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RESEARCH PROJECT REPORT
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SMRI-Research and Development Project

SMRI Reference for

External Well Mechanical Integrity Testing / Performance, Data Evaluation and Assessment

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0 Summary

An important prerequisite for assuring the secure and reliable operation of storage caverns is the verification of External Well Mechanical Integrity (EWMIT - tightness of cased and cemented borehole, particularly in the area of the final casing seat against the host rock, including water bearing formations). This provides the proof that leakage will not result in the contamination of usable drinking water sources, e.g. aquifers; or the uncontrolled escape of flammable storage products to the surface.

Interface tests have developed worldwide into the standard method of verification; this involves injecting a limited volume of a test medium which is lighter than the fluid in the cavern at the time of the test. By evaluating various parameters such as head pressure and interface depth, it is possible to draw conclusions as to well tightness.

The Solution Mining Research Institute (SMRI) commissioned this report in response to an unsatisfactory situation where the performance and, in particular, the data evaluation and assessment of External Well Mechanical Integrity Tests, currently involves various and widely differing approaches.

The initial objective was to develop a standard for EWMITs on storage caverns based on a firm scientific basis which would satisfy legal requirements in the US and also be acceptable to the non-US SMRI membership.

After presentation of proposals for future standards to the SMRI membership it became apparent that the companies in question did not think a rigid *standard* formulated by the SMRI would be worthwhile , because a) such a standard would only poorly reflect the diverse requirements of the various countries and b) a certain degree of flexibility is considered necessary when discussing the results of such tests with the pertinent authorities / agencies.

Detailed discussions finally resulted in the modification of the task to the formulation of an SMRI REFERENCE FOR EWMIT PERFORMANCE, DATA EVALUATION AND ASSESSMENT. This reference allows first assessment of in-house procedures compared with international and national practice. It does, however, remain the responsibility of the testing company or the operator to adapt previous procedures if necessary. At the same time, this approach simplifies the job of storage cavern operators when comparing EWMITs offered by various service providers and during discussion of results with authorities/agencies.

The basis for the formulation of the SMRI Reference is provided by a comprehensive collation and evaluation of current engineering practice with respect to EWMITs. The main results are:

- Three basic test methods are used worldwide:

  (1) In-Situ Balance Method (determination of volume or mass of the test medium confined in the well as a function of time using interface level and pressure measurements),

(2) In-Situ Compensation Method (adjusting a defined interface depth; any subsequent rise of interface level due to leakage is compensated by injection of test medium),

(3) Above Ground Balance method (test medium is injected into the well and withdrawn after a test period; the difference in volume determined at surface is a measure of tightness)

- Interface tests are primarily performed prior to commissioning of the storage and, in the case of liquid storage caverns, often during operations, as well.
- While the interface test is stipulated in most of the North American states, there are no uniform standards in Europe.
- Almost without exception, a well has mechanical integrity if the test result is less than the Minimum Detectable Leak Rate (MDLR); the values specified for the MDLR have a wide range. In some cases no value is specified, and the evaluation is limited to monitoring head pressure.

The proposal for the SMRI Reference for EWMIT performance, data, and assessment is focused on fulfilling certain requirements during performance (time, test period, variables evaluated) and, in particular, assessment.

It is necessary here to differentiate between the Minimum Detectable Leak Rate (MDLR) and the Maximum Admissible Leak Rate (MALR): The MDLR is the well specific accuracy of the individual test, the MALR the well independent assessment criteria.

It is shown that no scientific based value for an MALR can be formulated because this would require the performance of extensive and expensive reservoir simulations for each leak scenario.

As an alternative, an *engineering* approach to an MALR is proposed based on the following criteria:

- current engineering practice
- time and costs
- practical experience in the application of current standard methods and acceptance by operators and agencies.

The first step in measuring technology is normally to first specify the limiting value - here the Maximum Admissible Leak Rate (MALR); the next step is then to specify the measurement accuracy - here the Minimum Detectable Leak Rate (MDLR) which is dependent on the limiting value. The returned questionnaires indicate however that in the practical application and evaluation of EWMITs, results refer with very few exceptions only to the accuracy (MDLR) of the test and not to the value of some Maximum Admissible Leak Rate (MA LR).

It was thus necessary to "put the cart before the horse" when establishing the reference values for MDLR and MALR:

Step I: Determination of the reference MDLR based on an error analysis for standard interface tests,

Step II: Determination of the reference MALR based on the MDLR established in Step I.

The proposed value for the reference Minimum Detectable Leak Rate (MDLR) is:

The reference Minimum Detectable Leak Rate (MDLR) is 50 kg/d related to nitrogen as the test medium.

This value is based on the evaluation of the questionnaires: By maintaining this MDLR, all cavern wells - which were deemed to be technically tight on the basis of a test using one of the three test methods discussed (in accordance with current engineering practice and with this MDLR) - were able to fulfil the following conditions for cavern well integrity:

- no detectable contamination of hydro- or biosphere
- safety at surface
- no detectable loss of stock in store.

Based on the reference MDLR of 50 kg/d and the constraint that the smallest possible reliably determinable measured value - in this case the MALR - must be at least a factor of 3 larger than the measuring accuracy, then the below value is proposed:

The reference Maximum Allowable Leak Rate (MALR) is 150 kg/d based on nitrogen as the test medium.