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MACONDO WELL EVALUATION OF 60% FOAM QUALITY FOAM STABILITY TESTING

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SECTION 1. SAMPLE DESCRIPTION

Four 5-gallon buckets of Lafarge Class H cement were received on Monday, June 27th, 2011. Some dry and wet additives were received from Halliburton, Friday, July 1, 2011, which included the following: SS1 (200-mesh) Silica flour, SS2 (100-mesh) Silica sand, SCR-100L retarder, ZoneSealant 2000 foam stabilizer, D-Air 3000 defoamer, SA-541 polysacharide, EZ-FLO flow enhancer, and KCL (Potassium Chloride) salt.

The base slurry composition in the form of lab weights for a 600-mL portion of the 16.7 ppg, 0.09 gps SCR-100L slurry was given as:

- Class H cement- 659.06 g
- SSA-1- 131-81 g
- SSA-2- 98.86 g
- KCL- 13.18 g
- D-Air 3000- 1.65 g
- SA-541- 1.32 g
- EZ-FLO- 0.46 g
- Fresh Water- 281.38 g
- SCR-100L- 6.10 g
- Zonesealant 2000- 6.85 g

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SECTION 2. MIXING AND BLENDING

The slurry was prepared as described in API RP 10B-2 Clause 5, or API RP 10B-4 Clause 7 (for foamed cement), as applicable.

Base Slurry Preparation

- Both the cement and the water temperature were tested before beginning.
- The cement and the water were weighed in a clean dry container to an accuracy of 0.01 grams. The water was weighed immediately before use to prevent loss due to de-hydration.
- The mixer had a blade assembly with ≤ 10% wear on the blade and no obvious deformation.
- The dry cement was added to the water at a uniform rate in ≤ 15 seconds while the mixer maintained a speed of 4,000 rpm (±200 rpm).
- The mix was monitored for a clear vortex, and mixability is noted in the table below.
- The slurry was then mixed at 12,000 rpm (± 500 rpm) for 35 seconds, and an average speed under load for all slurries was documented.

Foamed Slurry Preparation

The foam was achieved using a multi-blade assembly in a retro-fitted slurry cup that had a threaded cap, an o-ring, and a removable plug with a vent hole. The base slurry was prepared as described above, then the appropriate weight of slurry was placed in the cup which was then sealed. The mixer was turned to 12,000 rpm or the highest achievable rpm (and recorded) for 15 seconds.

Composition and Test Conditions Defined

#	COMPOSITION	Pre-condition Time	Pre-condition Temp	Foam slurry ppg	Foam slurry % gas
FM-60	16.7 ppg Base Slurry (0.09 gps SCR-100)	20 min	110°F	6.68	60%

BASE SLURRY PREPARATION DATA

#	Cement °F (avg)	Water °F (avg)	Load Rpm (avg)	Add'l seconds	Vortex & Mixability notes
FM-60	71.4	70.8	12240	0	Vortex visable

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SECTION 3. FLUID CONDITIONING

Fluids were conditioned according to the requirements given by API RP 10B-2, Clause 12.4, using an atmospheric consistometer

The consistometer cup was at room temperature when slurry was added to it. The atmospheric consistometer was pre-heated to 110°F. The slurry was mixed according to Section 2 mixing procedure, and then was immediately poured into the consistometer cup for test initiation. After adding the slurry to the vessel, the temperature was monitored until it reached the designated temperature. At that time, a timer was set to run for 20 minutes. Once the conditioning time was completed, every effort was made to prevent the slurry from remaining static for any period of time and was vigorously stirred with a spatula for 5 seconds immediately before removing the slurry from the vessel. At that time, the slurry was then promptly used.

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SECTION 4. FOAM STABILITY

The fluid was tested for foam stability according to API RP 10B-4. The 16.7 ppg base slurry was prepared and conditioned as described in Sections 1-3 for 20 minutes. Foam stability tests were performed for a 6.68 ppg foamed slurry prepared at atmospheric conditions.

As per the third-party contractors observing this line-up of testing, on behalf of BP, the total volume of the blender cup was measured on a scale with tap water prior to testing. The total volume measured was 1148.00 mL. This total volume was used to calculate the amount of base slurry and foamer required to generate 60% Foam Quality.

The stability was assessed using visual inspection (e.g. FF, settling, bubble conc.), as well as two density measurement methods, described below:

Density measurement of slurry sampled from the blender

Determined by the volume and weight of the slurry in the container.

Density measurement via graduated cylinder

Determined by the volume and weight of the slurry sampled from graduated cylinder after a 2-hour quiescent period according to API RP10B-4/ISO 10426-4 Clause 9.3.1.

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SECTION 5. SUMMARY OF RESULTS

All testing was observed by BP Representatives; furthermore, photography and video recordings of all testing was taken to further document all findings during this study.

The slurry was foamed for 15 seconds at 12,000 rpm, according to API RP 10B-4. During the mixing process, there was no noticeable change in the pitch from the blending container observed. The blender cup lid was removed and the foamed slurry was not observed to fill the whole volume of the cup. The top 2 blades of the 5-stacked blade assembly were visible, showing the lack of foam generated from the process (a fully foamed fluid would fill the entire volume).

As recommended by the BP Representatives, the lid was placed back onto the mixing cup and the slurry was foamed for 45 additional seconds at 12,000 rpm. This additional mixing period was performed to determine if the slurry could generate foam with more time. Again, the high pitch was not observed during the additional mixing period, and the top two blades were still visible (see Figure 1).

Due to lack of foam quality, the slurry was checked for density in a container with a known volume. The density was measured at 11.3 ppg, which equated to approximately 30% Foam Quality. All testing was halted at this time, due to observed slurry instability.

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Figure 1. Depiction of lack of foam after mixing