DESIGN OF TIGHTNESS TEST – PUBLIC SUMMARY

HYPSTER PROJECT

Deliverable 2.3

Authors: P. Berest (Armines), B. Brouard (Brouard Consulting), G. Hevin (Storengy), A. Bannach, M. Glöckner and M. Schlichtenmayer (ESK)

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Coordinator's contact details:	Germain Hurtado - germain.hurtado@storengy.com

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1. PUBLIC SUMMARY

The threat of global warming calls for a major energy transition. Hydrogen is considered as one of the most promising energy vectors. Germany and France, for instance, plan to invest a billion Euros per year to promote hydrogen for transport, heating and energy storage. However, the hydrogen strategy depends critically on mass-storage capacity. Mass storage in salt caverns is an attractive option.

Storage of gaseous and liquid hydrocarbons in salt caverns is a mature technology. More than 2000 caverns are operated worldwide. A lot of experience has been gained. However, storing hydrogen raises a couple of new problems, related to hydrogen high mobility (tightness) and the frequent cycles required when operating a storage cavern as a buffer between a distribution grid and electrolysis production fed by intermittent electricity. The tightness issue is addressed in this paper.

Tightness is a fundamental requisite of any storage cavern. Tightness results from (Bérest and Brouard, 2003):

1. the properties of the rock formation,
2. the nature of the stored product (density, viscosity)
3. the pressure selected for storage operation.
4. the design of wellbore completion, and
5. the quality of the cementing job and steel equipment.

Much information and experience are available from the 2000+ salt caverns used worldwide for hydrocarbon storage. Generally speaking, salt permeability is exceedingly small. Several incidents proved that breaches or conduits can be created between a cavern and a neighboring cavern, or between a cavern and the boundaries of the salt formation. The origin of most of these incidents is the presence of Anomalous Zones in the salt formation. In-situ tests proved that the overall cavern permeability experiences a significant increase when fluid pressure at cavern depth is larger than 80-85% of the geostatic pressure.

However, as in most pressure vessels, it is the “piping” (the access well) that most often is the weakest point. Several incidents are described in this Deliverable. The origin of most of these incidents is the presence of a single casing between the stored product and the rock formation.

In this context, tightness tests are mandatory. It is suggested to test the wellbore after drilling and to test the cavern before commissioning. The Nitrogen Leak Test, a high-resolution measurement technique, has become a standard. It consists of filling the annular space with pressurized nitrogen, setting the gas-brine interface below the last casing shoe, and tracking this interface with a logging tool. The mass of gas is very small when compared to brine mass, and accurate measurement of gas-mass changes during the test is possible.

A complementary interpretation method, based on the analysis of wellhead-pressure evolutions during the test rather than on interface tracking, can also be used. This method is cost-effective; it is especially attractive when several tests must be performed.

Several cases of tightness loss in gas storage caverns were described. They originate in a weakness of the salt formation (Anomalous Zone) or in the presence of a single casing between the stored gas and the rock formation (Single Barrier). It is recommended to have two barriers between the rock mass and the salt formation (according to the current practice, two cemented casings in North America, and one cemented casing and one gas completion in Europe). The maximum gas pressure must be lower than 80-85% of the geostatic pressure at the casing-shoe depth. Tightness tests must be performed both before leaching the cavern and before the first gas fill. For demonstration projects like HyPSTER, the well should be tested with nitrogen and hydrogen, successively. During these tests, the gas-brine interface is can be set at distinct depths to assess the tightness of the various parts of the wells. For measuring the leak rate during the test, in addition to interface tracking, a continuous and non-intrusive method is suggested.

It is expected that

- The measured leak rates are well below the reference value.
- For each test gas the leak rate may stay constant (at least some time after pressurization) at all interface levels or experience small depth changes with deeper interface levels.
- The leak rate measured with hydrogen is approximately 2,2 times higher than the one measured with nitrogen.

Following a detailed assessement of the test results to be obtained and comparison with results from other pilot projects, a dedicated reference value for the tightness test of hydrogen caverns could be established, if sufficient data can be collected. This could read as follows :

- The established test methods (in-situ balance, in-situ compensation, above-ground balance) can be further applied without substantial changes
- Reference MDLR = 50 liter/day (N_2) or 110 liter/day (H_2) for hydrogen storages [ESK] or MALR = 50 kg/day (H_2) [Armines-X]
- Other criteria like waiting time before test, test duration, evaluated parameters can remain unchanged

Final recommendations can only be given after test execution in 2022.

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Hydrogen Storage

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