piping and Well Casing Integrity Analysis *Presenter: The Pennsylvania State University*
12:00 – 1:00	**Lunch**
1:00 – 3:00	GSTC Strategic Planning
3:00 – 3:30	**Break**
3:30 – 4:00	Wellbore Cement Bond Integrity *Presenter: UTX Austin*
4:00 – 4:30	Enhancing OpEx Economics by Improving the Analysis & Periodicity of Gas Storage Well Testing *Presenter: West Virginia University*
4:30	**Day 1 Wrap-up**
6:00	Reception (Marriott)

May 17, 2007	
7:30 – 8:30 am	Continental Breakfast (GSTC membership)
8:30 – 9:00	Smart Gas: Using Chemicals to Improve Gas Deliverability – Phase II *Presenter: Correlations Company*
9:00 – 9:30	Water Control, Measurement, and Removal for Gas Storage Field Operations *Presenter: Colorado Engineering Experiment Station*
9:30 - 10:00	**Meeting Wrap-up**
10:00 – 2:00	Executive Council Meeting

APPENDIX B
2007 Project Executive Summaries

Public Executive Summary

Each year, more than 17,000 gas storage wells in the United States lose from 3–5% of their storage capacity and deliverability. The gas storage industry spends $80–100 million annually to revitalize existing wells with methods such as mechanically removing debris, washing, injecting acids, and creating new perforations in the well pipe. Only limited and temporary improvements have been achieved. There is a need to cost effectively increase the deliverability and hence the flexibility of the Nation's underground gas storage facilities.

It is known that water-wet porous media imbibe water in a fashion similar to water rising in a glass capillary tube. In the reservoir of a gas storage well, the imbibition force promotes the retention of water in the pore space, which curtails the deliverability of gas to the wellbore during periods of high demand. Similarly, the injection of gas during the fill cycle is restricted. In addition, the pore space occupied by irreducible water is not available to hold gas.

The overall objective of the proposed project is to develop new technology to improve gas deliverability from gas storage wells. During the first year of the original project, two cost-effective surfactants were selected from 11 candidates through screening tests prior to reservoir core tests. Reservoir cores from three gas storage facilities including sandstone and dolomite reservoirs were used to evaluate the two surfactants. The imbibition and core flood tests showed that gas deliverability and storage capacity were improved in surfactant-treated sandstone cores. However, the surfactants had a very limited effect on dolomite cores. An engineering analysis was conducted to develop an analytical method to evaluate future field tests of the new technology. It was concluded that the aquifer storage facilities are candidates for field testing. Results from the first year provided the foundation for this continuation project.

During Phase II, we propose to field test the surfactant that produced favorable laboratory results. Two operators of aquifer gas storage sites are interested in testing the wettability-altering concept. The analytical approach developed during the original project will be used to evaluate the proposed field tests. Many variables are expected to affect the field results. New smart technology based on fuzzy logic and neural networks will be used to analyze the results of the field tests and generate correlations that will optimize future commercial applications.

Although storage facility costs where gas is bought and sold remain relatively constant, the economic benefits of increasing gas deliverability by 50%, while difficult to quantify, should be considerable. Operating economics are frequently proprietary in this competitive industry making a detailed economic analysis difficult, but the improved flexibility in the form of greater deliverability could significantly increase profitability.

Laboratory results consisting of screening additional surfactants, crude oil, and crude oil plus surfactant will be compared to the two surfactants known to be effective. An additional laboratory screening technique based on contact angle observations will be examined. The use of a centrifuge technique for evaluating changes in core wettability induced by surfactants will be investigated.

Correlations Company staff has experience directing both university research programs and the application of laboratory results to commercial oilfield projects. The company has considerable experience with reporting requirements and has successfully completed several Department of Energy-funded projects.

PUBLIC EXECUTIVE SUMMARY

Evaluation of Magnetic Pulse Welding (MPW) for Improved Casing Repair

Principal Investigator: Mr. Matt Boring, P.E.
Edison Welding Institute, Inc. (EWI)
1250 Arthur E. Adams Drive, Columbus, Ohio 43221
Phone: (614) 688-5257, Fax: (614) 688-5001, Email: matt_boring@ewi.org

Background

Natural gas storage well casings occasionally require repair as the result of deterioration over time. Currently-used repair methods are costly and often create flow restrictions and subsequent operational limitations. Alternative repair methods for natural gas storage well casings are required to lower the costs of casing repairs and to reduce operational constraints. Magnetic Pulse Welding (MPW) was identified as one of the most promising candidate repair technologies identified by GSTC Project No. 3138-EWI-DOE-1779, State-of-the-Art Assessment of Alternative Casing Repair Methods.

Objective

The objective of this project is to determine the feasibility of using Magnetic Pulse Welding for improved casing repair.

Statement of Work

The statement of work is summarized as follows:

- Development of a Robust Coil System Design for Repetitive Use
- Numerical Modeling to Determine Initial Welding Parameters
- Coil Fabrication
- Welding Evaluation Trials
- Reporting

Budget and Duration

The project is estimated as a 12 month, $150,750 effort. The portion of the estimated cost that is being cost shared by PRCI and Whipstock Natural Gas is $60,750.

Anticipated Results

If Magnetic Pulse Welding is determined to be feasible for casing repair, use of this process will potentially reduce the costs of repair and reduce operational constraints following repair.

Contractor Information

Based in Columbus, Ohio, EWI is North America's leading engineering and technology organization dedicated to welding and materials joining. EWI's staff provides materials joining assistance, contract research, consulting services, and training to over 3,300 member company locations representing world-class leaders in the aerospace, automotive, defense, energy, government, heavy manufacturing, medical, and electronics industries. Cost sharing contribution is being provided by Pipeline Research Council International Inc. (PRCI).

PUBLIC EXECUTIVE SUMMARY

RGD X-ray Technology Well Bore Inspection and Assessment - A Feasibility Study

Research Focus Area: Mechanical

Scaling, Corrosion, Precipitates, and Casing defects are all issues storage operators face on a continual basis in managing the integrity of their gas storage assets. These issues often lead to diminished deliverability (5 to 20%), as well as casing integrity issues requiring costly remediation. The mineral scale formation and material defect assessment process in well bores is complicated, time consuming, and costly due to the range of storage conditions and existing technologies.

GTI proposes to study, develop, and demonstrate a real-time RGD tool for in-situ compositional identification and quantification of scale in gas storage wells and pipelines. The RGD tool will also assess and quantify material defects, pitting, and penetrations in casings and associated piping. The system consists of a RGX Source tube to produce and scan the object with X-rays with single exposure (with minimum dosage). An array of crystal detectors simultaneously acquires RGX-ray images from several different positions. The separate images are combined to produce individual "slices" through the object. By shifting the images with respect to one another, different planes within the object volume come into focus. This technology determines the gray value of every point in the three-dimensional space of an object that makes it possible to reconstruct any layer.

The gas storage industry will benefit from this innovative technology as it can provide real time data and analysis on both scale formation inside the well bore as well as assess the well bore casing integrity itself. The proposed technology can provide this information in a single scan, creating an ideal application of for determining pre and post remedial treatment effectiveness. The assessment process will be significantly streamlined, eliminating the delay for lab analysis and reducing rig time considerably. Cost savings will be in the tens of thousands on an annual basis for a typical integrity management program. The project goals include improved well bore integrity assessment, flow deliverability, and reduced O&M costs.

The following table summarizes the team members involved in the proposed project.

Table 1 – Team Member Roles and Qualifications for the Proposed Project

Team Member	Role	Qualification
Gas Technology Institute	Project Manager/Lab Analysis	• The leading natural gas R&D organization • 60 years of developed technology-based solutions for consumers, industry, and government
CMOSXRAY	X-Ray tool manufacturer	• 10+ years of portable X-ray tool manufacturing experience • Equipped with large test facilities, safety and field experience

Public Executive Summary

PENETRATION POWER OF ULTRASONIC GUIDED WAVES FOR PIPING AND WELL CASING INTEGRITY ANALYSIS

Cliff J. Lissenden and Joseph L. Rose
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Storage of natural gas in underground facilities requires tubing for extraction, steel casings to protect the tubing, and steel piping to transfer the natural gas from the well to the transmission and distribution pipeline networks. Each of these resides in an environment that causes degradation of the steel. Corrosion, erosion, and cracking can compromise the structural integrity of the steel cylinders (tubing, casing, piping, and pipelines; henceforth referred to simply as piping). To ensure the safety of the public and the environment it is necessary to monitor the integrity of these mechanical systems. The limited accessibility to much of this piping often makes this a time intensive operation, and therefore expensive. Currently, piping integrity is assessed by magnetic flux leakage and eddy current techniques that require point by point scanning of the piping, which again is time consuming.

Guided wave ultrasonics is an emerging inspection/monitoring technique that enables large sections of pipe (or other structures that are suitable waveguides) to be interrogated from a single point by propagating long wavelength ultrasonic energy along the pipe. This technology is now used to inspect gas pipelines, especially unpiggable sections under highway crossings where point by point methods are not possible. Guided waves have many other nondestructive testing applications, such as for boiler tubes, aircraft skin, helicopter transmission beams and rotors, and for quality control in intelligent manufacturing processes. Guided wave ultrasonics is an active method that relies on specially designed transducers. Piezoelectric sensors are commonly used to transmit and receive energy. The effectiveness of guided waves for inspection depends on many things (e.g., excitability, dispersivity, attenuation, sensitivity), as will be discussed in the project description. Great advances have recently been made in tuning and focusing to improve sensitivity to defects. The work proposed herein will concentrate on the penetration power of guided waves, i.e., the length of piping that can be inspected from one location. To achieve long range inspection capabilities the excitation energy needs to be increased. In this project, mechanical impact, which is used in some applications such as concrete water pipes, and the novel use of a sonic horn will be investigated. A sonic horn is a device that produces high pressure acoustic energy. This energy has a variety of different applications ranging from welding plastics to breaking up clumps in powders, to sonication of well casings. **The objective of the project is to dramatically improve the penetration power of guided waves in piping for the long range detection of defects like cracks and wall thinning from corrosion. The impact of the project will be to improve the safety of gas storage systems and reduce maintenance costs.**