Section 11

Lost-Circulation Materials

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Section 11

Lost-Circulation Materials

Introduction

Lost circulation normally refers to the loss of whole drilling fluid or cement slurry (not filtrate) to a thief zone in the wellbore which prevents these fluids from being circulated back to the surface.

Lost circulation can be expected to cause trouble in three types of formations:

1. Unconsolidated or Highly Permeable Formations
   Generally, the permeability must exceed 100 darcies to allow solid particles from the drilling fluid or cement slurry to enter the formation and cause lost circulation. The normal result is a gradual loss of fluid, unless there are large segments of this kind of formation exposed. It is usually easily controlled.

2. Fractured Formations
   These include naturally and artificially fractured formations. Natural fractures can be encountered anywhere. During drilling, circulation lost to fractures starts slowly and increases as drilling continues. Induced fractures generally occur in characteristically weak (i.e., shale) formations when the hydrostatic pressure of the fluids in the wellbore exceeds the fracture breakdown pressure threshold. When this occurs, a rapid, complete loss of circulation normally occurs. Pressure surges from running drillpipe (or casing) can induce fractures in weak formations and cause this type of loss. Cement-slurry loss in weak formations can be lessened by reducing the cement slurry density or using a thixotropic cement.

3. Cavernous Formations
   These formations are generally formed by the erosive action of subsurface waters on formations, particularly limestone. In the course of drilling, the caverns are encountered erratically and unexpectedly, and complete loss of circulation of the drilling fluid occurs suddenly. It is difficult to restore circulation where the voids in the formation are so large. Fortunately, zones of this type do not occur in all producing areas.

Materials for controlling lost circulation can be divided into seven basic types:

1. Fibrous
   Fibers form mats on the surface of high permeability formations or flow into channels of fractured formations to form bridges or plugs. Low concentrations of fiber materials are normally used because large concentrations can cause mixing problems and malfunctions of downhole cementing equipment.

2. Granular
   Coarse particles are carried into fractures, channels, or large vugs to form bridges or plugs caused by:
   a. concentrated granular material packing off the opening when portions of the carrier fluid is lost to the formation opening
   b. restrictions smaller than the largest granules are encountered

3. Laminated
   Chemically inert flake materials, such as fibers, also form mats or bridges and are normally effective in sealing or resealing very narrow fractures. They also help control fluid loss.

4. Quick Setting Cements
   These materials are essentially cement slurries with very short set times. The thin slurry is pumped into the vicinity of the lost-circulation zone. It will either set up while being displaced or shortly after entering the lost-circulation zone.

5. Flash Setting Formulations
These formulations are thin slurries of fluids which form semisolid materials when mixed with water or water-based drilling fluids. The mixing is normally achieved downhole, in the wellbore, or within the lost-circulation zone.

6. Thixotropic Cements

These slurries are specially formulated to have a low viscosity during mixing and displacement. However, the slurry viscosity increases as the displacement rate decreases and increases rapidly when the slurry becomes static. Since the properties of the different thixotropic slurries vary considerably, the one that works best for the specific problems of the well being cemented should be chosen.

7. Lightweight Additives

(See Lightweight Additives section for materials not shown in detail in this section). These materials' primary function is to decrease the slurry density and subsequently reduce the hydrostatic pressure in the well. The density reduction is generally a function of the additives' high water requirement, its low specific gravity, or a combination of the two.

Often the most effective approaches to solve a lost-circulation problem is to combine bridging materials with quick-setting, flash-setting, thixotropic, or lightweight slurries or fluids. Selecting the proper lost-circulation material should be based on one or more of the following factors:

1. Economics
2. Formation Characteristics
   Does the formation require bridging, rapid setting or gelling, low density, or combination of materials to control the lost-circulation problem?
3. Material Size
   Bridging materials must be small enough to be handled by the pumping equipment and large enough to bridge or seal the formation.
4. Compressive Strength
   The lost-circulation slurry or fluid should set hard enough to allow continued drilling or completion of the well.
Bentonite-Cement-Diesel Oil Slurry (BCDO)

Description and Primary Function: BCDO is a blend of bentonite and cement mixed with diesel oil to obtain a pumpable slurry. The slurry forms a very thick paste-like material when contacted by water or water-based drilling muds, making it a very effective lost-circulation material. The cement allows this material to develop a low compressive strength, which is not possible with BDO.

Interaction with Other Additives: Fibrous, granular, and flake lost-circulation materials can be used in the slurry to improve sealing properties. Water contamination in mixing or pumping equipment can cause severe gelation.

Safety and Handling Procedures: Dust can cause eye and skin irritation. Flush affected area with plenty of water, and apply a neutral oil (caster or light mineral) to eyes after flushing. Remove slurry from skin by washing with soap and water.

Properties:
Additive: BCDO
Part No.: none, field formulation
Specific Gravity: 2.89 (1 Bentonite: 1 Cement)
            3.00 (1 Bentonite: 3 Cement)
Form: powder
Color: gray
Water Requirement: none
Absolute Volume: 0.0415 gal/lb (1 Bentonite: 1 Cement) (0.1197 L/kg); 0.0400 gal/lb (1 Bentonite: 3 Cement) (0.3323 L/kg)
Solubility in Water: @ 20°C, insoluble
Odor: diesel

Normal Range of Use in Wells:
Temperature: 60°F to 250°F (16°C to 121°C)
Concentration: Normal usage is 1 sk (100 lb) Bentonite and 1 sk (94 lb) cement. Higher compressive strengths are obtained with 1 sk Bentonite and 3 sk cement. By varying diesel oil, slurry weights can be varied from 10.0 to 14.0 lb/gal.

Usage Restrictions: BCDO has the same mixing and placement procedures as BDO.
Bentonite-Diesel Oil Slurry (BDO)

Description and Primary Function: BDO is a slurry of bentonite and diesel oil. When the slurry is contacted by water, a very thick paste-like material is formed, which makes it an effective lost-circulation material. It has proven effective in regular and cavernous lost-circulation zones and where drilling needs containing fibrous, granular, or flake materials have been ineffective.

Interaction with Other Additives: Fibrous, granular, and flake lost-circulation materials can be used in the slurry to improve sealing properties.

Safety and Handling Procedures: Dust can cause eye and skin irritation. Flush affected area with plenty of water, and apply a neutral oil (castor or light mineral) to eyes after flushing. Remove slurry from skin by washing with soap and water.

Properties:

Additive: BDO

Part No.: none, field formulation

Formulation: The normal BDO slurry consists of 3 sk (300 lb or 136.1 kg) bentonite mixed with 1 bbl (42 gal or 159 L) diesel oil. Because bentonite has a specific gravity of 2.65 (absolute volume of 0.0453 gal/lb or 0.3774 L/kg) and No. 1 diesel oil weighs 6.86 lb/gal (0.82 sp. gr.) and No. 2 diesel oil weighs 7.09 lb/gal (0.85 sp. gr.), the resultant slurry weight will be about 10.50 to 10.75 lb/gal (1.26 to 1.29 kg/L).

Normal Range of Use in Wells:

Temperature: 60°F to 230°F (16°C to 110°C)

Special Information: When preparing and pumping BDO:

1. Drain all water and mud from pumps and tanks.
2. Use diesel oil to thoroughly flush tub, mixer, pumps, and tanks on all trucks.
3. Avoid contaminating BDO slurry with mud or water in suction lines and pumps. Water contamination can lead to severe gelation and prevent mixing or pumping the BDO.

Usage: The BDO job is performed by pumping the BDO to the point of lost circulation through the drillpipe while drilling mud is pumped down the annulus. The bottom of the drillpipe is located in the area of the lost-circulation zone. When the BDO exits the drillpipe, it mixes with the drilling mud and forms a very thick putty-like material which is then displaced into the lost-circulation zone to seal it. The BDO and drilling mud are pumped so when they mix, the initial BDO-to-drilling-mud ratio will be about 8 to 1. It will decrease gradually, and by the end of the job, the ratio is about 3 to 1. An oil-based spacer is recommended for use ahead and behind the BDO in the drillpipe to prevent gelation problems while still in the drillpipe.
Diesel Oil-Cement Slurry (DOC)

Description and Primary Function: DOC is a slurry composed of cement mixed with diesel oil (or kerosene), a surface-active agent, and no water. The slurry thickens rapidly when it contacts water, making it useful in the same manner as BDO. DOC forms a dense, hard cement when set.

Secondary Effects: (See the Diesel Systems section) DOC squeezes off formation water and repairs casing leaks behind pipe.

Related Information: See DOC-3 and DOC-10 in Diesel Slurries section for more information.

Interaction with Other Additives: HI-DENSE® weighting materials can be included if higher slurry densities are required. Fibrous, granular, and flake lost-circulation materials can be used in the slurry to improve sealing properties. Water contamination in mixing or pumping equipment can cause severe gelation.

Safety and Handling Procedures: Dust can cause eye and skin irritation. Flush with plenty of water, and apply a neutral oil (castor or light mineral) to eyes after flushing. Remove slurry from skin by washing with soap and water.

Properties:

Additive: DOC

Part No.: none, field formulation

Formulation: The DOC slurry is prepared using either 4, 5, or 6 gal (15.1, 18.9 or 20.7 L/kg) oil/sk of cement. DOC-3 or DOC-10 is also used at a concentration of 0.0075 gal/gal (0.028 L/L) of oil.

Components:

1. Water-free diesel oil or kerosene
   The DOC slurry weight will vary slightly with different mixing fluids because of their different densities: (6.86 lb/gal (0.823 kg/L) for diesel NO. 1; 7.09 lb/gal (0.85 kg/L) for diesel; and 16.2 and 6.67 lb/gal (0.8 kg/L) for kerosene. Crude oils are not recommended.

2. Cement
   Premium Plus cement can also be used, but because of its greater surface area, a higher oil/cement ratio is required which results in a lighter slurry weight and lower compressive strengths. POZMIX® cements and retarded cements are not recommended.

3. Surfactant
   Surfactants permit the use of lower oil-cement ratios which results in higher compressive strength and improved pumpability of the slurry. The surfactant also helps achieve faster water entry into the slurry when water is contacted in the well which causes very high viscosities and limits slurry penetration into a thief zone to prevent lost circulation.

   a. DOC-3, Part No. 70.15494, specific gravity 0.907 and a weight of 7.57 lb/gal (907 kg/m³). DOC-3 permits rapid water entry into the DOC slurry, creating very rapid viscosity increases.

   b. DOC-10, Part No. 70.15509, specific gravity 0.95 to 1.0 and a weight of 7.92 to 8.33 lb/gal (949 to 1000 kg/L). DOC-10 results in slower water entry into the DOC slurry than DOC-3. DOC-10 can be useful in preparing a lead slurry ahead of a slurry containing DOC-3 or in instances where DOC-3 performs unsatisfactorily because of premature setting.

4. HI-DENSE® No. 3 or HI-DENSE No. 4
   These weighting materials can be used in DOC when higher than normal slurry weights are needed.

Usage:

1. Drain all water from pumps and tanks, and flush with diesel.

2. Use a diesel flush ahead of DOC.

3. Add DOC-3 or DOC-10 to the required volume of diesel, and agitate until dissolved.

4. Mix cement with diesel oil containing DOC-3 (or DOC-10).

5. Use diesel spacer between DOC and displacing fluid.

WOC times of 18 to 24 hours are generally sufficient for DOC because hydration begins as soon as the water contacts cement particles. In many cases, 6 hours provides sufficient strength to resume well operations.
Normal Range of Use in Wells:

**Temperature:** 60°F to 300°F (16°C to 149°C)

**Typical Laboratory Data:** (10 psi forcing fresh water* through a DOC slurry containing DOC-3)

<table>
<thead>
<tr>
<th>Time (Hours)</th>
<th>120°F</th>
<th>130°F</th>
<th>170°F</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>425</td>
<td>1,500</td>
<td>1,705</td>
</tr>
<tr>
<td>4</td>
<td>1,350</td>
<td>2,350</td>
<td>4,440</td>
</tr>
<tr>
<td>6</td>
<td>2,420</td>
<td>3,085</td>
<td>6,040</td>
</tr>
</tbody>
</table>

*Most formation waters which contain inorganic salts will provide higher strength.
**Cal-Seal/Thixotropic Cement Additive**

**Description and Primary Function:** Cal-Seal is primarily a hemihydrate form of calcium sulfate (gypsum) which has a short thickening time and rapid compressive strength development. Cal-Seal added to cements results in very short pumping times, rapid compressive strength development, and thixotropic properties.

**Secondary Effects:** Cal-Seal is commonly used in dump bailer applications. It has expanding properties.

**Related Information:** See Cal-Seal, Expanding Cement (EA-2) and Thixotropic Cement in Special Cements section for more information and typical performance characteristics.

**Interaction with Other Additives:** It accelerates the set of cements.

**Safety and Handling Procedures:** Avoid getting in the eyes and inhaling the dust. Wear face mask and goggles. Wash affected areas with plenty of water.

**Properties:**

- **Additive:** Cal-Seal
- **Part No.:** 890.50131 (Cal-Seal 60)
- **Specific Gravity:** 2.70
- **Form:** powder
- **Color:** white
- **How Packaged:** 100-lb sk
- **Bulk Density:** 75 lb/cu ft (1201.4 kg/m³)
- **Water Requirement:** 4.8 gal (18.17 L)/sk
- **Absolute Volume:** 0.0444 gal/lb (0.3704 L/kg)
- **Solubility in Water:** @ 20°C, 0.2 to 0.8%
- **Odor:** none

**Normal Range of Use in Wells:**

- **Temperature:** 40°F to 140°F (4°C to 60°C) Cal-Seal 60
  140°F to 180°F (60°C to 82°C) Cal-Seal HT
  40°F to 100°F (4°C to 38°C) Thixotropic Cement

**Concentration:** Cal-Seal and water used as a fast-setting cement. Cement + 8 to 10 lb (3.62 to 4.50 kg) Cal-Seal/sk of cement for Thixotropic Cement.

**Special Information:**

- **Usage Restrictions:** Rapid setting and/or gelation properties make it necessary to keep the slurry in motion until it is placed at the required location.

**Effect on Slurry Properties:**

1. increases viscosity, water requirement, and early strength
2. decreases density (slightly) and thickening time
Flocele

**Description and Primary Function:** Flocele consists of cellophane flakes available in two sizes. The 3/8-in. size is used most often in cement slurries to overcome lost circulation. It is sometimes used with gilsonite, BDO, DOC, and other materials.

**Interaction with Other Additives:** It is an inert material.

**Safety and Handling Procedures:** Avoid creating and inhaling dust. Fine particles or dust can cause eye irritation. Flush the affected area with plenty of water. If irritation persists, get medical attention. Use foam, dry chemicals, carbon dioxide, or water spray as an extinguisher.

**Properties:**

- **Additive:** Flocele
- **Part No.:** 890.50071, 3/8 in.; 890.50111, 3/4 in.
- **Specific Gravity:** 1.42
- **Form:** flakes
- **Color:** transparent to white
- **How Packaged:** 50-lb sk
- **Bulk Density:** 15 lb/cu ft (240.3 kg/m³)
- **Water Requirement:** none
- **Absolute Volume:** 0.0845 gal/lb (0.7042 L/kg)
- **Solubility in Water:** @ 20°C, insoluble
- **Odor:** none

**Normal Range of Use in Wells:**

- **Temperature:** 60°F to 260°F (16°C to 127°C)
- **Concentration:** 1/8 to 1/2 lb (0.06 to 0.22 kg)/sk

**Special Information:**

- **Usage Restrictions:** Most of the Flocele used is the 3/8-in. size.
Foam Cement

Description and Primary Function: Foam cement slurries consist of normal cement slurries, including HOWCO-SUDS and Halliburton Foam Stabilizer. They are injected with varying amounts of nitrogen to generate the foam in the cement slurry to obtain the required density. Attaining an extremely low density is useful to prevent formation breakdown to weak formations and prevent lost circulation.

Secondary Effects: Foam cement improves insulating properties.

Related Information: See Foam Cements in the Lightweight Additives section for more information and typical performance characteristics.

Interaction with Other Additives: Avoid using dispersants or defoamers additives.

Safety and Handling Procedures: The foam cement slurry in the lines and well is under pressure. The return relief lines should be chained and staked, and precautions should be taken when releasing the pressure because the foam cement will expand greatly when released to atmospheric pressure. Avoid getting dust in eyes and inhaling dust. Wash the affected area with plenty of water.

Properties: See Table 11-1 on page 18.

Normal Range of Use in Wells:

Temperature: 28°F to 600°F (-2°C to 316°C)

Concentration: 1.5% HOWCO-SUDS bwow; 0.75% Stabilizer (Halliburton Foam Stabilizer or HC-2.) Nitrogen content varies with density and wellbore hydrostatic pressures.

Special Information:

Usage Restrictions: 4 to 15 lb/gal (0.48 to 180 kg/L). In salt cement slurries, use 3.0 to 4.5% CFA-S by weight of water instead of HOWCO-SUDS.

Effect on Slurry Properties:

1. increases yield
2. decreases density and strength
3. imparts compressibility
4. reduces filtrate loss
## Table 11-1: Properties of Foam Cement

<table>
<thead>
<tr>
<th>Additive</th>
<th>Part No.</th>
<th>Specific Gravity</th>
<th>Form</th>
<th>Color</th>
<th>How Pkg.</th>
<th>Density</th>
<th>Water Req.</th>
<th>Absolute Volume at 20°C</th>
<th>Solubility in Water at 20°C</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>CFA-S</td>
<td>516.00604</td>
<td>1.05</td>
<td>Liquid</td>
<td>Light Yellow</td>
<td>52 gal</td>
<td>8.75 lb/gal (1.05 kg/L)</td>
<td>N/A</td>
<td>0.1143 gal/lb (0.9524 L/kg)</td>
<td>Soluble</td>
<td>100%</td>
</tr>
<tr>
<td>HOWCO-SUDS</td>
<td>70.15602</td>
<td>1.04</td>
<td>Liquid</td>
<td>Yellowish</td>
<td>55 gal</td>
<td>8.66 lb/gal (1.04 kg/L)</td>
<td>N/A</td>
<td>0.1154 gal/lb (0.9615 L/kg)</td>
<td>Dispersable</td>
<td>100%</td>
</tr>
<tr>
<td>Halliburton Foam Stabilizer</td>
<td>516.00116</td>
<td>1.09</td>
<td>Liquid</td>
<td>Colorless</td>
<td>55 gal</td>
<td>9.08 lb/gal (1.09 kg/L)</td>
<td>N/A</td>
<td>0.1101 gal/lb (0.9174 L/kg)</td>
<td>Soluble</td>
<td>100%</td>
</tr>
<tr>
<td>HC-2</td>
<td>70.15308</td>
<td>9.95</td>
<td>Liquid</td>
<td>Straw</td>
<td>5 gal</td>
<td>8.55 lb/gal (0.95 kg/L)</td>
<td>N/A</td>
<td>0.1264 gal/lb (1.0526 L/kg)</td>
<td>Soluble</td>
<td>100%</td>
</tr>
<tr>
<td>Nitrogen</td>
<td>70.00002</td>
<td>0.00125 at atm. pressure</td>
<td>Vapor</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>N/A</td>
<td>Varies with Pressure</td>
<td>--</td>
<td>100%</td>
</tr>
</tbody>
</table>
Gilsonite

Description and Primary Function: Gilsonite, an asphaltene, is a hydrocarbon in granular form with a particle size of 4 to 100 mesh. It is used to control lost circulation by the bridging action of the granules and the reduced slurry weight caused by its low specific gravity.

Secondary Effects: Increasing the slurry yield per sack of cement saves money. It is resistant to shattering when perforated and does not significantly affect cement setting time. It normally gives higher strength at same density than heavier, high water requirement additives.

Related information: See Gilsonite in Lightweight Cements section for further information and typical performance characteristics.

Interaction with Other Additives: Gilsonite is an inert material. Because of its low specific gravity, thin slurries or dispersants can cause the Gilsonite to segregate to the top of the slurry. It is normally used with 2% or more bentonite to prevent segregation and obtain lower slurry densities.

Safety and Handling Procedures: Avoid creating and inhaling the dust. Wear goggles and a face mask. It can cause an allergic skin reaction. Flush contacted area with plenty of water. If irritation persists, get medical attention. Avoid sources of ignition where there are concentrations of dust. Use foam, dry chemical, carbon dioxide, or water spray to extinguish.

Properties:
Additive: Gilsonite
Part No.: 70.15573
Specific Gravity: 1.07
Form: solid granules
Color: black
How Packaged: 50-lb sk
Bulk Density: 50 lb/cu ft (801 kg/m³)
Water Requirement: 0.04 gal/lb (0.222 L/kg)
Absolute Volume: 0.1122 gal/lb (0.9345 L/kg)
Solubility in Water: @ 20°C, insoluble

Odor: asphaltic

Normal Range of Use in Wells:
Temperature: 60°F to 230°F (16°C to 110°C)
Concentration: 5 to 50 lb (2.27 to 22.6 kg)/sk

Special Information:
Usage Restrictions: Concentrations greater than 50 lb (22.68 kg)/sk and/or use of bottom cementing plug occasionally cause bridging inside the casing. Bottom plugs are not recommended.

Effect on Slurry Properties:
1. increases water requirement
2. decreases density, early strength, and final strength
Granulite TR 1/4

**Description and Primary Function:** Granulite TR 1/4 is a chopped-rubber by-product used to control lost circulation.

**Interaction with Other Additives:** Granulite TR 1/4 is an inert material. Because of its low specific gravity, thin slurries with dispersants can cause the Granulite TR 1/4 to segregate to the top of the slurry.

**Safety and Handling Procedures:** Avoid creating and inhaling dust. Wear goggles and a face mask to avoid getting dust in the eyes. Flush with plenty of water. Use foam to extinguish fires.

**Properties:**

- **Additive:** Granulite TR 1/4
- **Part No.:** 516.00573
- **Specific Gravity:** 1/4
- **Form:** chopped chunks
- **Color:** black
- **How Packaged:** 50-lb sk
- **Bulk Density:** 33.2 lb/cu ft (532 kg/m)
- **Water Requirement:** none
- **Absolute Volume:** 0.1053 gal/lb (0.8772 L/kg)
- **Solubility in Water:** @ 20°C, insoluble
- **Odor:** rubber

**Normal Range of Use in Wells:**

- **Temperature:** less than 400°F (204°C)
- **Concentration:** 1 to 3 lb (0.45 to 1.36 kg)/sk of cement

**Special Information:**

**Usage Restrictions:** High concentrations can cause pumping problems.
Perlite

Description and Primary Function: Regular Perlite is a type of crushed volcanic rock. It has been expanded by heat to produce a lightweight cellular material which is useful in controlling lost circulation and decreasing slurry weight.

Secondary Effects: When Perlite is added, slurry costs per unit volume are reduced by the increased yield per sack of cement.

Related Information: See Perlite-Regular in Lightweight section for more information and typical performance characteristics.

Interaction with Other Additives: Perlite is an inert material. Because of its low specific gravity at atmospheric pressure, Perlite can segregate to the top of the slurry during mixing if a slurry is too thin.

Safety and Handling Procedures: Avoid creating and inhaling dust. Wear goggles and a face mask. Avoid getting the dust on the skin and in the eyes. It can be irritating to skin and eyes. Flush affected area with plenty of water. If irritation persists, get medical attention.

Properties:

Additive: Perlite-Regular

Part No.: NIS.92

Specific Gravity: 0.67 at atmospheric pressures; 2.2 at 3,000 psi (20.7 mPa) pressure

Form: angular granules

Color: white

How Packaged: 32 lb (4 ft³) sk

Bulk Density: 8 lb/cu ft (1.28 kg/m³)

Water Requirement: 4 gal/bulk cu ft or 0.5 gal/lb (4.17 L/kg)

Absolute Volume: 0.1788 gal/lb (1.49 L/kg) at atmospheric pressure; 0.0546 gal/lb (0.46 L/kg) at 3,000 psi (20.7 mPa) pressure

Solubility in Water: @ 20°C, insoluble

Odor: none

Normal Range of Use in Wells:

Temperature: 60°F to 260°F (16°C to 127°C)

Concentration: 0.5 to 1.5 cu ft (0.014 to 0.042 m³)/sk in normal wells, as much as 12 cu ft (0.34 m³)/sk in stream injection wells

Special Information:

Usage Restrictions: Normally 2 to 6% bentonite (bwoc) is used to prevent Perlite particles from segregating in the slurry. Avoid using bottom plugs when using high concentrations of Perlite.

Effect on Slurry Properties:

1. increases water requirement.
2. decreases density, early strength, and final strength
Perlite-Six

Description and Primary Function: Perlite-Six is a mixture of 8 lb (3.62 kg) Perlite-Regular and 30 lb (13.61 kg) POZMIX® A. It is used to control lost circulation and decrease slurry density.

Secondary Effects: Adding Perlite-Six reduces slurry costs per unit volume by increasing the yield per sack of cement. It improves insulating properties.

Related Information: See Perlite-Six in Lightweight section for more information and typical performance characteristics.

Interaction with Other Additives: The Perlite-Regular portion is inert. POZMIX A will react with free lime in cement to form a cementitious material. The Perlite-Regular may segregate to top of slurry during mixing if the slurry is too thin because of its low specific gravity at atmospheric pressure.

Safety and Handling Procedures: Avoid creating and inhaling dust. Wear goggles and a face mask. Avoid getting the dust on the skin and in the eyes. It can be irritating to skin and eyes. Flush affected area with plenty of water. If irritation persists, get medical attention.

Properties:

Additive: Perlite-Six

Part No.: NIS.93

Specific Gravity: 1.58 at atmospheric pressure; 2.4 at 3,000 psi

Form: powder and angular granules

Color: light gray

How Packaged: bulk

Bulk Density: 38 lb/cu ft (608.7 kg/m³)

Water Requirement: 5.8 gal/bulk cu ft or 0.1526 gal/lb (1.27 L/kg) 0.0761 gal/lb (0.635 lb/kg) at atmospheric pressure

Absolute Volume: 0.0499 gal/lb (0.416 L/kg) at 3,000 psi (20.7 mPa) pressure

Solubility in Water: @ 20°C, insoluble

Normal Range of Use in Wells:

Temperature: 60°F to 260°F (16°C to 127°C)

Concentration: 0.5 to 1.5 ft³ (0.014 to 0.042 m³)/sk in normal wells; up to 12 ft³ (0.34 m³)/sk in steam injection wells

Usage Restrictions: Normally 2 to 6% bentonite (bwoc) is used to prevent Perlite particles from segregating in the slurry. Avoid using bottom plugs when using high concentrations of Perlite.

Effect on Slurry Properties:

1. increases water requirement
2. decreases density, early strength, and final strength
SPHERELITE

Description and Primary Function: SPHERELITE is low specific gravity microspheres used to decrease cement slurry density and prevent formation breakdown and loss of slurry to the formation.

Secondary Effects: It improves the insulating properties.

Related Information: See SPHERELITE Cements in Lightweight Cements section for more information and typical performance characteristics.

Interaction with Other Additives: Avoid using with dispersants.

Safety and Handling Procedures: Avoid breathing dust and getting dust in eyes. Wear dust-proof goggles. With high levels of dust, wear a toxic dust mask.

Properties:
Additive: SPHERELITE
Part No.: 516.00002
Specific Gravity: 0.685 (increases with pressure)
Form: powder
Color: gray
How Packaged: 50-lb sk
Bulk Density: 25 lb/cu ft (400.5 kg/m³)
Water Requirement: 65 to 75% by weight of SPHERELITE
Absolute Volume: varies with pressure (See graph in Lightweight Cements section.)
Solubility in Water: @ 20°C, insoluble
Normal Range of Use in Wells:
Temperature: 60°F to 800°F (16°C to 427°C)
Concentration: 10 to 180 lb (4.54 to 81.65 kg/sk) of cement

Special Information:
Usage Restrictions: Do not use in thin slurries. The insufficient viscosity causes SPHERELITE to segregate and float to the top.

Effect on Slurry Properties:
1. increases water requirement
2. decreases density and strength
SUPER FLUSH 100
(formerly FLO-CHECK® Liquid)

**Description and Primary Function:** SUPER FLUSH 100 is a liquid material which is reactive to salt in formation waters. It reacts in salt cements to form a viscous gel. It is used to prevent lost circulation. For severe lost circulation, use SUPER FLUSH 100 undiluted. For less severe lost-circulation problems, dilute SUPER FLUSH 100 with fresh water (1:1 or 1:2, SUPER FLUSH 1: fresh water for SUPER FLUSH 101 or 102 respectively) for economic reasons.

**Secondary Effects:** It improves mud displacement and cement bonding. (Also see Spacers section.)

**Related Information:** See SUPER FLUSH or FLO-CHECK in Special Cements section for more information.

**Interaction with Other Additives:** SUPER FLUSH 100 is highly reactive in the presence of divalent metal ions (such as calcium, i.e., cement), high saline solutions, and acids. Using fibrous, flake, or granular lost-circulation materials can often improve lost-circulation control efficiency.

**Safety and Handling Procedures:** Contact with skin and eyes can cause burns. Inhaling the mist causes severe irritation of upper respiratory system. Wear butyl-impervious gloves, neoprene-coated clothing over any skin which may contact material, and wear goggles and a face shield. In case of contact, immediately flush eyes and skin with plenty of water for at least 15 minutes while removing contaminated clothing and shoes. Continue to wash the skin until there is no slick feeling. Wash clothing and discard contaminated shoes.

**Properties:**

**Additive:** SUPER FLUSH 100

**Part No.:** 70.15607, 55 gal; 70.15644, bulk

**Specific Gravity:** 1.40

**Form:** liquid

**Color:** translucent

**How Packaged:** drum and bulk

**Density:** 11.66 lb/gal (1.40 kg/L)

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**Absolute Volume:** 0.0858 gal/lb (0.7143 L/kg)

**Solubility in Water:** @ 20°C, miscible

**Odor:** slightly soapy

**Freeze Point:** 30°F (-1°C)

**Pour Point:** 35°F (2°C)

**pH:** 11.2

**Activity:** 39%

**Normal Range of Use in Wells:**

**Temperature:** 60°F to 450°F (16°C to 232°C)

**Concentration:** Normally 200 gal (757.1 L) SUPER FLUSH 100/ft (0.305 m) of lost-circulation zone.

**Special Information:**

**Usage Restrictions:** Fresh water must be used as a spacer before and after SUPER FLUSH 100.

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**The SUPER FLUSH 100 Process**

The SUPER FLUSH 100 Process is a highly effective squeezing method for controlling underground water flows and sealing off lost-circulation intervals. The basic process involves pumping a fresh-water spacer and a cement slurry. As SUPER FLUSH 100 contacts the divalent ions in brine (either formation brine or injected brine), it forms a gel. When the salt in the cement contacts the SUPER FLUSH 100 of the gel, the cement flash-sets.

Depending on the conditions in the formation and the problem to be solved, the following procedures can be applied:

1. **Procedure for Sealing Off Formation Brine**
   a. Pump one tubing/drillpipe volume of fresh water.
   b. For each ft of zone, pump 200 gal (757 L) of SUPER FLUSH 100 containing 10 lb/gal (1.20 kg/L) of silica sand (SSA-2) or of 20-40 mesh sand and 1/4 to 1/2 oz (1/64 to 1/32) gal (1.87 to 3.7 g/L) of Tuf Additive No. 2.
   c. Pump a 5-bbl spacer of fresh water.
   d. Mix and pump cement, Tuf Additive No. 2, and sand (or some other medium-density material as required for controlling lost circulation).
e. Finish with the appropriate displacement and squeezing technique.

2. Procedure for Combating Lost Circulation

a. For a brine-water or very low-salt zone, pump 50 bbl of 10% brine containing at least 10% calcium chloride and follow with a 5-bbl spacer of fresh water.

b. Follow Steps 2 through 5 of Procedure 1 to complete the process.

3. Procedure for Cutting Off Bottomwater Production

a. Inject salt water into the bottom set of perforations or perforate below the existing perforations.

b. Set an EZ DRILL® packer between sets of perforations.

c. Pump a fluid compatible with the formation into the upper set of perforations while treating the lower set of perforations with SUPER FLUSH 100.

d. For each ft of zone, pump 200 gal (757 L) of SUPER FLUSH 100.

e. Pump a 2-bbl spacer of fresh water.

f. For each ft of zone, mix and pump 10 to 20 sk of low water-loss cement (use twice the normal volume of slurry used for squeeze jobs in the area).

g. In squeezing, do not let the squeezing pressure exceed the fracturing pressure or the injection pressure plus 500 psi (3.45 mPa), whichever is lower.

h. Pull out of the EZ DRILL packer and reverse circulate the excess cement slurry.

i. Replace the production equipment and resume production 24 hours after the SUPER FLUSH 100 treatment is complete.

The materials used in the SUPER FLUSH 100 Process are:

Cements
SUPER FLUSH 100
Tuf Additive No. 2
Sand (20-40 mesh)
THIXOMIX

Description and Primary Function: THIXOMIX is a thixotropic cement slurry consisting of cement, salt, sodium hydroxide, SUPER FLUSH 100, and water. Because of its thixotropic properties, THIXOMIX cement slurry has a long pumping time if it is kept in motion, but when pumping stops, the slurry gels to a viscous material. As a result, large volumes of slurry can be pumped into cavernous formations to seal them off.

Related Information: See THIXOMIX in Special Cements section for more information and typical performance characteristics.

Interaction with Other Additives: The mixing tank must be perfectly clean, and the pH of the mixing water should be at least 7.0. To prevent excessively high slurry viscosities when mixing the slurry, the salt should be added to the mixing water not to the dry cement.

Safety and Handling Procedures: Contact with skin and eyes can cause caustic burns. Wash affected areas with plenty of water. Inhaling the dust or mist can irritate the upper respiratory system. Wear protective clothing, goggles, and a face mask.

Properties:

Additive: THIXOMIX Cement

Part No.: none: It is a field blend of cement, salt, caustic (sodium hydroxide), SUPER FLUSH 100, and water. See individual materials for properties of specific materials.

Normal Range of Use in Wells:

Temperature: 50°F to 120°F (10°C to 49°C)

Concentration: 1 sk (94 lb) cement (Class A, B, C, G, or H), Salt (2 to 18% bwow), Caustic (0.3 to 1.5 lb sodium hydroxide/gal or 0.06 to 0.18 kg/L of SUPER FLUSH 100)

Mixing Fluid (80 parts water, 20 parts SUPER FLUSH 100 by volume) to yield a density of 12.5 to 14 lb/gal (1.50 to 1.68 kg/L)

Special Information:

Usage Restrictions: THIXOMIX is not recommended for use across a producing interval or at high temperatures because of its strength retrogression.

Effect on Slurry Properties:
1. increases viscosity, water requirement, and early strength
2. decreases density, thickening time, and final strength
THIX-SET A

Description and Primary Function: THIX-SET is a thixotropic cement consisting of Class A, B, C, D, or H cement, THIX-SET A, THIX-SET B, and mixing water. The thixotropic properties provide easy placement of the cement slurry as long as it is in motion. Rapid gelation when movement is stopped helps seal off lost-circulation zones. THIX-SET A provides much higher compressive strengths than THIXOMIX.

Related Information: See THIX-SET Cements in Special Cements section for more information and typical performance characteristics.

Interaction with Other Additives: It is compatible with fibrous, flake, and granular lost-circulation materials, SSA-1 and SSA-2. THIX-SET can be accelerated with CaCl₂ or retarded with HR®-4. Do not use with dispersing materials.

Safety and Handling Procedures: Avoid getting dust in the eyes and inhaling the dust. Wear a face mask and goggles. Wash the affected areas with plenty of water.

Properties:
Additive: THIX-SET A
Part No.: 70.15347
Specific Gravity: 1.97
Form: granules
Color: pale yellow
How Packaged: 50-lb drum
Bulk Density: 68 lb/cu ft (1,097 kg/m³)
Water Requirement: none
Absolute Volume: 0.069 gal/lb
Solubility in Water: @ 20°C, fully soluble
Odor: chlorine
Normal Range of Use in Wells:
Temperature: 60°F to 170°F (16°C to 77°C)
Concentration: 1.0% bwoc

Special Information:
Usage Restrictions: Dispersing additives should not be used in THIX-SET cement because they can destroy its thixotropic properties.

Effect on Slurry Properties:
1. increases viscosity
**THIX-SET B**

**Description and Primary Function:** THIX-SET is a thixotropic cement consisting of cement, THIX-SET A, THIX-SET B, and mixing water. The thixotropic properties provide easy placement of the cement slurry as long as it is in motion. Rapid gelation when movement is stopped helps seal off lost-circulation zones. THIX-SET B provides much higher compressive strengths than THIXOMIX.

**Related Information:** See THIX-SET Cements in the Special Cements section for more information and typical performance characteristics.

**Interaction with Other Additives:** It is compatible with fibrous, flake, and granular lost-circulation materials, SSA-1, and SSA-2. THIX-SET can be accelerated with CaCl₂ or retarded with HR⁶-4. Do not use with dispersing materials.

**Safety and Handling Procedures:** Avoid getting dust in the eyes and inhaling the dust. Wear a face mask and goggles. Wash the affected areas with plenty of water.

**Properties:**

- Additive: THIX-SET B
- Part No.: 70.15299
- Specific Gravity: 1.37
- Form: fine powder
- Color: white
- How Packaged: 50-lb sk
- Bulk Density: 32 lb/cu ft (5851097 kg/m³)
- Water Requirement: none
- Absolute Volume: 0.0876 gal/lb
- Solubility in Water: @ 20°C, forms a gel
- Odor: none

**Normal Range of Use in Wells:**

- Temperature: 60°F to 170°F (16°C to 77°C)
- Concentration: 0.25% bwoc

**Special Information:**

**Usage Restrictions:** Do not use with dispersing additives because they can destroy its thixotropic properties.

**Effect on Slurry Properties:**

1. increases viscosity
THIX-SET 31A

Description and Primary Function: THIX-SET 31A is a thixotropic cement additive which can be formulated using any class of cement or blends of POZMIX® A cement, THIX-SET 31B, and water. The rapid gelation of the THIX-SET 31A cement slurry when the slurry is static (after placement) enables the slurry to resist slurry flow and minimize cement slurry loss into a lost-circulation zone. THIX-SET 31A cement slurries can be used at much higher temperatures than thixotropic cement, THIXOMIX Cement, and THIX-SET.

Secondary Effects: THIX-SET 31A controls annular gas flow.

Related Information: See THIX-SET 31 Cements in the Special Cements section for more information and typical performance characteristics.

Interaction with Other Additives: It is compatible with fibrous, flake, and granular lost-circulation materials. It is also compatible with SSA-1, SSA-2, KCl, Diacel LWL, Component R, HR®-4, and other non-dispersing materials.

Safety and Handling Procedures: Avoid inhaling the dust and getting it in the eyes. Wash the affected areas with plenty of water.

Properties:
Additive: THIX-SET 31A
Part No.: 516.00151
Specific Gravity: 1.45
Form: powder
Color: white
How Packaged: 50-lb drum
Bulk Density: 66 lb/cu ft (1057.2 kg/m³)
Absolute Volume: 0.0602 gal/lb (0.0535 L/kg)
Solubility in Water: @ 20°C, decomposes
Odor: acidic
Normal Range of Use in Wells:
Temperature: 60°F to 400°F (16°C to 203°C)
Concentration: 0.15 to 1.0% (normally)

Special Information:
Usage Restrictions: Slurry densities range from 12 to 16.5 lb/gal (1.44 kg/L). Use Diacel LWL at elevated temperatures.

Effect on Slurry Properties:
1. increases viscosity
THIX-SET 31A Special

**Description and Primary Function:** THIX-SET 31A Special is a thixotropic cement additive which can be formulated using any class of cement or blends of POZMIX® A cement, THIX-SET 31B, and water. The rapid gelation of the THIX-SET 31A Special cement slurry when the slurry is static (after placement) enables the slurry to resist slurry flow and minimize cement slurry loss into a lost-circulation zone. THIX-SET 31 cement slurries can be used at much higher temperatures than thixotropic cement, THIXOMIX Cement, and THIX-SET.

**Secondary Effects:** THIX-SET 31A Special controls annular gas flow.

**Related Information:** See THIX-SET 31 Cements in the Special Cements section for more information and typical performance characteristics.

**Interaction with Other Additives:** It is compatible with fibrous, flake, and granular lost-circulation materials. It is also compatible with SSA-1, SSA-2, KCl, Diacel LWL, Component R, HR®-4, and other non-dispersing materials.

**Safety and Handling Procedures:** Avoid inhaling the dust and getting it in the eyes. Wash the affected areas with plenty of water.

**Properties:**

- **Additive:** THIX-SET 31A A Special
- **Part No.:** 516.00302
- **Specific Gravity:** 2.65
- **Form:** powder
- **Color:** white
- **How Packaged:** 50-lb drum
- **Bulk Density:** 66 lb/cu ft (1057.2 kg/m³)
- **Absolute Volume:** 0.0453 gal/lb (0.3774 L/kg)
- **Solubility in Water:** @ 20°C, decomposes
- **Odor:** acidic

**Normal Range of Use in Wells:**

- **Temperature:** 60°F to 400°F (16°C to 203°C)
- **Concentration:** 0.15 to 1.0% (normally)

**Special Information:**

**Usage Restrictions:** The density of slurries range from 12 to 16.5 lb/gal (1.44 kg/L). Use Diacel LWL at elevated temperatures.

**Effect on Slurry Properties:**

1. increases viscosity
THIX-SET 31B

Description and Primary Function: THIX-SET 31B is a thixotropic cement additive which can be formulated using any class of cement or blends of POZMIX® A cement, THIX-SET 31A, THIX-SET 31A Special, and water. The rapid gelation of the THIX-SET 31B cement slurry when the slurry is static (after placement) enables the slurry to resist slurry flow and minimize cement slurry loss into a lost-circulation zone. THIX-SET 31B cement slurries can be used at much higher temperatures than thixotropic cement, THIXOMIX Cement, and THIX-SET.


Related Information: See THIX-SET 31 Cements in the Special Cements section for more information and typical performance characteristics.

Interaction with Other Additives: It is compatible with fibrous, flake, and granular lost-circulation materials. It is also compatible with SSA-1, SSA-2, KCl, Diacel LWL, Component R, HR®-4, and other non-dispersing materials.

Safety and Handling Procedures: Avoid inhaling the dust and getting it in the eyes. Wash the affected areas with plenty of water.

Properties:

- **Additive:** THIX-SET 31B
- **Part No.:** 516.00152
- **Specific Gravity:** 1.38
- **Form:** powder
- **Color:** white
- **How Packaged:** 50-lb bag
- **Bulk Density:** 32 lb/cu ft (585 kg/m³)
- **Absolute Volume:** 0.0870 gal/lb (0.7246 L/kg)
- **Solubility in Water:** @ 20°C, slightly soluble
- **Odor:** mild alcohol

Normal Range of Use in Wells:

- **Temperature:** 60°F to 400°F (16°C to 203°C)
- **Concentration:** 0.0 to 0.04% (normally)

Special Information:

Usage Restrictions: Slurry densities range from 12 to 16.5 lb/gal (1.44 kg/L). Use Diacel LWL at elevated temperatures.

Effect on Slurry Properties:

1. increases viscosity
Thix Lite 373

Description and Primary Function: Thix Lite 373 is a thixotropic cement additive normally used in slurries ranging from 10.5 to 14.5 lb/gal (1.26 to 1.74 kg/L). It yields a highly thixotropic slurry with low mixing viscosities.

Secondary Effects: The short transition times caused by its thixotropic properties are useful in minimizing gas migration.

Safety and Handling Procedures: Thix Lite 373 is considered nonhazardous in normal working conditions, but normal safety precautions should be used to minimize contact with skin and eyes and inhaling dust.

Properties:
Additive: Thix Lite 373
Part No.: 516.00404
Specific Gravity: 2.34
Form: powder
Color: light pink
How Packaged: 50-lb sk
Bulk Density: 78.6 lb/cu ft (1259.1 kg/m³)
Water Requirement: 0.66 to 0.84 gal/lb
Absolute Volume: 0.0513 gal/lb (0.4274 L/kg)
Solubility in Water: @ 20°C, slightly soluble
Normal Range of Use in Wells:
Temperature: 60°F to 120°F (16°C to 99°C)
Concentration: from 5.3 to 43%.

Special Information:
Usage Restrictions: For temperatures less than 80°F (27°C), add 1 to 4% Thix Lite 373A and 0.5 to 4% ECONOLITE to the Thix Lite 373 slurry to obtain better thixotropic properties. At temperatures higher than 170°F (77°C), add 20 to 30% SSA-1 to Thix Lite 373 slurries to promote compressive strength.

Effect on Slurry Properties:
1. increases viscosity
2. decreases density
**Thix Lite 373A**

**Description and Primary Function:** Thix Lite 373A is a thixotropic cement additive normally used in slurries ranging from 10.5 to 14.5 lb/gal (1.26 to 1.74 kg/L). It yields a highly thixotropic slurry with low mixing viscosities.

**Secondary Effects:** The short transition times caused by its thixotropic properties are useful in minimizing gas migration.

**Safety and Handling Procedures:** Thix Lite 373A is considered nonhazardous in normal working conditions, but normal safety precautions should be used to minimize contact with skin and eyes and inhaling dust.

**Properties:**
- **Additive:** Thix Lite 373A
- **Part No.:** 516.00405
- **Specific Gravity:** 2.45
- **Form:** fine granular
- **Color:** white
- **How Packaged:** 50-lb sk
- **Bulk Density:** 78.6 lb/cu ft (1259.1 kg/m³)
- **Absolute Volume:** 0.0490 gal/lb (0.4082 L/kg)
- **Solubility in Water:** @ 20°C, soluble
- **Normal Range of Use in Wells:**
  - **Temperature:** 60°F to 170°F (16°C to 77°C)
  - **Concentration:** from 5.3 to 43%.

**Special Information:**
- **Usage Restrictions:** For temperatures less than 80°F (27°C), add 1 to 4% Thix Lite 373A and 0.5 to 4% ECONOLITE to obtain better thixotropic properties. At temperatures higher than 170°F (77°C), add 20 to 30% SSA-1 to Thix Lite 373A slurries to promote compressive strength.

**Effect on Slurry Properties:**
1. increases viscosity
2. decreases density
Tuf Additive No. 2

**Description and Primary Function:** Tuf Additive No. 2 is a fibrous material which can be added to cement slurries or SUPERFLUSH fluids to impart bridging and matting properties to prevent lost circulation.

**Secondary Effects:** Tuf Additive No. 2 also imparts shatter resistance to a set cement fracture damage when perforating.

**Interaction with Other Additives:** Tuf Additive No. 2 is an inert material.

**Safety and Handling Procedures:** Avoid inhaling fibers. Avoid getting fibers in the eyes.

**Properties:**

- **Additive:** Tuf Additive No. 2
- **Part No.:** 70.15286
- **Specific Gravity:** 0.95
- **Form:** fibers
- **Color:** various colors
- **How Packaged:** 50 lb
- **Water Requirement:** none
- **Absolute Volume:** 0.1264 gal/lb (1.0526 L/kg)
- **Solubility in Water:** @ 20°C, insoluble
- **Odor:** None

**Normal Range of Use in Wells:**

- **Temperature:** 60°F to 260°F (16°C to 127°C)
- **Concentration:** 1/8 to 1/2 lb (0.06 to 0.23 kg)/sk

**Special Information:**

- **Usage Restrictions:** There are mixing problems with large concentrations. Because it can cause bridging at valves, batch mix fibers on the job and not in any pneumatic plant.

**Effect on Slurry Properties:**

1. increases durability
**Tuf Plug (Ground Walnut Shells)**

**Description and Primary Function:** Tuf Plug consists of walnut shells ground to a specific size (coarse, medium, or fine). The medium grade is the most common grade used in cement slurries. It is used to combat lost circulation.

**Interaction with Other Additives:** Tuf Plug is an inert material.

**Safety and Handling Procedures:** Avoid creating and inhaling dust. Avoid getting dust in the eyes. Dust can irritate eyes. Flush affected area with plenty of water. Apply neutral oil to the eyes. If irritation persists, get medical attention. Use foam, dry chemical, carbon dioxide, or water spray as an extinguisher.

**Properties:**

**Additive:** Tug-Plug

**Part No.:** 890.51043, fine; 890.510.44, medium; 890.51045, coarse

**Specific Gravity:** 1.28

**Form:** granules

**Color:** tan

**How Packaged:** 50-lb sk

**Bulk Density:** fine, 40 lb/cu ft (640.7 kg/m³); medium and coarse, 50 lb/cu ft (820.9 kg/m³)

**Water Requirement:** none

**Absolute Volume:** 0.0938 gal/lb (0.7813 L/kg)

**Solubility in Water:** @ 20°C, insoluble

**Odor:** none

**Normal Range of Use in Wells:**

**Temperature:** 60°F to 290°F (16°C to 143°C)

**Concentration:** 1 to 5 lb (0.45 to 2.27 kg)/sk

**Special Information:**

**Usage Restrictions:** To avoid pumping problems, do not use more than 4 lb (1.8 kg)/sk in normal slurries or more than 8 lb (3.62 kg)/sk of gel cement.

**Effect on Slurry Properties:**

1. increases density (slightly)