LIGHTWEIGHT SYSTEMS

INTRODUCTION

The set strength of Portland cement is usually greater than that required for cementing casing in the well. There is a wide range of lightweight cements that are currently in use. Their primary purpose is to have a greater yield in terms of volume per sack of cement. The result is a less expensive slurry with the sacrifice of some compressive strength.

Lightweight systems can be divided into two categories: lightweight cements and extended systems. When an extender is added to Portland cement during its manufacture, the resulting product is called a lightweight cement. An extender is any material added to cement to increase slurry volume.

A host of materials are used for extending cement slurries. Extenders add to slurry volume or they absorb water in order for additional water to be added to the slurry without creating the problem of too much free water:

Extended cements also have a higher degree of permeability. The effect of permeability increase may vary with the extender used and is a factor that must be considered. The following table indicates the effect of reduced density on permeability and compressive strength.

EFFECT OF DENSITY ON COMPRESSIVE STRENGTH AND PERMEABILITY

WEIGHT		Compressive Strength		Permeability	
lb/gal	**lb/ft^3**	**350°F**	**350°F**	**Above 350°F**	**Below 350°F**
13.6102	2000	2000		0.002	0.1
12.090	1000-2000	1000		0.004	0.2
11. 485	600-1600	400-1000		0.01	0. 4
10.881	500-900	300-8000		0.03	0.8

Besides giving an increase in yield, another benefit of extenders is that it provides reduced densities. The risk of fracturing the formation and losing the slurry to weak zones is reduced when cementing. Such applications are extremely important when cementing through lost circulation zones. The use of a light slurry creates the possibility of cementing the zone in one stage or at least a reduction in the number of stages.

CLAYS AS EXTENDERS

The first material that was extensively used as an extender for cement was P-EBA (gel). This was due to its availability since it was widely used in drilling muds. P-EBA is able to absorb large quantities of water. It improves the suspension of solids by increasing the gel strength of the slurry. It also prevents the separation of bridging agents. P-EBA also provides some improvement in fluid-loss control.

If P-EBA is pre-hydrated in fresh water for approximately one hour before the actual mixing of the slurry, a much larger volume of water can be added. Pre-hydrating allows the preparation of much lighter density slurries than the method of dry blending. Our laboratories have proven that 2.2 % pre-hydrated yields the same as 8.0 % dry blended.

Attapulgite is a magnesium clay. Due to the fact that it is not greatly affected by the salt water or calcium in cement, it serves as an excellent extender for high salt content slurries.
Unlike P-EBA, it does not have fluid-loss properties and its quality varies considerably.

POZZOLAN EXTENDERS

The main reason for using pozzolans as extenders is due to the fact that they produce slightly stronger cements. If it is available locally, pozzolans provide a very economic slurry. A reaction between the calcium hydroxide released by set Portland cement results in the formation of a cementitious product. This product causes much improved strength in comparison to non-reactive extenders. Pozzolans cannot be mixed at as low densities as P-EBA because they do not require as much water as P-EBA. At temperatures below 140°F, development of the reaction between calcium hydroxide and lime is slow.

The combustion of coal as a fuel, at high temperatures results in the production of an ash that has pozzolanic properties. This ash is available as fly ash, but product properties vary slightly. Fly ash has to be used in combination with other materials to produce a very lightweight slurry. However, its use is not recommended for temperatures exceeding 450°F.

DIATOMACEOUS EARTH

This is an extremely lightweight pozzolan which has a high silica content. It can be used effectively to prepare extenders for slurries at temperatures in excess of 450°F.

SILICATES

The reaction of calcium and other divalent ions found in cement or seawater forms a water-based gel that absorbs fairly large quantities of water thus producing lightweight slurries with minimum free water. There are certain sodium silicates which are used a chemical extenders that perform this reaction. However, before addition of silicate, the calcium must be dissolved in the water.

LIGHTWEIGHT PARTICLES

Lightweight materials are frequently added to zones where lost circulation has been experienced to reduce the hydrostatic pressure of the head of the slurry and serve as bridging agents to avoid excess slurry loss to fractured zones. They are classified as extenders due to the fact that they increase the slurry yield.

EXPANDED PERLITE

This product is manufactured by heating the mineral at temperatures almost equal to its melting point. A light inorganic foam is formed due to the expansion of the mineral which occurs as internal moisture is converted to steam. At atmospheric pressures, perlite function as a cement additive to produce very lightweight slurries but at 2000-3000 psi, the particles collapse and the slurries regain their original density (almost). When designing lightweight slurries using perlite, P-EBA is also added, because perlite (used in isolation) floats out of the slurry, thus increasing cement permeability.

GROUND COAL

With the exception of the lightest slurries, ground coal serves as an extender to reduce the weight of most cement slurries. Its main purpose is more of a bridging agent than a weight reducer. Ground coal can best be described as an angular, inert lightweight material.

GILSONITE

Gilsonite has basically the same properties as ground coal. It is also soluble in oil and softens at high temperatures. The melting point of gilsonite is approximately 385°F.

SPECIAL LIGHTWEIGHT CEMENT

There are cements specially designed to provide lightweight slurries. They are sold as Lightweight Cements and are basically finely grounded pozzolans that require more water than normal cements mixed at lighter densities. Lightweight cements can also be mixed with P-EBA to produce super lightweight slurries. However these cements should not be used in systems where the BHCT exceeds 450°F.

COMPARISON OF EXTENDERS

Table I provides a comparison of various extenders by showing the amount of extra water required by the extender. The percent extender is based on a 94-1b sack of cement. For comparison, the values shown for gallons of extra water required are all based on 94-1b sacks, even though actual calculation for some systems would use an equivalent sack.

The values shown are approximate. Water requirements for extenders change with variations in material or particle size. Actual water requirements should be established by the laboratory.

Water percentage is given for each percent extender used or for each pound of extender where applicable. For example, to fine the extra water required for a 10 percent (P-EBA) slurry.

10 % P-EBA requires 10 x 5. 3 = 53 % water

0.53 x 94/8.32 = 6.0 gal of extra water per sack of cement.

TABLE I

COMPARISON OF INCREASED WATER

REQUIREMENT BY EACH EXTENDER

Extender	% Water For each Extender	% Water per lb of Extender	Extra Water gal per sack of Cement
CLAYS			
P-EBA, Blended with cement	5.3	--	0.60
P-EBA, with Aluminous cement	8.0	--	0.93
P-EBA, Pre-hydrated	21.2	--	2.4
Attapulgite	10-15	--	1.13-1. 69
POZZOLAN EXTENDERS			
(Fly Ash)	--	0.7-1.0	0.08-0.11
Diatomaceous Earth	--	4.0	0.45
Silica	0.3	--	0.03
Lime	--	1.0	0.11
SILICATES			
P-EXT (2-4% Free Water)	55	--	6.2
P-EXTL (liquid) (2-4% Free Water)	--	265(per gal)	30
PARTICULATED SOLIDS			
Perlite	--	3.7	0.42
Gilsonite	--	0.35	0.04

The percent water shown for each percent P-EXT (55 %) and for each gallon of P-EXTL (265%) results in 2 to 4% free water. A small amount of silicate (0.5% P-EXT or 0.17 gal P-EXTL) must be added before an effective gel forms. No water separation occurs when the water requirement is calculated from percent P-EXT minus 0.5% or gallons P-EXTL minus 0.17 gal.