P-MS3

CEMENTING SERVICE BULLETIN

09/25/18

P-MS3 (PETROCHEM – HIGH STRENGTH LOW WEIGHT POWDER)

TECHNICAL DATA

P-MS3 is primarily a cement extender which can be used to formulate lightweight slurries ranging in density from 10 to 13 PPG. It is usually used in the concentration range of 5 to 20% BWOC. With proper slurry design, good compressive strength at low temperatures with acceptable free water and thickening time can be achieved.

P-MS3 slurries exhibit rheological properties with good laminar-flow characteristics. With concentrations greater than 10% BWOC, P-MS3 imparts some fluid-loss control to the slurry.

The use of P-MS3 as an extender is only recommended up to 185°F (85°C). Above this temperature and up to about 300°F (149°C), only P-SRL/P-TTCL will retard P-MS3 extended slurries. However, it often has a detrimental effect on fluid-loss control and sometimes leading to strong gelation.

Due to its small particle size, any bulk handling requires P-MS3 to be pre-blended with P-FFA (Petrochem - Free-Flow Additive) or other bulk additive. P-MS3, alone, cannot be moved pneumatically. Once blended with another material using a recommended technique, it can be handled, blended and mixed normally. Slurry mixing rates, however, will be limited to 4 BPM.

SLURRY DESIGN

As with most cement additives, P-MS3 performance depends greatly on cement class, brand and even batch. Therefore, the data presented in this section should be considered as a guideline only and the slurry properties must be checked and fine-tuned in the laboratory prior to each job.

P-MS3 COMPOSITION AND BEHAVIOR

P-MS3 is composed of spheres of amorphous silica with an average particle between 0.1 and 1.0 micron and a purity of around 90%. It is a manufacturing process by-product of silicon metals and ferrosilicon alloys. The addition of P-MS3 to cement slurries is beneficial for the following reasons:

- It acts as an additional cementitious material, reacting with calcium ions in solution in the cement slurry to form calcium silicate hydrate (C-S-H) gel. It is this gel, which allows the use of large quantities of mix water without excessive free-water separation. This formation of C-S-H gel also accelerates the reaction of tricalcium silicate with the mix water by lowering the concentration of divalent calcium in solution, thus reducing the thickening time and improving early compressive strength development.

- Since it is composed of small particles, it acts as an excellent plugging agent, decreasing the permeability by filling the void space around the cement particles which are normally up to fifty times larger than P-MS3.

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SLURRY DENSITY

Extender P-MS3 and cement are used to formulate lightweight slurries normally ranging in density from 11 to 13 PPG. Slurry densities as low as 10.5 PPG can be achieved by incorporating LITEPOZ (EXTENDER). With Extender P-SL60 or P-SL50 and cement, a slurry density of 10 PPG can be obtained.

P-MS3 CONCENTRATION

At a fixed slurry density, increasing the P-MS3 concentration improves the early compressive strength development and reduces the free water. But it slightly increases the slurry viscosity. High slurry viscosities can be reduced by using dispersants (like P-D88/L) but concentrations will be limited by the acceptable amount of free water.

With decreasing slurry densities, the increased mix-water content allows higher P-MS3 concentrations to be used while maintaining acceptable slurry viscosities. But it results in lower compressive strengths.

The P-MS3 concentration must be selected initially based on the desired slurry density and acceptable free water. Through laboratory testing, its final concentration along with the concentration of other required additives will be determined as the acceptable slurry and set-cement properties are achieved.

FLUID-LOSS CONTROL

At concentrations greater than 10% BWOC, P-MS3 imparts some fluid-loss control to the slurry. Normally this is sufficient for most lightweight cement applications. If additional fluid-loss control is required, any Petrochem fluid-loss additive can be used. However, many fluid-loss additives promote slurry viscosification which may make their use unacceptable.

DISPERSANTS

Due to the high surface area of P-MS3, some mixing difficulties may be encountered even at densities not ordinarily associated with high viscosity. Addition of P-D88, P-D88L or
P-D90/L dispersants to the mix water will improve the mixability of the slurry and, in normal concentrations, should not cause free-water problems. At low temperatures where thickening times with these dispersants are too long, P-LTDL has been successfully used with P-MS3.

Occasionally, gelation experienced with P-MS3 has been successfully reduced with P-D88 (also used as a Gel Suppressing Agent) however, this is a sensitive solution and should be thoroughly evaluated at the Regional Laboratory for precise slurry designs before field use.

RETARDATION

Up to 185°F (85°C) BHCT, any retarder can be used to extend the thickening time of slurries containing P-MS3. Due to the high reactivity of P-MS3 in the slurry, effective retardation of slurries with P-MS3 becomes a problem above this temperature.

From 185°F (85°C) to about 300°F (149°C), only P-SRL/P-TTCL will retard P-MS3 extended slurries. Since P-MS3 is always reactive, the effectiveness of P-SRL/P-TTCL as a retarder is limited as well. For this reason, P-MS3 does not have an unlimited temperature range.

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STRENGTH RETROGRESSION

P-MS3 reacts with calcium hydroxide in the cement slurry to form additional calcium silicate hydrates. P-MS3 will also alter the overall cement-to-silicate ratio of the cement slurry when used in high concentrations. However, there is sizable debate over whether P-MS3 alone is sufficient for preventing long-term strength retrogression. As mentioned earlier, there is also a problem of retardation of P-MS3 slurries at high temperatures. For these reasons, P-MS3 is not designed to replace P-SF in low-density slurries where strength retrogression is required.

In cement designs with P-MS3 that will be exposed to temperatures greater than 230°F (110°C), a combination of P-MS3 and P-SF or P-SS should be used with a total silica content of 40% BWOC. If P-MS3 must be used alone for strength retrogression, its concentration should be at least 50% BWOC. Since this is higher than the recommended bulk blending concentrations, part of the material must be added to the mix water. In most cases, this application is operationally impossible because slurry viscosity increases with increasing P-MS3 concentrations.

ANTIFOAM AGENTS

Foaming problems encountered with P-MS3 due to air entrainment can be avoided by adding P-AFAL or P-DFL to the mix water first. P-AFA will not be effective at high concentrations of P-MS3 and mixing difficulties will be encountered.

EXTENDER P-SL50 & P-SL60

Cement designs with P-SL50/P-SL60 often develop density segregation of solids similar to free water. Due to the extreme density differential between the P-SL50/P-SL60 spheres and cement, the spheres tend to rise to the top of the slurry and the cement settles to the bottom. This can result in extreme decreases in compressive strength at the top of the cement column.

The addition of P-MS3 to P-SL50/P-SL60 slurries stabilizes the density gradient of the slurry by eliminating the sphere separation. The addition of P-MS3 can also enhance the compressive strength to values suitable for completion with slurry densities as low as 10 PPG. This blend has been used with great success.

FIELD MIXING PROCEDURES

Extender P-MS3 poses some problems for both bulk handling and field mixing because of its extremely small particle size. In both cases, the best success is first to blend the P-MS3 with P-FFA (Petrochem – Free Flow Additive) or with other bulk additive, and always maintain P-MS3 concentrations of less than 20% BWOC in any blend. At these concentrations and with good bulk handling techniques, P-MS3 should move pneumatically and slurry mixing will be possible with conventional mixing equipment. However, mix rates will be limited to four barrels per minute, and higher than normal dust hazards can be expected.

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BULK HANDLING GUIDELINES

P-MS3, alone, will not move through conventional pressurized bulk cement moving systems. The material is too fine to pack and flow under air pressure like other bulk additives. The best solution to this problem is to blend P-MS3 with P-FFA or directly from the sacks with some other bulk material. P-MS3 will adhere to the surface of the larger-grained material and then can be handled normally without bulk delivery problems or higher than normal dust hazards.

Possible additives that can be blended with P-MS3 are P-SL50/P-SL60, P-SF or simply API cement. In all cases, the P-MS3 sacks will have to be cut directly into a bulk blender that already contains a quantity of the second material. More of the binding material must then be added on top of the P-MS3 to sandwich the fine grains into the bulk blend. After this process is finished, the blend can be stored, handled normally, or delivered to mixing equipment through pneumatic bulk systems.

P-MS3 concentrations must be limited to 20% BWOC during any blending, handling or delivery operations to avoid any bulk-handling or field-mixing problems. For slurry designs using more than 20% P-MS3 BWOC, the additional P-MS3 above 20% BWOC must be dissolved in the mix water.

Excellent success has been achieved in the past by following these procedures with a P-MS3: P-SL50/P-SL60: ratio of 1:3 by weight. Since this procedure is time-consuming, areas performing high volumes of low-density work, in advance can prepare these blends and then store them in a cleaned bulk silo.

Once P-MS3 has been blended properly with another material, it can be transferred conventionally and blended with cement, when required.

SLURRY MIXING GUIDELINES

Even after blending with other materials, the bulk delivery of systems with P-MS3 can be erratic. To maintain good density control, continuous mix rates usually are limited to four barrels per minute or less. If higher rates for pumping are required, batch mixing may be necessary.

However, foaming should be anticipated, so P-DFL or P-AFAL should be blended in the mix water first to avoid operational problems. Higher than normal dust hazards can be expected during slurry mixing.

JOB DESIGN DATA

At concentrations from 5 to 15% BWOC, P-MS3 and cement slurry formulations at 11 to 13 PPG have performance properties similar to those expected when using P-EXT instead. For example, Class G cement with 15% P-MS3 mixed at 12.5 PPG will have a 48-hr compressive strength around 500 psi at 80°F (27°C) with 1% or less free water. These numbers are very similar to the performance of 2% P-EXT with the same Class G cement.

By increasing the P-MS3 concentration to 25% BWOC, this same P-MS3 system will have 500 psi compressive strength in 24 hr. with zero free water. At 40% BWOC P-MS3 concentration, 24-hr compressive strength will exceed 1000 psi. However, the slurry viscosity must be carefully observed when increasing the P-MS3 concentration to ensure slurry mixability in the field.

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