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Permanent downhole fiber optic pressure and temperature monitoring during CO2 injection

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Permanent downhole monitoring of pressure and temperature, ideally over the entire length of the injection string, is essential for any smooth and safe CO2 injection within the framework of geological CO2 storage: i) To avoid fracturing of the cap-rock, a certain, site dependent pressure threshold within the reservoir should not be exceeded; ii) Any CO2 phase transition within the injection string, i.e. either condensation or evaporation, should be avoided. Such phase transitions cause uncontrolled and undetermined P-T regimes within the injection string that may ultimately result in a shut-in of the injection facility; and iii) Precise knowledge of the P and T response of the reservoir to the CO2 injection is a prerequisite to any reservoir modeling. The talk will present first results from our permanent downhole P-T monitoring program from the Ketzin CO2 storage test site (CO2SINK). At Ketzin, a fiber Bragg grating pressure sensor has been installed at the end of the injection string in combination with distributed temperature profiling over the entire length (about 550 m) of the string for continuous P-T monitoring during operation. Such fiber optic monitoring technique is used by default in the oil and gas industry but has not yet been applied as standard on a long-term routine mode for CO2 injection.

Pressure is measured every 5 seconds with a resolution of < 1 bar. The data are later processed by user-defined program. The temperature logs along the injection string are measured every 3 minutes with a spatial resolution of one meter and with a temperature resolution of about 0.1°C. The long-term stability under full operational conditions is currently under investigation. The main computer of the P-T system operates as a stand-alone data-acquisition unit, and is connected with a secure intranet in order to ensure remote data access and system maintenance. The on-line measurements are displayed on the operator panel of the injection facility for direct control.

The monitoring program started already prior to CO2 injection and runs since 6 months without any fatal errors. The recorded data cover the pre-injection well-testing phase, the initial injection phase as well as several shut-in and re-start phases during routine injection. Especially during the initial and re-start phases the monitoring results significantly optimized and improved the operation of the injection facility in terms of injection rate and injection temperature. Due to the high qualitative and also quantitative resolution of this technique even shortest-term transient disturbances of the reservoir and injection regime could be monitored as they may occur due to fluid sampling or logging in neighboring wells. Such short-term transient effects are normally overlooked using non-permanent monitoring techniques. On the long-term perspective, this monitoring technique will also support the control of CO2 injection tubing integrity, which is a prerequisite for any secure long-lasting CO2 injection and storage.