Effect of Ester Based Drilling Mud Contamination on the Behavior of Smart Oil Well Cement

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Abstract: The properties of cement with 0%, 0.1% and 1% EBM contamination were investigated. The test results showed EBM contamination affected the density, electrical resistivity and compressive strength of oil well cement. The cement contaminated with 1% EBM decreased the density, initial electrical resistivity and compressive strength (one day) of cement by 7%, 51% and 55%, respectively. The compressive strength reduction was reduced with increased curing time.

1. Introduction: Well cementing is one of the key processes performed during drilling and completion of wells. The main objective of primary cementing is to provide zonal isolation (Agbasimalo 2012). Failure of cement to provide zonal isolation can lead to contamination of fresh water aquifers, sustained casing pressure, or blowout. EBM have higher initial cost but disposal costs can be considerably low as they are less toxic. Some of the undisplaced mud contaminates the cement affecting its mechanical and chemical properties. Mud contamination has also been identified as a major cause of cement plug failure (Fosso et al 2000).

2. Objective: In this study, the effect of the EBM contamination on the initial behavior of the smart cement density, electrical resistivity and compression strength were investigated.

3. Materials and Methods: The basic components of EBM were water and fatty acid methyl ester of soybean oil. The ester to water ratio of 80:20 was finalized and 1% of chemical surfactant was added to get homogeneous emulsion. Class H oil well cement was modified to have better sensing properties as smart cement. EBM was added based on the total weigh of the smart cement slurries. After mixing, the slurries were casted into the plastic cylindrical molds with the dimension of 4 inches (height) ×1 inch (radius).The modes were embedded by two wires with 2 inches distance in order to monitor the resistivity development. Specimens were cured up to 28 days at room temperature. The electrical resistivity of the cement slurries with 0%, 0.1% and 1% EBM contamination were measured using API standard resistivity meter and conductivity meter. Also, the electrical resistance of the specimens was measured continuously by LCR meter after cement hardening at high frequency of 300 kHz. Electrical resistivity of hardening cement can be calculated by K factor and resistance measurement using following equation (1):

$$R = \rho \frac{L}{A} = \rho K \quad (1)$$

In which L is the distance between the wires, A is the cross-sectional area which the current flowing through and K is the geometry factor which is equal to $\frac{L}{A}$.

4. Results and Analysis: In Table 1, the density of the cement slurry was reduced from 16.71ppg to 16.59 and 16.54 ppg with 0.1% and 1% EBM contamination because of lower density and a small amount of EBM contamination. In Table 2, the initial electrical resistivity of cement increased with the increasing in mud contamination. For neat cement slurry, the initial resistivity is 1.03 Ω.m. It was increased to 1.12 Ω.m (9% changes) and 1.56 Ω.m (51% changes) by adding 0.1% and 1% of EBM contamination, respectively. The 24-hr compressive strength of cement with 0.1% and 1% of EBM contamination dropped by 13.4% and 55.4%. After 7days, 0.1% and 1% mud contamination caused the compressive strength

decreased by about 11.9% and 38.6% while during the 28 days test the reduction was by 11.7% and 18.2% respectively.

Table 1 Effect of EBM on the density of cement

Cement slurry with OBM Contamination	Density(ppg)	% Change
Cement only	16.71	—
Cement +0.1% OBM	16.59	-0.7%
Cement +1% OBM	16.54	-1%

Table 2 Electrical resistivity development of cement specimens during 24 hours of curing

Cement slurry with EBM Contamination	Initial resistivity(Ω.m)	ρ-min (Ω.m)	t-min (min.)	ρ-24 (Ω.m)	(ρ-24-ρ-min)/ρ-min
Cement only	1.03	0.88	70	2.41	174%
Cement +0.1% EBM	1.12	0.90	90	2.00	122%
Cement +1% EBM	1.56	1.01	130	1.72	70%

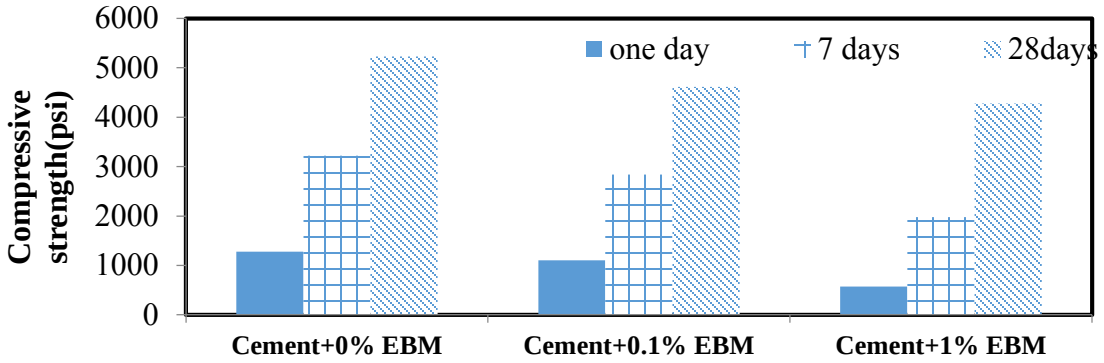

Figure 1. Compressive strength development of EBM contaminated cement at 1, 7 and 28 days or curing

5. Conclusion: EBM contamination reduced the density of cement. The change of initial resistivity can reflect the degree of EBM contamination in the cement, even the percentage of contamination for cement is as low as 1%. Studies done also showed that compressive strength of the cement was reduced by the contamination. The alteration in compressive strength of the smart cement with EBM contamination tends to be more pronounced for one day curing but tends to be less critical for 7 and 28 days.

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7. References:

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