AGA Horizontal Well Workshop
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BACKGROUND

Columbia Gas Transmission, a subsidiary of the Columbia Energy Group, operates one of the nation's largest underground natural gas storage systems, injecting natural gas into underground storage wells during warm months for withdrawal during the winter. Columbia owns and operates 44 gas storage fields in four states (New York, Ohio, Pennsylvania and West Virginia), where 3,700 wells inject gas during periods of light demand and withdraw it when demand outstrips transported supply. At a gas inventory of about 600 Bcf, Columbia Gas Transmission's storage system is presently the fourth largest in the country and eighth largest in the world.

The 44 storage fields range in size from very small (1 well) to very large (over 400 wells). These fields are all depleted dry gas reservoirs dating in age from 1936 to 1977. About two-thirds of the wells and one-half of the performance are in Ohio. As of November, 1998 the fields were capable of storing and withdrawing 235 Bcf of working gas at a design rate, based on the point when 70% of the working gas has been withdrawn, of 4.3 Bcf/d.

BUSINESS DRIVERS

As with other storage operators, Columbia observed a decline in performance of its storage wells over time. With FERC Order Number 636 implementation, November 1, 1993, fast approaching Columbia made a decision to return and maintain the storage performance at designed levels. Horizontal well drilling was an emerging technology that looked promising for storage operations. Columbia expected a horizontal performance increase of 2 to 5 times that of a vertical well with an associated cost increase of 2 to 3 times vertical. In 1997, Columbia embarked on a three-year expansion project representing a 7 percent increase in system capacity. The expansion included constructing new pipelines, adding compression, enhancing wells and drilling new wells, including horizontal wells, in the company's storage fields. When the Market Expansion project is complete on November 1, 1999, the working gas capacity will be approximately 238 Bcf with a designed peak delivery of 4.4 Bcf/d.

HORIZONTAL ADVANTAGES

Horizontal drilling brings the opportunity for both surface and sub-surface advantages over vertical wells. Surface advantages to horizontal wells in storage operations are expected to include the following:

- Avoiding hostile landowners by drilling from surrounding properties, assuming all sub-surface rights are in place
- Reaching beneath surface obstructions

- Reducing the environmental footprint by drilling a new well from an existing site
- Constructing the well site close to an existing pipeline thus reducing surface pipe costs

In addition sub-surface, or reservoir, considerations are also important.

- Additional reservoir area is exposed which should result in performance gains of 2-5 times the performance of a vertical well
- Compartmentalized reservoirs can be connected
- Natural fractures can be intersected.

HORIZONTAL CHALLENGES

Challenges to horizontal drilling include:

- Increased drilling time and associated costs (50% of the time is spent tripping)
- Bit life - weight on bit (longer life; less trip time; lower cost)
- The inherent risks of achieving the estimated performance at the estimated cost.
- Fluid loss is also a concern and underbalanced drilling may be a solution.

COLUMBIA'S DECISION

In 1993 Columbia drilled its first horizontal well in the Coco storage facility in Kanawha County, West Virginia. The wells in this field provide an average of 6 MMcf/d deliverability from a pay zone 8-15 feet thick with 10-40 md permeability and 6%-10% porosity. Columbia's storage engineers used the Joshi Technologies International, Inc. software as the forecasting model. The engineers found this model to work well if the input data was accurate (as with any modeling software). The key input values needed to predict the flow rate versus horizontal well length include the reservoir pressure/flowing pressure combinations, the drainage area, the formation thickness, the horizontal and vertical permeabilities and the wellbore diameter.

EXPERIENCES

Columbia's experience includes 6 horizontal or near horizontal wells with 2 more planned for 1999. All of these wells are openhole completions located in the Oriskany sandstone in West Virginia and Pennsylvania; a very abrasive and hard quartzite sand. Columbia's first horizontal well resulted in a 4 to 5 fold improvement, but took about 3 years to clean up. In 1994, Columbia drilled 1 well, but eventually plugged it due to drilling and reservoir fluid complications. In 1998 Columbia drilled 4 wells as part of its Market Expansion project. The results of these drills were 300 feet to 1000 feet horizontal lengths drilled at only 50 feet to 75 feet per bit. The extreme abrasion of the Oriskany sand took its toll on the bits. The bit life was 12 to 15 hours per bit with another 12 to 14 hours of trip time per bit, so rig costs escalated rapidly. The bit life has increased with successive new drills and underbalanced technology has helped on at

least one location. The wells were drilled to true vertical depths of 5,200 to 6,000 feet with corresponding 6,800 to 8,200 feet measured depths.

LESSONS LEARNED

- Horizontal wells in storage operations can be successful if properly managed on both cost and estimated performance issues. This management takes a concerted team effort among all functional disciplines involved.
- Since horizontal wells are more risky ventures than vertical wells, the Corporate risk profile must be understood so the "what's acceptable" can be communicated.
- A probabilistic range of performance and costs should be developed up front and communicate to all involved with the project.
- The offset permeabilities and geology are critical. If possible, a pilot hole should be drilled and plugged back in order to confirm predictions. If the formation is naturally fractured, use of a formation-imaging log is beneficial.
- The site selection should be heavily weighted towards the horizontal well design, and less so to the location of existing surface pipe. Costs of laying pipe at the surface will likely be the costs of extending the near horizontal section of the wellbore.
- A capable rig and crew are essential, otherwise the rig costs will escalate quickly.
- Gas/water contacts should be avoided, or risk of losing the well is a real possibility
- Clean up will take multiple seasons, so be patient waiting on the well to perform as predicted.