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Monitoring of well integrity by magnetic imaging defectoscopy (MID) at the Ketzin pilot site, Germany

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One of the key requirements for safe CO_2 storage operation is to ensure wellbore integrity. The CO_2 triggered acid in-well environment may lead to pitting and/or surface corrosion and eventually to fatigue of well casings and cementation by this giving raise to wellbore leakage. Corrosion effects are conventionally monitored by measurement of inner casing surface, internal diameter and wall thickness. Caliper logging provides inner surface and internal diameter data while ultrasonic tools measure both the internal diameter and casing thickness as well as the bonding between casing and cement. However, both tools can only monitor and characterize the most inner casing and ultrasonic tools in addition can only be applied in fluid filled wells. At the Ketzin CO_2 storage test site, Germany, about 67 kt of CO_2 were injected between June 2008 and August 2013 and an interdisciplinary monitoring concept was developed with focus on the storage complex, the overburden, the surface and the wellbores. Four deep wells penetrate the reservoir and their integrity has been monitored by a combination of video inspection, pulsed neutron gamma logging PNG and magnetic imaging defectoscopy MID. MID is an advanced logging method for non-destructive testing and has the great advantages that it can be operated in gas filled boreholes and that it provides information also for outer casings. The MID tool generates electromagnetic pulsed transient eddy currents and records the response of the surrounding media. The distribution and strength of the eddy-currents is then converted into averaged, depth-resolved thicknesses of the individual casings. Run in time-lapse mode, MID provides a measure to detect changes in casing thickness and therefore hints to corrosion.
At Ketzin, the four deep wells haven been monitored by repeat MID logging on a roughly annual basis in cooperation with VNG Gasspeicher GmbH (VGS) and GAZPROMENERGODIAGNOSTIKA, applying their in-house MID tool. The MID based depth-resolved casing thickness data clearly image the thickness of at least the two innermost casings and the depth positions of the pipe-connectors and of all downhole installations in perfect agreement with depth data from the drilling reports. Also the transition from steel casing to glass fiber reinforced casing in well Ktzi 203 is well resolved. The MID derived casing thicknesses are within the production specifications and also confirm to the API standards. Comparison between the different time-lapse data sets provides no hints to time dependent changes in casing thickness or to any other signs of corrosion. These results agree with the video inspection of the wells and the investigation of in-situ samples of pulled casing material recovered during abandoned of well Ktzi 202.
The Ketzin time-lapse MID data set provides unique field experience on applicability of MID monitoring and longevity of wellbore steel casing under real CO_2 storage environment. It thereby substantially improves our knowledge on CCS safety assessment due to the key role of well integrity during the entire storage lifecycle.