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RESEARCH REPORT 2013-01

Analysis of Moss Bluff Cavern #1 Blowout Data

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1. EXECUTIVE SUMMARY

In August 2004, Moss Bluff natural gas storage Cavern #1 (MB #1) experienced a major gas release and fire. The incident initiated when debrining the cavern; gas entered the brine string and caused the pipe to burst on surface. An ensuing fire resulted in the separation of the wellhead assembly and an uncontrolled loss of gas from the 20-inch production casing. The cavern fully depressurized when the fire self-extinguished approximately 6.5 days after all the gas was burnt. Cavern rewatering began less than 1 month later, and the cavern was back in gas storage operation less than 1 year after the blowout incident. The calculated pressure history at the casing seat, determined by Rittenhour and Heath (2012), immediately before and after the event is shown in Figure 1.

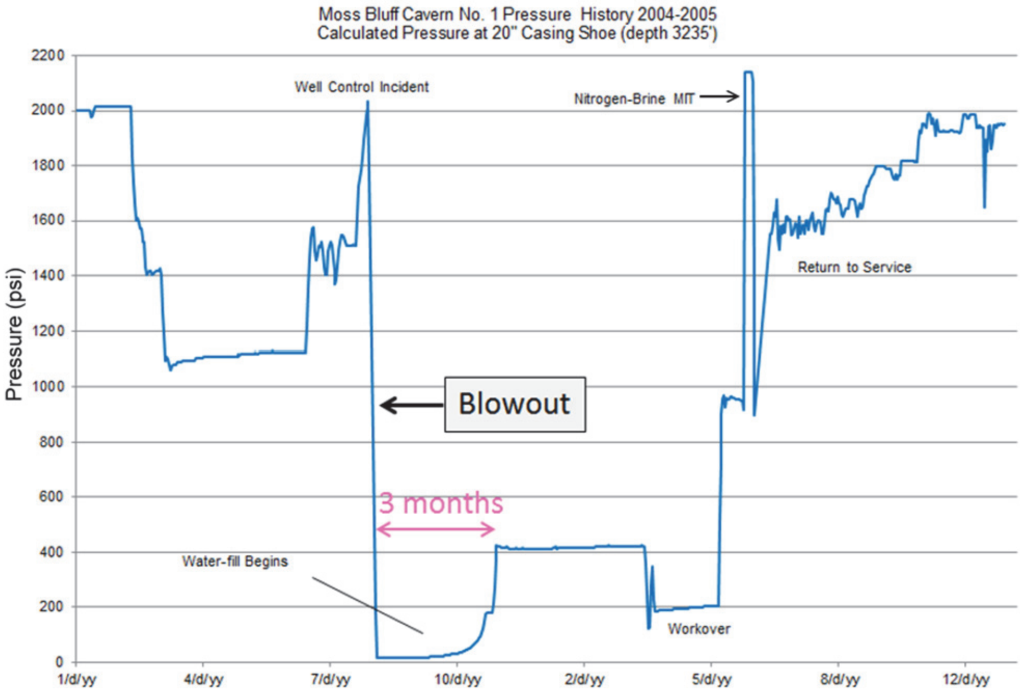

Figure 1. Pressure history before and after the blowout (After Rittenhour and Heath, 2012).

Spectra Energy Transmission (Spectra) made data available to SMRI, who decided to solicit proposals for studies addressing the following:

1. Use the available preincident data to evaluate the pressure and temperature evolutions during depressurization and fit them with available incident data; calculate/describe the depressurization scenario and provide the applied theoretical background
2. Input the obtained pressure and temperature evolutions in thermomechanical computations to evaluate the geomechanical consequences in MB #1 and confirm the results with available postincident data
3. Conclude on the reliability and performance of the industry's available tools and models to predict the consequences of such a gas depressurization scenario.

This report documents the work effort and findings of the SMRI-funded research.

1.2 Project Overview

Numerical simulations using the finite element method were used to predict the depressurization scenario and geomechanical consequences of the MB #1 blowout event. Because the calculated results are likely to differ depending on software limitations, results were obtained from two different software packages. Brouard Consulting was responsible for numerical simulations using the software program LOCAS (Brouard et al., 2006a) and RESPEC was responsible for numerical simulations using the software package consisting of SCTS (Nieland, 2004), SPECTROM-41 (Svalstad, 1989), and SPECTROM-32 (Callahan et al., 1989), which are collectively referred to as SPECTROM in this report.

LOCAS is a fully coupled two-dimensional (2D) thermo-hydro-mechanical finite element program. The fully coupled functionality of the program is conducive to the solution of the blowout simulation in a single analysis. In other words, LOCAS includes modules that simultaneously predict the thermal, thermodynamic, and geomechanical history of the cavern. In addition to modeling the cavern, LOCAS includes the capability to fully model the well and mechanical behavior of the cementation, a final component of this study.

SPECTROM-32 is a finite element program developed specifically for analyzing 2D and axisymmetric thermomechanical stress analysis problems encountered in investigations involving salt and a variety of other geomechanical problems. Transient temperature fields computed by SPECTROM-41 are read as input by SPECTROM-32. SPECTROM-41 is a finite element heat transfer program developed specifically for analyzing underground problems. SPECTROM-41 does not simulate the thermodynamic history of gas movement. Therefore, temperature histories of the gas in the cavern and well, determined by SCTS, are used as input to SPECTROM-41.

A flowchart of the project is shown in Figure 2. Comparisons of the predicted results, determined from the two software packages with available pre- and postincident measurements, were made. Measured data available for comparison include blowout duration, postincident temperature, and postincident sonar surveys. Predicted data compared primarily focused on the temperature of the gas in the cavern both during the blowout and while the cavern was at atmospheric pressure, temperature of the salt surrounding the cavern, cavern closure, locations and depths of tensile stresses, and the locations and depths of dilating salt. Other predictions presented include displacement trajectories, principal stresses and orientations, the effect of water content in the gas during the blowout, and stresses in the cemented well. Because field data of the thermo-hydro-mechanical response of the cavern during the blowout are extremely limited, a major component of this study was to compare the predictions of the two different software packages. A comparison of the results obtained from two different researchers provides confidence in the results, if they are similar and in agreement with measured observations. If the results are substantially different, the need for further software development can be identified.