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Three-Dimensional Pillar-to-Diameter Calculations for Caverns at each of the Four U. S. Strategic Petroleum Reserve Sites

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Abstract

A pillar-to-diameter ratio (P/D) is a measure used to establish a limit for the spacing between phase-3 salt caverns used by the U.S. Strategic Petroleum Reserve. "Pillar" refers to the minimum thickness of the web of salt remaining between any two adjacent caverns. "Diameter" refers to the average cavern diameter. The P/D ratio will decrease as either the distance to a neighboring cavern decreases or the diameter of a cavern increases. This ratio is used as a measurement to monitor cavern structural integrity. The Department of Energy (DOE) has mandated that the P/D ratio of each cavern, developed since 1983, at the Strategic Petroleum Reserve must be greater than 1.78 after five complete oil draw down cycles.

In the past, the P/D ratio has been calculated as a single value for an entire cavern. Sandia National Laboratories has extended this concept into three dimensions so that specific regions of a cavern, where integrity may be at increased, risk can be identified and monitored. Such information will be valuable for deciding from which of the available caverns oil should be withdrawn, and in identifying caverns that should be treated with caution.

A computer program was developed that calculates a P/D ratio for each node or point that defines the 3-D surface of a cavern. At each point, the P/D ratio is equal to the minimum distance from that point to neighboring caverns divided by the average diameter of the cavern at the depth of the point. Output from the program may be visualized, using the Mining Visualization System software, over an entire cavern based on the distance to neighboring caverns and cavern diameter at any one depth location.

The results will help identify areas of concern that should be considered during future drawdowns at the Strategic Petroleum Reserve. This paper discusses the computational tool developed to calculate three-dimensional P/D ratios and presents the results for all caverns at each of the four Strategic Petroleum Reserve sites as visualizations.

Key Words: Cavern Design, Cavern Development, Caverns for Liquid Storage, Computer Modeling, DOE, Strategic Petroleum Reserve, Storage Cavern