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OCTG Connections Evaluation for Underground Hydrogen Storage

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Abstract

Hydrogen storage is a key technology to deploy a sustainable hydrogen supply from producers to users. Such hydrogen can be massively stored underground in salt caverns through wells. Storage safety needs to be carefully managed especially by ensuring the gas tightness of hydrogen wells. Vallourec Research and Development department has investigated a qualification protocol to assess tightness, to validate proprietary premium connection for underground hydrogen storage.

A storage involves injection wells, made of one production tubing and several casing strings. Each tubing or casing pipe is assembled with a connection made with a metal-to-metal seal capable to withstand the different combined loads (tension, compression, bending and pressure) while remaining tight. In 2021, a 9-5/8" (244.48 mm) 47.00# L80 proprietary connection has been tested with a dedicated hydrogen protocol up to 470 bar (6,816 psi) at full scale. At the same time, this product has been used by EnergyStock in a 1757m (5,764 ft) depth underground hydrogen test borehole in the Netherlands from February 2022 to January 2023. Several pressure cycles were made with 100% (pure) hydrogen in this storage. The storage maximum pressure was 200 bar (2,900 psi). Then the tubing was pulled-out for analysis. The connection and the pipe were inspected by Gasunie and Vallourec teams to check if any cracks or corrosion were visible. Ultrasonic and micrographic inspections were performed. No microstructure deviation nor crack were detected in the pipes or in the connections.

Each connection has a surface treatment and a lubricant added. Generally, the lubricant is a thread compound used in oil and gas industries. A full-scale test has been performed with a new coating in Zinc-Nickel and with a proprietary dry lubricant. This new surface treatment avoids any potential lubricant discharge in the well. This test demonstrated a good connection performance with the dedicated hydrogen protocol, as the connection successfully passed 5500 internal pressure cycles at 275 bar (3,988 psi) and 30 thermal cycles from 10°C (50°F) up to 70°C (158°F) with tension and 250 bar (3,625 psi) of internal pressure.

No current standard is available to assess OCTG connection for underground storage applications. The test protocol developed demonstrated that the connection evaluation is necessary for such application, and it has also been verified in a salt cavern injection well under 100% hydrogen. The connection has been also assessed through finite element analysis (FEA) to validate that the testing protocol covered the targeted cycling conditions.

Key words: Gas Storage, Hydrogen Storage, OCTG Connection, Production Tubing, Safety