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NOVEL MONITORING TECHNOLOGIES FOR GAS STORAGE CAVERN MONITORING

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Abstract

Mechanical integrity testing (MIT) of caverns can be a costly and time consuming process. With current best practices, these valuable assets are sometimes taken out of service for many months. Operators are impacted with a significant loss of revenue yet the MIT only provides a single snapshot of the cavern's condition which may not be revisited for years. MIT's may also affect a cavern's integrity through unwanted erosion.

There are a number of monitoring techniques that are gaining acceptance in the oil & gas, geothermal and carbon sequestration markets which may offer cost effective and near real-time alternatives for monitoring gas storage cavern integrity. This paper will discuss the feasibility of using various techniques such as high frequency pressure and temperature monitoring, micro-deformation monitoring, microseismic monitoring and fiber optic sensing for storage cavern integrity analysis.

High frequency pressure transient monitoring involves the use of a high sensitivity electronic pressure gauges with analysis of pressure fluctuations over very short time periods. This permits leak identification during injection or withdrawal periods with minimal impact on operations. Data derived from this method can also be used for salt creep-closure rate analysis and inventory control.

Micro-Deformation monitoring involves the use of Interferometric Synthetic Aperture Radar (InSAR), Tiltmeters and Differential Global Positioning Systems (DGPS) to look for sometimes sub-millimeter deformations in the surface above a cavern which might indicate a leak or fracture developing. The micro-deformation technique can also be used to monitor slope stability and other natural geologic movement which might cause problems with surface hardware and wellbore integrity. Applied in the cavern itself, micro-deformation data may have the capacity to much better define the salt creep process which can then in turn refine other monitoring techniques. This technique has been successfully used to identify hydraulic fracture development as deep as 4500m with tiltmeters and InSAR is proving to be a very cost effective gross surveillance tool. Once surface movement is detected, data is inverted through a geomechanical model to identify what subsurface mechanisms are causing the surface disturbance.

Microseismic monitoring uses an array of sensitive geophones which are listening for micro-earthquakes which may indicate the presence of fracturing or faulting. The technique may also be able to identify out of zone pressure movement which would indicate a leakage path. Microseismic monitoring uses the same hardware that would be mobilized for a vertical seismic profile.

Fiber optic sensing has come a long way in the last 5 years. In addition to distributed temperature sensing which is used to identify injection/production rates and volumes, a whole host of new sensing techniques are coming on the market including pressure, acoustic and strain monitoring. All of these should have application to gas storage projects. Distributed readings provide a much better image of the dynamics downhole.

The various monitoring methods will be described, deployment hurdles identified and examples cited where they are being successfully utilized by various industries today. The author will also cite how these monitoring technologies may be specifically applied to cavern monitoring.

Key words: Cavern Gas Storage monitoring, Downhole Instrumentation, Downhole Gauges, Mechanical Integrity, Real Time Pressure Temperature Data, Real Time Monitoring, Interferomeric Synthetic Aperture Radar (InSAR), Tiltmeter, Microseismic, Fracture Detection, Fracture Mapping, Micro-Deformation