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**Research
Report
2017-2**



**SMRI Research Report RR2017-2:
Past Salt Caverns Incidents Database
Part 1: Leakage, Overfilling and Blow-out**

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Solution Mining Research Institute Project Sponsor's Statement

SMRI Research Report RR2017-2: Past Salt Caverns Incidents Database Part 1: Leakage, Overfilling and Blow-out

Various products are stored in underground salt cavities, and such underground storage has proven to be very safe when compared to surface storage. Nevertheless, a few incidents have happened, and the SMRI membership sponsored developing a database of these past incidents and their causes. The database provides our industry an additional tool to efficiently analyze and learn from past incidents to avoid repeating in the future. The database provides basic (publically available) information on each incident, but more importantly, highlights the geological and/or technical origin of the problem. Such highlights immediately focus on the lessons learned and the practical steps our industry has taken to avoid similar incidents.

Phase I of this project addresses below-ground incidents/failures exclusively (including well-head) for storage in salt caverns, and intentionally focuses on just three "operational" domains: (1) leakage, (2) overfilling, and (3) blow-out.

An international and multi-disciplinary team went on massive data processing effort to end up with 21 incidents or case studies. The present report is the culmination of their work. Each case is presented, described, explained, and analyzed with enough details to illustrate root causes and/or indications that can benefit the salt cavern community. The report benefits anyone tasked to scrutinize an underground storage, either existing or proposed, from safety point of view.

When reading this report, I (as the SMRI's project sponsor) suggest to the reader that they read only 1 or 2 cases per day to avoid being overwhelmed in technical details and fully benefit from the past experience. Rapid reading of accident case after accident case might cause the reader to get the impression that salt cavern storage is dangerous. I want to stress here that products are stored deep underground in salt because those products are inherently dangerous, either because of their chemical composition or their energetic content. Nevertheless, cavern storage is safe, especially when compared to alternatives. I personally thank the authors for their diligent work and feel strongly that the report will help the industry be even safer.

Yvan Charnavel, Storengy, SMRI Project Sponsor

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FOREWORD

The RFP 2015-1 “Development of a Database of Past Salt Cavern Incidents” seeks to extend SMRI efforts to mitigate risks by compiling a database that will provide industry with a resource of “Lessons Learned”. Phase 1 of these efforts exclusively addresses below-ground incidents/failures in storage salt caverns and intentionally focuses on three specific categories: (1) leakage; (2) overfilling; and (3) blowout. These terms are defined in the Appendix 1.

This Phase 1 report includes the following:

- (1) a note on incidents and casualties in the oil and gas production/supply chain and petrochemical industry, aimed at putting the risks of the salt-cavern industry in perspective with other industries and alternative storage options (David Evans);
- (2) a brief description of each incident involving salt-storage caverns since 1960. This information is used to produce a searchable database of past incidents accompanying the present report (Arnaud Réveillère);
- (3) for each case, a short description of the incident (all members of the Research Group);
- (4) a summary of the information process to the operators concerned with the incidents (Arnaud Réveillère).
- (5) a note on the physics of leakage, blowout and overfilling in salt caverns in Appendix 1 (Pierre Bérest and Arnaud Réveillère), and
- (6) A list of all historical events that were reviewed but not included in the present report due to lack of technical information or because they were out of the scope in Appendix 2 (Arnaud Réveillère)

In addition, during the course of this research project, several cases were found that do not fit the above definition for Phase 1 work (not an “incident”; not much information; not “leakage, overfilling or blowout”). However, it was considered that these cases might be useful for future phases of the SMRI research programme. They are, therefore, gathered in the Appendix 2 which, by nature, cannot claim to be exhaustive or fully consistent. This Appendix 2 also includes nine cases for which a public document reports a leakage, an overfilling or a blow-out from a storage cavern. But currently available information has been judged too scarce and/or not technical enough to provide a satisfying technical understanding. It is thought that more information may be available and that a better understanding can be achieved in the future.

In undertaking this work, previous papers (e.g. NTSB, 2003; Bérest & Brouard, 2003; Evans, 2008a&b, 2009) provide the initial starting point and database, which has been augmented by the Proceedings of the SMRI Meetings and Technical Classes. In addition, various publicly available reports by the Texas Railroad Commission, Federal Energy Regulatory Commission (FERC), Alberta Energy and Utilities Board (EUB), other regulatory bodies, Court findings or press releases have been accessed for additional information. If found online, then where ever possible, the web address is provided.

Within this work, a definition of “incident” was needed. As in any industrial activity, problems during cavern creation and operation cannot be entirely avoided. An extensive list of all the problems encountered (and solved) in the industry would be thousands of pages long. Whilst, it would be extremely valuable, it is unattainable. The more than 2000 papers published in the Proceedings of the SMRI Meetings and Technical Classes provide much of the desired published information. In this report, an “incident” is an unexpected event leading to casualties, evacuation, environmental damage, large product losses or, generally speaking, an event that draws the attention of the general public. This definition may not be perfect but, in most cases, it allows a clear distinction between “incidents” and “non-incidents”.

It is stressed that only reference to publicly available information has been made and the list does not (and cannot) claim to be either exhaustive or definitive.

The searchable database contains 21 incidents related to leakage (16), overfilling (1) and blowout (4). Among these incidents, 6 can be considered as “severe”, as they led to casualties and/or permanent evacuation: West Hackberry (1978), Hutchinson (2001), Mont Belvieu (1980), Conway (1956-2000), Brenham (1992) and Grand Bayou (2003). Other incidents (blowouts) led to the loss of the full inventory of a cavern with significant loss of economic value and environmental detriments: Moss Bluff (2004) and Prud’homme (2014).

It is noteworthy that most of these “severe” incidents occurred during the 20th Century. There are thought to be several reasons for this. Many advances have been made by the oil & gas industry — more specifically, by the cavern industry — with regard to equipment, logging, cementing, rock-mechanical testing and cavern design, tightness tests, monitoring and safety analysis. Lessons also were culled from past incidents. The joint efforts of the regulatory bodies and the industry to improve practices after the Brenham (1992) and Hutchinson (2001) incidents led to more precise regulations in Texas and Kansas, reported in the description of the cases within this report. Similar efforts also were made in Canada and Europe.