SECTION VII

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SPECIAL CEMENTS

ENGLISH UNITS

FOAM CEMENT

Halliburton's FOAM CEMENT makes lightweight slurries (6 to 11 lb/gal) for well cementing relatively easy to produce. Also, FOAM CEMENT makes ultra-lightweight slurries (3 to 4 lb/gal) for specialty applications readily available.

Lightweight FOAM CEMENT slurries are especially useful for cementing wells that pass through zones having very sensitive fracture gradients that have consistently failed to support the hydrostatic pressure of conventional lightweight slurries. Also, FOAM CEMENT has potential for low density grouting mixtures and for lightweight slurries used for cementing offshore conductor and casing pipe in weak unconsolidated formations. It can also be used to form floating cement plugs on hydrocarbon or aqueous fluids.

The nature of Halliburton's FOAM CEMENT helps make it economically attractive. It increases the yield of a sack of cement from 1 cu. ft. to as much as 4 cu. ft. depending on weight of the foamed slurry. Also FOAM CEMENT acts as a lost circulation aid thereby reducing the amount of other additives required.

FOAM CEMENT may be formed by using readily available, standard equipment and a gas such as nitrogen. Halliburton's FMCEM computer program can provide the proper mixing rates and volumes for the desired final slurry weight.

Whether you need a lightweight slurry for cementing through problem zones, an ultra-lightweight slurry for specialty applications, or a slurry to provide inexpensive fillup, Halliburton's FOAM CEMENT may meet your needs.

COMPRESSIVE STRENGTH OF FOAM CEMENT CURED AT ATMOSPHERIC PRESSURE

CLASS A CEMENT

Surface Slurry: Class A cement + 2.0% CaCl2 + 5.2 Gal/Sk - 15.6 Lb/Gal

Curing Temperature:	65°F			100°F			140°F		
Density of FOAM CEMENT	Compressive Strength (psi)								
(lbs/gal)	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.
10	390	480	1540	850	1460	1900	980	1120	1530
8	160	250	1020	470	650	1020	440	460	740
6	50	90	400	140	250	400	230	250	360

CLASS C CEMENT

Surface Slurry: Class C cement + 2.0% CaCl2 + 6.3 Gal/Sk - 14.8 Lb/Gal

Curing Temperature:	65°F			100°F			140°F		
Density of FOAM CEMENT	Compressive Strength (psi)								
(lbs/gal)	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.
10	480	890	1680	1110	1380	1880	1220	1250	1790
8	290	440	920	690	790	1000	530	590	720
6	150	270	410	320	330	720	360	280	460

CLASS G CEMENT

Surface Slurry: Class G cement + 2.0% CaCl2 + 5.0 Gal/Sk - 15.8 Lb/Gal

Curing Temperature:	65°F			100°F			140°F		
Density of FOAM CEMENT	Compressive Strength (psi)								
(lbs/gal)	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.
10	200	470	1070	620	890	1100	600	900	1270
8	120	260	500	260	420	570	310	330	550
6	40	80	140	130	170	220	150	160	180

CLASS H CEMENT

Surface Slurry: Class H cement + 2.0% CaCl2 + 4.3 Gal/Sk - 16.4 Lb/Gal

Curing Temperature:	65°F			100°F			140°F		
Density of FOAM CEMENT	Compressive Strength (psi)								
(lbs/gal)	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.
10	100	180	710	270	600	760	400	620	750
8	70	90	250	160	370	540	200	300	350
6	30	50	150	130	130	240	90	130	150

METRIC UNITS

FOAM CEMENT

Halliburton's FOAM CEMENT makes lightweight slurries (0.72 to 1.32 Kg/L) of well cementing relatively easy to produce. Also, FOAM CEMENT makes ultra-lightweight slurries (0.36 to 0.48 Kg/L) for specialty applications readily available.

Lightweight FOAM CEMENT slurries are especially useful for cementing wells that pass through zones having very sensitive fracture gradients that have consistently failed to support the hydrostatic pressure of conventional lightweight slurries. Also, FOAM CEMENT has potential for low density grouting mixtures and for lightweight slurries used for cementing offshore conductor and casing pipe in weak unconsolidated formations. It can also be used to form floating cement plugs on hydrocarbon or aqueous fluids.

The nature of Halliburton's FOAM CEMENT helps make it economically attractive. It increases the yield of a sack of cement from 28.32 L. to as much as 113.27 L. depending on weight of the foamed slurry. Also FOAM CEMENT acts as a lost circulation aid thereby reducing the amount of other additives required.

FOAM CEMENT may be formed by using readily available, standard equipment and a gas such as nitrogen. Halliburton's FMCEM computer program can provide the proper mixing rates and volumes for the desired final slurry weight.

Whether you need a lightweight slurry for cementing through problem zones, an ultra-lightweight slurry for specialty applications, or a slurry to provide inexpensive fillup, Halliburton's FOAM CEMENT may meet your needs.

COMPRESSIVE STRENGTH OF FOAM CEMENT CURED AT ATMOSPHERIC PRESSURE

CLASS A CEMENT

Surface Slurry: Class A cement + 2.0% CaCl2 + 19.7 L/Sk - 1.87 Kg/L

Curing Temperature:	18°C			38°C			60°C		
Density of FOAM CEMENT	Compressive Strength (MPa)								
(Kg/L)	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.
1.20	2.68	3.31	10.62	5.86	10.07	13.10	6.76	7.72	10.55
0.96	1.10	1.72	7.03	3.24	4.48	7.03	3.03	3.17	5.10
0.72	0.34	0.62	2.76	0.97	1.72	2.76	1.59	1.72	2.48

CLASS C CEMENT

Surface Slurry: Class C cement + 2.0% CaCl2 + 23.8 L/Sk - 1.77 Kg/L

Curing Temperature:	18°C			38°C			60°C		
Density of FOAM CEMENT	Compressive Strength (MPa)								
(Kg/L)	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.
1.20	3.31	6.14	4.58	7.65	9.51	12.96	8.41	8.62	12.34
0.96	2.00	3.03	6.34	4.76	5.45	6.89	3.65	4.07	4.96
0.72	1.03	1.86	2.83	2.21	2.28	4.96	2.48	2.62	3.17

CLASS G CEMENT

Surface Slurry: Class G cement + 2.0% CaCl2 + 18.9 L/Sk - 1.89 Kg/L

Curing Temperature:	18°C			38°C			60°C		
Density of FOAM CEMENT	Compressive Strength (MPa)								
(Kg/L)	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.
1.20	1.38	3.24	7.38	4.27	6.14	7.58	4.14	6.21	8.76
0.96	0.83	1.79	3.45	1.79	2.90	3.93	2.14	2.28	3.79
0.72	0.28	0.55	0.97	0.90	1.17	1.52	1.03	1.10	1.24

CLASS H CEMENT

Surface Slurry: Class H cement + 2.0% CaCl2 + 16.3 L/Sk - 1.97 Kg/L

Curing Temperature:	18°C			38°C			60°C		
Density of FOAM CEMENT	Compressive Strength (MPa)								
(Kg/L)	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.	12 Hr.	24 Hr.	72 Hr.
1.20	0.69	1.24	4.90	1.86	4.14	5.24	2.76	4.27	5.17
0.96	0.48	0.62	1.72	1.10	2.55	3.72	1.38	2.07	2.41
0.72	0.21	0.34	1.03	0.90	0.90	1.65	0.62	0.90	1.03

GAS-CHEK® CEMENT

GAS-CHEK® cement additive has been introduced to provide an effective means of helping prevent gas flow into the annulus after cement has been placed. Historically, the industry has been plagued with the problem of annular gas flow following completion of cementing jobs. Numerous corrective practices have been attempted in order to help prevent annular gas flow, but previously no completely reliable process had been found.

GAS-CHEK® cement provides a new cementing technique for annular gas flow problems. GAS-CHEK® cement does not have to be used in the entire cementing operation but should be used across all possible gas invasion zones.

A cement slurry mixed and initially placed into a well annulus behaves as a fluid, i.e. it transmits hydrostatic pressure throughout the cement column based on slurry density and depth. After the cement sets, it behaves as a solid. Solids do not transmit hydrostatic pressure. However, between the liquid and solid states of the cement it passes through a transition or plastic phase. In this transition phase the cement is neither a fluid nor a solid. When in this phase the cement will not transmit hydrostatic pressure but is not strong enough to prevent gas cutting or flow.

When the cement slurry in the annulus enters this transition phase, the original hydrostatic pressure is trapped within the cement matrix. This pressure is maintained by the water present in the cement matrix.

This water within the cement matrix is not compressible; therefore, any change in volume will cause a rapid decrease in pressure which in this transition state cannot be resupplied from the column above. This decrease in volume can and does occur by two mechanisms:

1. Fluid Loss-Although it is possible to reduce fluid loss of a slurry to a low value, sufficient to prevent dehydration, it is impossible to reduce fluid loss to zero.
2. Cement Hydration-During initial cement hydration, the same time period in which the slurry fails to transmit hydrostatic pressure, water within the pore space undergoes a decrease in volume. The chemical reactions involved cause decreases in volume by a factor of 0.2-0.5 percent.

These decreases in volume, since the pressure-maintaining water phase is not compressible to any great extent, allows the original trapped hydrostatic pressure to decrease. When the pressure decreases to less than formation gas pressure, annular gas flow can occur.

Expanding cements undergo these same decreases in internal volume and pore pressure. Their expansion only occurs after the cement reaches a set or solid condition. By this time, gas invasion may already have occurred. Expanding cements, zero free water cements and gel cements do nothing towards solving annular gas migration.

GAS-CHEK® cement slurries are designed and tailored to meet the requirements of individual job conditions. Knowledge of downhole conditions is a necessary element of proper planning and job design. Information requested for GAS-CHEK® cement slurry design includes:

1. Temperature at T.D. (log, circulating or static)
2. Well geometry (hole and casing diameters and true vertical depth)
3. Density of wellbore fluid
4. Desired cement slurry density
5. Desired height of cement
6. Anticipated cement and displacement pumping rates

ENGLISH / METRIC UNITS

CAL-SEAL

Cal-Seal is a high strength, controlled setting gypsum cement, which has been designed specifically for use in oil and gas wells. Its controlled setting makes Cal-Seal highly adaptable to a wide range of remedial jobs such as bridging plugs, split pipe and lost circulation. It can be placed by either conventional cementing methods or Dump Bailer equipment; however, the dump bailer technique is generally preferred.

SLURRY PROPERTIES

Cal-Seal Lbs. (Kg)	Water Gal. (L)	Slurry Weight Lbs./Gal. (Kg/L)	Slurry Volume Gals. (L)	Setting Time 60° - 180°F (16° - 82°C)	Compressive Strength psi (MPa)
100 (45.4)	4.8 (18.2)	15.1 (1.81)	9.2 (34.8)	50-60 Min.	2500 psi (17.24 MPa) (within 1 hr. after setting)

HYDROMITE

Hydromite is a combination of a powdered resin and gypsum cement. It is mixed with fresh water and a catalyst, or retarder, to form a slurry with a setting time controlled to fit the temperature conditions of the well in which it is to be used.

TEMPERATURE RANGE		ADDITIVE
60° - 120°F	(16° - 49°C)	Catalyst A
120° - 180°F	(49° - 82°C)	Catalyst A-120
180° - 225°F	(82° - 107°C)	Sodate Retarder

Hydromite is placed in the well with regular Dump Bailer equipment. With the application of pressure, the resin phase is squeezed into the formation where it sets to form a hard impervious barrier to formation fluids or gases.

SLURRY PROPERTIES

Hydromite Lbs. (Kg)	Water Gal. (L)	Slurry Weight Lbs./Gal. (Kg/L)	Slurry Volume Gals. (L)	Setting Time 60° - 225°F (15° - 107°C)	Compressive Strength 3 Hours psi (MPa)
100 (45.4)	3.0 (11.4)	14.9 (1.79)	8.4 (31.8)	75-100 Min.	1500 psi (10.34 MPa)

ENGLISH UNITS

MICRO MATRIX CEMENT

Description and Primary Function: Micro Matrix is an ultra-fine cement designed to penetrate gravel packs, very small channels, and repair casing leaks. Micro Matrix can be used as a lightweight cement for primary cementing. Its primary application is to squeeze off gravel packs and repair casing leaks. It can penetrate openings as small as 0.05 mm because it is as much as ten times smaller than standard cement.

Usage Restrictions: MICROSAND must be added when Micro Matrix is used at temperatures higher than 140°F. Do not mix 100% Micro Matrix at a density greater than 12 lb/gal because severe gelation problems will occur. **To overcome gelation problems, use Micro fly ash at a 50:50 ratio.**

Summary of Compressive Strength (psi)
Development for Various Micro Fly Ash and Micro Matrix Systems

	3 Days	7 Days	21 Days	3 Days	7 Days	21 Days
Slurry #	150°F Data			200°F Data		
1	777	727	748	—	—	—
2	517	710	1,111	—	—	—
3	N.S.	2,260	2,150	2,200	3,110	—
4	661	1,379	1,910	—	—	—
	200°F Data			350°F Data		
1	576	592	601	88	70	60
2	1,654	1,904	2,370	1,262	1,120	259
3	1,400	1,814	2,500	1,233	657	671
4	1,484	2,100	2,370	769	1,581	1,412
5	—	—	—	1,607	—	2,250

Cube Descriptions **(all mixed at 12.0 lb/gal)**

1. Micro Matrix +0.05 gal/sk defoamer + 1.0% fluid loss + 0.05 gal/sk retarder + 116.4% Water
2. Same as #1 + 60% MicroSand + 178.4% water
3. 50:50 Blend + 0.05 gal/sk defoamer + 1% fluid loss + 0.05 gal/sk + 106.2% water
4. Same as #3 + 40% MicroSand (by weight of blend) + 148.24% water
5. Same as #3 + 35% MicroSand (by weight of cement) + 124.6% water

ENGLISH UNITS

MICRO BOND CEMENT

MicroBond was developed to provide cement expansion for a wide variety of cements at in place static conditions of 32 to 175 deg F.

Low Temperature Class A Slurries with Salt, 80 deg F
Cement: Foreman Class A, Duncan, Oklahoma

	A	B	C	D
Formulation (% bwc)				
MicroBond	8.2	8.2	11.5	11.5
Fluid Loss Additive	0.4	0.4	0.4	0.4
Dispersant	0.51	0.51	0.6	0.6
Salt	2.14	2.14	3.0	3.0
Calcium Chloride	0	2.0	0	2.0
Water	50	50	51.6	51.6
Slurry Properties				
Density (lb/gal)	15.5	15.6	15.5	15.6
Yield (cu ft/sk)	1.30	1.31	1.34	1.35
Expansion (% linear)(b)				
1 Day	0.13	0.19	0.18	0.33
3 Day	0.16	0.31	0.24	0.44
28 Day	0.26	0.33	0.36	0.64
UCA Compressive Strengths				
Initial Set (hr:min)	4:09	7:26	8:33	8:02
24 Hour (psi)	2100	1800	1800	1600
3 Day (psi)	3750	3300	3100	2500
7 Day (psi)	4640	4130	4400	3700

(a) Atmospheric Consistometer, 80 deg F
(b) Water bath, unrestrained.

ENGLISH UNITS

MICROBOND M

MicroBond M is a chemical expansive additive that was developed specifically for use at moderate temperatures ranging from about 130°F to 210°F. It will provide more expansion than MicroBond at 130°F to 170°F. It will also provide significant expansion much quicker than MicroBond HT at 170°F to 190°F, i.e., in three days versus 7 to 14 days. The good expansive properties of MicroBond M make it very easy to design an expansive cement slurry at moderate temperatures.

TEST SLURRIES

	Slurry No. 1		Slurry No. 2		Slurry No. 3	
Component	Percent	lbs/sk	Percent	lbs/sk	Percent	lbs/sk
Premium cement	100	94	100	94	100	94
SSA-1	0	0	35	32.9	0	0
Salt	0	0	0	0	12	4.3
MicroBond M	5	4.7	5	4.7	5	4.7
Fluid Loss #1	0.5	0.47	0.5	0.47	0	0
Fluid Loss #2	0	0	0	0	0.5	0.47
Retarder	variable		0.2	0.188	0	0
Water	38.1	35.8		51.4	38.1	35.8

	Slurry No. 4		Slurry No. 5		Slurry No. 6	
Component	percent	lbs/sk	Percent	lbs/sk	Percent	lbs/sk
Premium Cement	100	94	100	94	100	94
SSA-1	0	0	0	0	35	32.9
Salt	18	6.45	Sat'd	13.3	34.8	18.9
MicroBond M	5	4.7	5	4.7	5	4.7
Fluid Loss #2	0.5	0.47	0.5	0.47	0.5	0.47
Fluid Loss #3	0	0	0	0	0.5	0.47
Dispersant	0	0	0	0	0.2	0.188
Retarder	0	0	0.2	0.188	0	0
Water	38.1	35.8	38.1	35.8	57.6	54.1

EXPANSION DATA

Slurry No.	Salt (%)	Curing Temp (°F)	Expansion 3 Day (%)	Expansion 7 Day (%)	Expansion 14 Day (%)
1	0	95	0.14[1]	0.18	0.27
1	0	110	0.17[1]	0.21	0.28
1	0	130	0.21	0.54	1.21[2]
1	0	150	0.13	0.68	1.45[2]
1	0	170	—	1.3	—
1	0	190	0.39	0.50	0.46[2]
1	0	210	0.36	0.44	0.37[2]
2	0	240	0.31[1]	0.30	—
3	12	150	0.40	0.84	1.27
4	18	150	0.40	0.58	1.02
5	37	150	0.42[3]	0.56	0.61
6	34.8	275	0.49	0.51	—

[1] Actual measurements made after 4 days.
[2] Actual measurements made after 15 days.
[3] Actual measurements made after 2 days.

ENGLISH UNITS

MICROBOND HT

MicroBond HT is an expansive cement additive for use at temperatures above 170 deg F. Previously, cement expansion additives have been limited by either the type of cement in which they could be used, or by a maximum effective temperature. MicroBond HT not only provides expansion above 170 deg F, but also is functional in all API cement classifications. MicroBond HT can provide up to 1 to 3% linear expansion from dosages ranging from approximately 3 to 5% (by weight of cement).

Dosage vs Expansion at 275 deg F and 3000 psi

MicroBond HT (%)	Water (%)	3 Day Expansion (%)
Class H cement, 40% SSA-2 + 10% SSA-1 + Fluid Loss Additive + Retarder		
2.00	37.0	0.14
3.00	37.5	1.73
2.66	42.1	0.28
3.55	41.4	1.18
4.44	41.8	2.96
5.33	41.0	4.49
Class H cement, 40% SSA-2 + Fluid Loss Additive + Retarder		
4.44	38	2.14
3.5	38	1.34
3.0	37.5	1.73
2.0	37	0.14

ENGLISH UNITS

SILICALITE

Silicalite consists of a finely divided, high surface area silica that can be provided as a liquid or a powder. The physical and chemical properties of this silica material make it very useful for a variety of cementing applications including (1) use as an extender for lightweight cement, (2) compressive strength enhancement of low temperature lightweight cement, (3) thixotropic properties for squeeze cementing, lost circulation and gas migration control. In addition to these properties, Silicalite also provides a degree of fluid loss control and acts as a low temperature accelerator for saturated salt slurries.

Compressive Strength Development of Blends Containing POZMIX® Silicalite and Cement

Silicalite Base: 1:1:2.54 POMIX:Silicalite:Cement (84 lb/sk)

Slurry Density (lb/gal)	Slurry Volume (cu ft/sk)	Water (gal/sk)	Additive (% by Wt.)	Cement Type	Compressive Strength (psi) 24 Hr	Compressive Strength (psi) 72 Hr
			60°F (Atmospheric)			
12.0	1.97	11.19	4%CaCl2	Standard	60	130
12.5	1.74	9.42	4%CaCl2 0.5% Dispersant	Standard	115	300
			80°F (Atmospheric)			
11.0	2.71	16.72	None	Standard	30	95
11.5	2.29	13.52	None	Standard	80	195
12.0	1.97	11.19	1% CaCl2	Standard	180	—
12.3	1.83	10.08	1% CaCl2	Standard	285	—
12.6	1.70	9.18	1% CaCl2	Standard	360	—
12.0	1.97	11.19	1% CaCl2	Premium Plus	170	455
12.1	1.92	10.80	0.5% CaCl2	Premium Plus	240	700
12.4	1.78	9.74	0.5% CaCl2	Premium Plus	350	960
			90°F (Atmospheric)			
11.5	2.29	13.52	None	Premium (4.3)	—	295
11.5	2.24	13.52	0.5% CaCl2	Premium (4.3)	—	320
11.5	2.29	13.52	1.0% CaCl2	Premium (4.3)	—	420
11.5	2.40	14.20	5.0% Salt	Premium (4.3)	—	515
11.75	2.12	12.27	0.5% CaCl2	Premium (4.3)	—	300
11.75	2.12	12.27	1.0% CaCl2	Premium (4.3)	—	370
11.75	2.24	13.10	5.0% Salt	Premium (4.3)	—	680
			95°F (Atmospheric)			
12.0	1.97	11.19	1%CaCl2	Standard	—	1585
12.2	1.87	10.43	1%CaCl2	Standard	—	1735
12.4	1.78	9.74	1%CaCl2	Standard	—	1525
12.0	1.97	11.19	1%CaCl2	Premium Plus	—	1520
			100°F (Atmospheric)			
11.0	2.71	16.72	None	PremiumPlus	60	330
12.0	1.97	11.19	None	Premium Plus	135	925
13.7	1.35	6.52	0.75% Dispersant 2% CaCl2	Standard	1835	4615
			140°F (Atmospheric)			
10.0	4.34	28.88	4% Bentonite	Standard	160	200
11.0	2.71	16.72	2% Bentonite	Standard	1115	1440
12.0	1.97	11.19	None	Standard	1290	1455
12.5	1.74	9.42	0.5% Dispersant	Standard	1825	2335
11.5	2.40	14.20	5% Salt	Premium(4.3)	825	—
			150°F (Atmospheric)			
11.5	2.29	13.52	None	Premium Plus	580	675
12.0	1.97	11.19	None	Premium Plus	900	1010
			230°F (Atmospheric)			
12.0	1.97	16.72	None	Standard	2380	1960
12.5	1.74	9.42	0.5% Dispersant	Standard	2750	2825
13.7	1.35	6.52	0.75 % Dispersant 2% CaCl2	Standard	5265	5600

PERMEABILITY OF VARIOUS CEMENTING COMPOSITIONS TO WATER (Millidarcies)

SLURRY COMPOSITION	Water Gal./Sk.	80°F (1) 1 Day	80°F (1) 7 Days	80°F (1) 28 Days	100°F (1) 1 Day	100°F (1) 7 Days	100°F (1) 28 Days	120°F (1) 1 Day	120°F (1) 7 Days	120°F (1) 28 Days	140°F (1) 1 Day	140°F (1) 7 Days	140°F (1) 28 Days
CLASS A CEMENT (COMMON PORTLAND)													
Neat	5.2	0.102	*	*	0.005	*	*	*	*	*	*	*	*
4% Bentonite	7.7	0.423	*	*	0.116	*	*	0.075	*	0.001	0.020	0.005	0.005
25 Lbs. Gilsonite	6.2	0.791	*	*	0.234	*	*	0.398	*	*	0.019	*	0.002
20% Diacel D	13.5	**	0.304	0.003	**	0.001	*	**	*	*	0.026	0.002	*
40% Diacel DLR-11 Resin	25.6	**	1.546	0.002	**	0.007	*	**	*	*	0.059	0.011	*
LR-11 Resin	3.4	**	0.005	0.002	0.017	0.003	*	**	0.003	*	0.004	0.002	*
0.9 Gal. LA-2 (Latex Cement)	6.0	3.00+	*	*	0.097	*	*	0.016	*	*	0.007	0.006	0.004
Pozmix® A Cement - 0% Bentonite	4.4	0.530	0.002	*	0.124	*	*	0.039	*	*	0.022	*	*
Pozmix® A Cement - 2% Bentonite	5.75	0.748	0.014	*	0.726	0.002	*	0.046	*	*	0.099	*	*
Pozmix® A Cement - 2% Bentonite (with 0.9 Gal. LA-2)	4.5	3.00+	0.004	*	0.452	*	*	0.012	*	*	*	*	*
CLASS C CEMENT (HIGH EARLY)													
Neat	6.3	0.030	*	*	0.002	*	*	*	*	*	*	*	*
3% Bentonite	8.3	0.006	*	*	0.011	*	*	*	*	*	0.003	0.003	0.016
25 Lbs. Gilsonite	7.3	0.202	*	*	0.078	*	*	0.049	*	0.002	0.017	0.003	0.005
LR-11 Resin	3.4	**	0.003	0.002	0.010	0.002	*	**	0.001	*	0.010	*	*
0.9 Gal. LA-2 Latex	6.0	0.086	*	*	0.003	*	*	*	*	*	0.002	*	0.002
Pozmix®A Cement - 0% Bentonite	5.1	0.420	*	*	0.116	*	*	0.014	*	*	0.006	*	*
Pozmix®A Cement - 2% Bentonite	6.1	1.466	0.002	*	0.147	0.002	*	0.044	*	*	0.016	*	*
CLASS E CEMENT (RETARDED)													
Class D - neat	4.5	—	—	—	0.223	*	*	—	—	—	1.240	*	*
Class D - 4% Bentonite	7.1	—	—	—	0.077	0.003	*	—	—	—	0.032	0.003	0.004

* Less than 0.001 millidarcies

** Specimen strength too low to permit measurement of permeability

(1) Atmpspheric Pressure

ENGLISH UNITS

ENGLISH / METRIC UNITS

TIME TO RUN TEMPERATURE SURVEYS

The following values are given as the approximate time to run temperature surveys when using different admixtures in oil well cements:

	Admixture	100°F 38°C	120°F 49°C	140°F 60°C	160°F 71°C
		TIME - HOURS			
Portland Cement	0 % Gel	8-12	8-12	6-9	4-8
	4% Gel	8-12	8-12	6-9	4-8
	8% Gel	9-12	9-12	6-9	6-9
	12% Gel	9-12	9-12	9-12	9-12
Pozmix® Cement	0% Gel	8-12	8-12	6-9	4-8
	2% Gel	8-12	8-12	8-12	6-9
	4% Gel	8-12	8-12	8-12	6-9
Portland Cement with 2 or 4% Gel and Perlite	0 cu. Ft. (0 cu. m)	8-12	8-12	6-9	4-8
	¼ cu. Ft. (.007 cu. m)	8-12	8-12	6-9	4-8
	½ cu. Ft. (.014 cu. m)	9-12	9-12	6-9	6-9
	1 cu. Ft. (.028 cu. m)	9-12	9-12	9-12	9-12
Portland Cement with Diacel D*	10%	10-14	10-14	9-12	9-12
	20%	10-14	10-14	9-12	9-12
	40%	12-16	12-16	10-14	10-14

HIGH TEMPERATURE CEMENTS

		140°F 60°C	160°F 71°C	180°F 82°C	220°F 104°C	260°F 127°C
Pozmix Cement or Portland Cement with Retarder	0.3%	15-18	12-15	9-12	8-12	6-9
	0.5%	16-24	16-24	12-18	9-12	8-12
Retarded Cements: Texcor®		16-24	16-24	12-18	9-12	9-12
Pozmix 140*		16-24	16-20	12-16	8-12	6-9

* Has low heat of hydration and may be difficult to pick up on a temperature survey.

ENGLISH/METRIC UNITS

TIME TO PERFORATE

The perforating properties of any cementing composition are largely dependent upon sheath thickness, cement strength at the time of perforating and the charge size to casing size relationship. Using expendable jet charges, higher compressive strengths yield less damage to casing or cement, while bullet perforators result in less penetration and more shattering. Generally hollow tube jet carrier perforators produce minimum damage to casing or cement.

An old technique using bullets was to perforate early or when the cement was strong enough to keep from flowing back or closing up the perforations. Then cement strength was allowed to build up for a period of 12-18 hours (depending on well temperature) before performing any additional work. The same procedure may be employed with hollow tube jet carrier perforators. However, with expendable type charges this method of perforating is not normally recommended.

The following indicated "time to perforate" data are based upon the cementing composition attaining a minimum compressive strength of 500 psi (3.450 MPa) at the corresponding temperature. These data are primarily to be used as a guide when perforating with bullets or hollow tube carrier perforators.

These times are only approximate since variations in the chemical and physical properties of different brands of cement as well as different batches of the same brand may result in variations in the data shown below.

CLASS A CEMENT

API CURING TEMPERATURE & PRESSURE

TIME - HOURS

Per Cent Retarder	110°F 43°C	140°F 60°C	170°F 76°C	200°F 93°C	230°F 110°C	260°F 127°C
0	12	10	8	6	—	—
0.30	—	20	16	12	8	6-8
0.40	—	22	18	16	10-12	8
0.50	—	24	30	18	14	10
4 Per Cent Bentonite						
0	18	16	14	10	8	—
8 Per Cent Bentonite						
0	24-36	24	20	18-20	16	—

POZMIX® CEMENT

Per Cent Retarder	110°F 43°C	140°F 60°C	170°F 76°C	200°F 93°C	230°F 110°C	260°F 127°C
0	18	14	12	8	—	—
0.2	—	24	20	18	16	12
0.3	—	30	20-24	18-20	16-18	14
0.4	—	36	24	20	18	16

CLASS E (RETARDED) CEMENT

140°F - 60°C	170°F - 76°C	230°F - 110°C	290°F - 143°C
0% Bentonite			
24	16-18	12	8
4% Bentonite			
36	24-30	18-24	12-14

POZMIX® 140

Per Cent Retarder	200°F 93°C	230°F 110°C	260°F 127°C	290°F 143°C	320°F 160°C
4 Per Cent Calcium Chloride					
0.00	24-28	20-24	18	12-16	—
2 Per Cent Calcium Chloride					
0.40	—	—	18-20	12	8