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## **Specially Customized System for Cementing Geothermal Wells in the Upper Rhine Graben**

*Innovative Systeme zur Zementierung von Geothermiebohrungen im Oberrheingraben*

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Cementing is one of the most critical steps during the drilling process of geothermal wells. Here, we employ many techniques and technologies well-known in the oil & gas industry. However, HT-conditions, as well as temperature-induced expansion or contraction of metal tubular during the life cycle of geothermal wells pose severe challenges to the long-term durability of cement systems. Thus, a dedicated design based upon extensive lab research and thorough engineering is crucial.

This paper focuses on the development and first field trial of an innovative cement blend specially customized for an ongoing geothermal project in the Upper Rhine Graben. For this project, thermal fluid temperature was expected to reach up to 180°C on surface. Thus, reactive silica flour addition exceeded the commonly used 35 – 40% for HT-Blends counteracting strength retrogression of the hardened Thermalite system. Additionally, the mechanical properties (i.e., Young's modulus and Poisson's ratio) of the cement sheath were measured via tri-axial compression tests. Based upon computer simulations and ultrasonic measurements, the "flexibility" of the Thermalite was determined, further optimized and consequently deemed adequate at a Young's modulus of 0.97 Mpsi and a compressive strength of 2.400 psi.

Prior to the actual cementation of the 20" casing, our abrasive spacer effectively removed the silicate-based mud system and its filter cake. For this cementing job, 20 m<sup>3</sup> of Power Spacer at 1.4 kg/L, 102 m<sup>3</sup> of Thermalite lead slurry and 24 m<sup>3</sup> of HT-Blend tail slurry were mixed and pumped at 800 L/min. Weak formations encountered during the drilling process resulted into a slurry density restriction of 1.60 kg/L and 1.90 kg/L, respectively, as well as the necessity of loss circulation material.

The quality of this application was quantified through logging and considered satisfactory to continue with the combination of Power Spacer and Thermalite system for cementing the 13 5/8", as well as the 9 5/8" liner sections. Laboratory and field results impressively proved the premium properties of these new technologies. Our state-of-the-art products definitely helped to deliver an excellent cement job for an ongoing geothermal project in the Upper Rhine Graben.