Characterization of OCTG material for the application in underground hydrogen storage caverns

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One key factor for decarbonization strategies of the industry is the use of hydrogen as renewable energy source. Due to the discontinuous availability of renewable primary energy for hydrogen production and energy demand, the underground storage of hydrogen plays an essential role in future. There are many activities worldwide to develop new or re-utilize existing salt caverns or porous media reservoirs for the application as an underground hydrogen storage under high gas pressure conditions. The filling and storage operation of these gas storages is done by applying typically subsurface completion equipment including low alloyed OCTG pipes. In a first application in a Dutch pilot project regarding the storage of hydrogen in a salt cavern well a 4 ½’’ L80-1 VAhyper pipe string with approximately 1500 m total length was used for debrining as well for filling of the well with hydrogen. Moreover, through this first of its kind application and setup, the hydrogen gas-tightness and hence integrity of the string and the used premium connections was successfully demonstrated at pressures of up to 220 bar of 100% pure gaseous hydrogen. Furthermore, within the project also the first snubbing operation under pressurized pure hydrogen retrieving the 4 ½’’ L80-1 VAhyper pipe string – was accomplished successfully and in a save manner. This paper describes briefly the performed field application and related overall setup of the applied technology and well installations. Majorly the paper covers the discussion of the comprehensive material characterization of the utilized steel pipes. The pipe material was thoroughly tested before installation after manufacturing, after the first mechanical integrity test of the salt cavern well with 20 days of hydrogen exposure and after the second field application (32 days) with pure 100% hydrogen. The material characterization at each stage was performed according to a defined extensive material test program consisting of standard material testing methods, sour service and specific hydrogen testing methods. Amongst them constant load tests up to 140 bar hydrogen, including determination of the hydrogen content in the steel after the test and hydrogen permeation testing have been conducted. Overall, next to the successful field application the material also showed a very good resistance against hydrogen during all stages of this field in the consecutive feasibility study including the aforementioned enhanced testing sequence. These first results are very promising for the use of threaded steel pipes for such hydrogen applications in future. Finally, further steps and possibilities for material tests under high pressure hydrogen loading of steel pipe materials will be described.