

Title

“Gas Storage: Case Studies and New Potential” by PTTC’s Appalachian Region on May 29, 2002 in Morgantown, West Virginia.

Bottom Line

Several DOE-funded projects directly address the deliverability issue in gas storage operations. Different approaches include CO₂ remediation of organic damage, sonication and other innovative approaches for inorganic damage, a systems approach whose effectiveness is supported by case studies, and, at least for one operator, a horizontal lateral. Improved electronic data management and geological/operations modeling are enabling storage operators to improve their operations.

Problem Addressed

Deliverability enhancement is and always will be a key issue in conventional storage reservoirs. In recent years, DOE and others have funded work to better understand damage mechanisms and develop new approaches for enhancing deliverability. To help storage operators understand recent developments, this workshop presents results from recent R&D projects, many of which are supported with field test data.

Key Words:

Deliverability Improvement
Gas Storage Operations
Reservoir Damage Removal

U.S. Gas Storage Industry

Data from DOE’s Energy Information Administration (EIA) show that there are 415 underground natural gas storage sites in the United States with combined deliverability of 78 Bcf per day and working gas capacity of 3,923 Bcf. Historically, natural gas storage has been for winter heating demand, but with natural gas emerging as the fuel of choice for power generation, demand will be less seasonal. A 1999 study by the National Petroleum Council predicts that by 2015, 0.8 Tcf of new working gas storage capacity will be required. This means that deliverability enhancement, the primary focus of this workshop, will remain a key issue. Results from several DOE-funded projects addressing different aspects of the deliverability problem are highlighted in the following. There is also a practical discussion of data management and the process of converting from hardcopy to electronic.

Since 1993, the storage industry has relied heavily upon weekly gas storage data compiled by the American Gas Association (AGA). This data was developed voluntarily by surveying operators. Late in 2001, AGA announced they would stop their weekly survey. Under direction from the Secretary of Energy, EIA has picked up this responsibility, publishing the first weekly results in May 2002. Weekly information is available on EIA’s website (www.eia.doe.gov)

CO₂ Remediation of Organic Damage. Early work by DOE and the Gas Research Institute (GRI) identified eight damage mechanisms within gas storage wells (SPE #38863). Of these, damage from hydrocarbons, organic residues and production chemicals was one of the major mechanisms. Earlier work by DOE/GRI demonstrated that liquid CO₂ hydraulic fracturing could be effective (SPE 51066 and 56728), but cost and reliability concerns limit application. In a current DOE project, Advanced Resources International is exploring a less expensive, non-fracturing, non-propped CO₂-based treatment. Two field test sites, one with Kinder Morgan in Nebraska and a second with Consumers Energy in Michigan, have been selected. In the two sites, different causes for damage were identified. In the Nebraska site, damage resulted from crude oil, valve grease and minor amounts of compressor oil. In the Michigan site, damage resulted from asphaltene and emulsions. Lab work has identified promising approaches for damage removal and field treatments are being planned.

Remediation of Inorganic Damage. DOE is also funding work addressing damage from inorganic precipitates, including a project in Summit Field in Pennsylvania exploring some innovative technologies. Partners, along with DOE, include Holditch Reservoir Technologies, National Fuel Gas and Penn State University.

In another project, lab work and early field testing in an Illinois well with Nicor Gas show that a sonication tool is looking promising for removing inorganic damage (http://www.fe.doe.gov/techline/tl_sonictool.shtml). A second field test has been scheduled for August 2002 with Nicor Gas, and discussions with several other operators for tests are underway. The prototype was developed through a cooperative agreement between Furness-Newburge, Nicor Technologies and TechSavants Inc., both of Naperville, IL, and Baker Atlas, Houston, TX. Composed of an oscilloscope, a power supply, a wire-line reel for the power cable, an acoustical transducer, a portable generator and waterproof connections, the device is about two feet in length, two inches in diameter, and weighs about 10 pounds. The acoustic portion of the tool is expected to sell for less than \$15,000 and is compatible with standard wire-line equipment. The tool is lowered into a well where it emits relatively low-frequency, high-intensity directed sound waves. After a relatively short time, the sound waves force scale to fall off.

Water analyses conducted during the field tests demonstrated the device's effectiveness in removing key constituents found in storage well deposits. Water samples collected after the sonication tool was used were compared with samples taken two months earlier. The water chemistry indicated a significant increase in mineral salts as well as increased levels of suspended matter—signs that the sonic cleaning device was doing its job. The amount of calcium, magnesium, iron, and bicarbonate in solution increased by 100 percent, 60 percent, 60 percent, and 5,300 percent, respectively, after sonication. The amount of suspended solids also increased by 230 percent after sonication.

Deliverability Enhancement—Six Case Studies. Halliburton Energy Services has developed a solution-driven process to help operators enhance deliverability in storage operations. The process integrates geologic and petrophysical modeling with reservoir engineering practices, enabling operators to make informed economic decisions. Damage diagnostic analysis, remediation candidate well ranking, and reservoir performance modeling can help identify areas that would benefit most from deliverability enhancement efforts. A fully coupled reservoir simulator can be used to integrate the well/reservoir system with surface and distribution systems to ensure increased production can be effectively transferred through the system. Data from six case studies, which represent a spectrum of reservoir types and damage mechanisms, were presented to demonstrate utility of the solutions approach.

Horizontal Laterals for Deliverability Improvement. In the Donegal gas storage field in Pennsylvania, Columbia Gas Transmission (Columbia) has been employing various recompletion and stimulation efforts since 1993. These included increasing perforating shot density, high sand concentration fracs, Tip Screen-Out Fracs, and Extreme Over-Balanced Technology—but needed improvements in skin factor and deliverability were not achieved. Columbia did achieve success using underbalanced coiled-tubing drilling techniques when drilling a horizontal lateral (about 450 ft horizontal exposure in the formation). Initial testing indicates that the horizontal lateral increased well deliverability by more than 8000% (SPE 72373).

Managing Gas Storage Related Well Data. Electronic well databases and geological software allow storage operators to effectively manage the dynamic data associated with storage operations. While profitable, this requires a commitment to converting hardcopy to electronic data. If manpower is an issue, retaining an experienced consultant can help with the conversion. Note—even when electronic, one should keep all paper and initial well records on file. Once the system has been developed, there should be a designated individual(s) responsible for data entry and QA/QC, security and updates. Database templates within Microsoft Access facilitate building the electronic databases. Data export capabilities to geologic packages are essential.

Brine Disposal for Salt Cavern Storage. Brine disposal is the most significant barrier to developing salt cavern storage in the Northeast. The New York State Museum is embarking upon a study to assess, using a regional geology approach, geologic formations for their “ability to accept brines,” along with potential salt bodies that could be developed into cavern storage. Researchers will develop a fully integrated formation characterization using state-of-the-art geologic reservoir evaluation techniques. This systems study will provide DOE, regulatory agencies and industry with a blueprint for further study of salt cavern storage in the Northeast.

Speakers

Katharine Lee Avary (*EIA Gas Storage Data*), West Virginia Geological and Economic Survey
Brad Tomer (*DOE's Natural Gas Storage R&D Program*), DOE National Energy Technology Laboratory
Jim Ammer (*Wellbore Remediation Using Sonication*), DOE National Energy Technology Laboratory
Larry Pekot (*CO₂ Remediation of Organic Damage*), Advanced Resources International
Ken Brown (*Status of Gas Storage Projects Funded by DOE, GTI and NYSERDA*), Schlumberger Holditch Reservoir Technologies
Kerima Haddad (*Underbalanced Coiled Tubing Drilling in Thin Gas Storage Reservoir*), Columbia Gas Transmission
Ronald Walden (*Managing Gas Storage Related Well Data Using Well Databases and Geological Software*), Dominion Transmission, Inc.
Taury Smith (*Salt Cavern Storage in the Northeast: Challenges & Opportunities*), Natural Gas Research Group, New York State Museum
John Guoynes (*Successful Deliverability Enhancement Projects in Gas Storage—Six Case Studies*), Halliburton Energy Services

Connections

Katharine Lee Avary
West Virginia Geological & Economic Survey
P.O. Box 879
Morgantown, WV 26507-0879
Phone: 304-594-2331 *Fax:* 304-594-2575 *e-mail:* avary@geosrv.wvnet.edu

DOE's National Energy Technology Laboratory
P.O. Box 880
Morgantown, WV 26507-0880
Brad Tomer *Phone:* 304-285-4693 *e-mail:* brad.tomer@netl.doe.gov
Jim Ammer *Phone:* 304-285-4383 *e-mail:* james.ammer@netl.doe.gov

Larry Pekot
Advanced Resources International
1110 North Glebe Rd, Suite 600
Arlington, VA 22201
Phone: 703-528-8420 *Fax:* 703-528-0439 *e-mail:* lpekot@adv-res.com

Ken Brown
Schlumberger Holditch Reservoir Technologies
1310 Commerce Dr, Park Ridge One
Pittsburgh, PA 15275-1011
Phone: 412-787-5403 *Fax:* 412-787-2906 *e-mail:* brown@pittsburgh.oilfield.slb.com

Kerima Haddad
Columbia Gas Transmission Corp.
P.O. Box 1273
Charleston, WV 25325
Phone: 304-357-3727 *e-mail:* khaddad@nisource.com

Ronald Walden
Dominion Transmission
445 West Main Street
Clarksburg, WV 26301
Phone: 304-627-3374 *Fax:* 304-627-3390 *e-mail:* Ronald_L_Walden@dom.com

Taury Smith

New York State Museum
3140 Cultural Education Center
Albany, NY 12230
Phone: 518-473-6262

Fax: 518-486-2034

e-mail: lsmith@mail.nysed.gov

John Guoynes
Halliburton Energy Services
P.O. Box 519
Kalkaska, MI 49646
Phone: 231-258-7022

Fax: 231-258-8018

e-mail: john.guoyes@halliburton.com