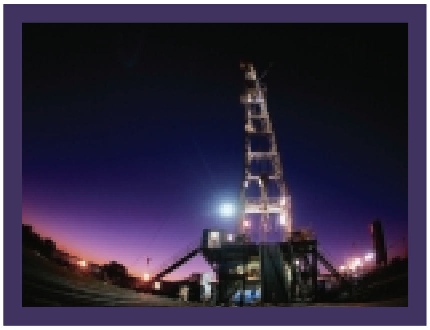
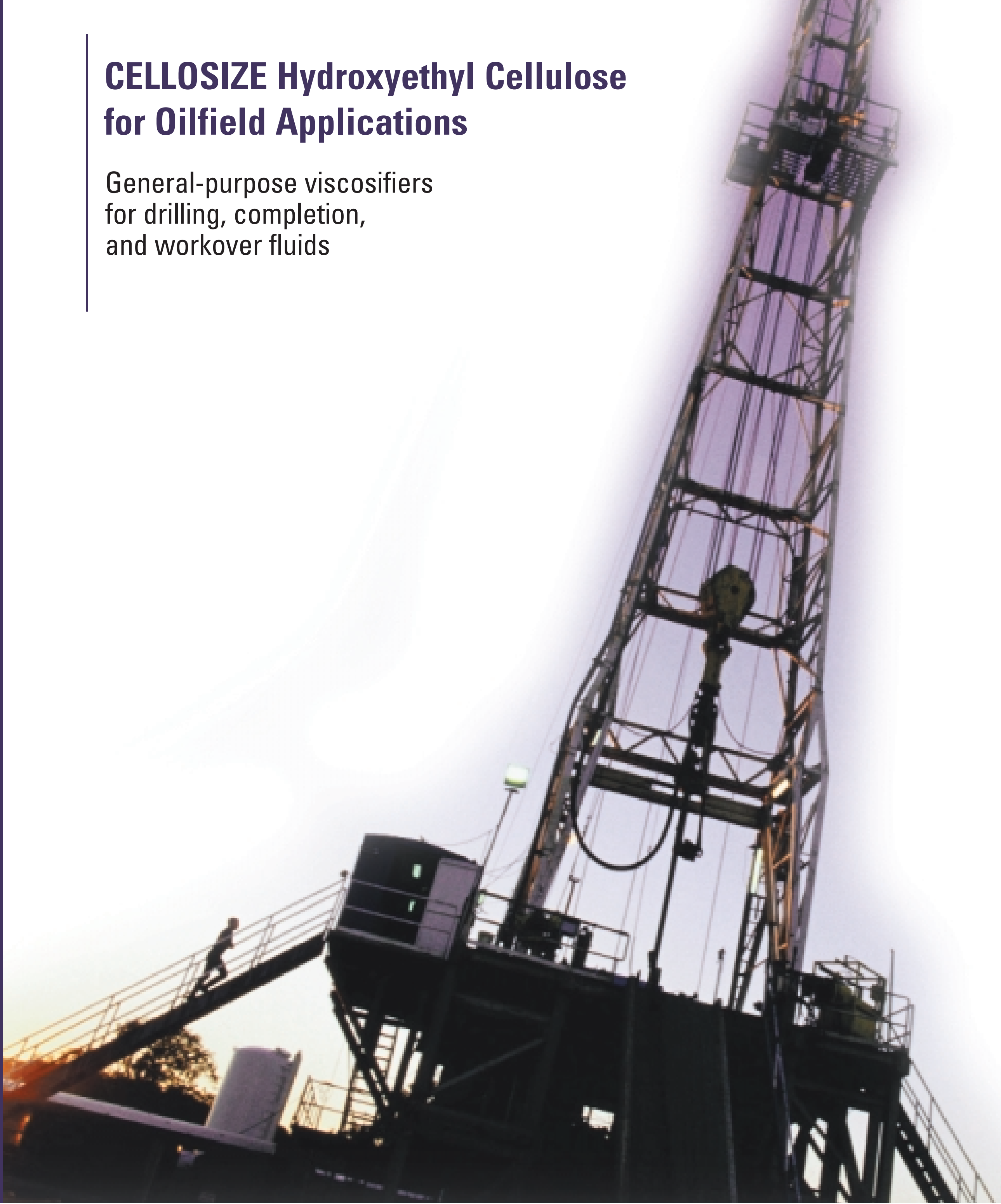


CELLOSIZE Hydroxyethyl Cellulose for Oilfield Applications

General-purpose viscosifiers
for drilling, completion,
and workover fluids



Oilfield Applications

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CELLOSIZE™ hydroxyethyl cellulose products are water-soluble polymers that have long set the standard among oilfield viscosifiers for drilling, completion, and workover fluids. CELLOSIZE products are easy to dissolve, provide high thickening efficiency, and break quickly and cleanly. They also have high salt tolerance and are readily compatible with a wide variety of other oilfield chemicals.

This brochure provides an in-depth look at the properties, performance, and handling characteristics of this versatile family of viscosifier products.

Contents

CELLOSIZE HEC-10 Polymer: A General-Purpose Viscosifier for Low-Solids Fluids

CELLOSIZE HEC-10 (Hydroxyethyl Cellulose) is a general-purpose viscosifier for low-solids drilling, completion, and workover fluids. Specifically designed for oilfield applications, CELLOSIZE HEC-10 is a free-flowing granular material that has been surface-treated to facilitate the preparation of clear homogeneous fluids.

In completion and workover operations, CELLOSIZE HEC-10 will increase oil production by minimizing formation damage.

In drilling fluids, CELLOSIZE HEC-10 can increase drilling rates, particularly in hard rock formations, and thereby produce substantial savings.

The efficient use of CELLOSIZE HEC-10 may require auxiliary products such as anti-microbials, antifoams, and other performance products. In addition, Dow supplies CELLOSIZE in a range of molecular weights for specific applications. For information, call the number listed on the back cover.

The Industry Standard for Completion and Workover Fluids

For completion and workover fluids, CELLOSIZE HEC-10 dissolves easily in water to give gel-free solutions that can be readily broken and minimize formation damage. The higher oil production rates and longer well life that derive from undamaged formations are responsible for the increase of completions and workovers using CELLOSIZE HEC-10.

CELLOSIZE HEC-10 polymer offers the following advantages in completion and workover fluids:

- **Convenient Handling**
  CELLOSIZE HEC-10 is a granular material that pours easily.
- **Ease of Dissolving**
  Special surface treatment of CELLOSIZE HEC-10 facilitates dispersion before solvation, thereby giving gel-free, non-damaging fluids.
- **Shear-Thinning Fluid Behavior**
  Favorable rheology lowers pump pressures and reduces horsepower requirements.
- **High Thickening Efficiency**
  Low solids concentrations minimize formation damage and maximize oil production.
- **High Salt Tolerance**
  Unaffected by water hardness or salt concentration, CELLOSIZE HEC-10 will thicken high-weight calcium and zinc brines.

- **Fast and Clean Breaking**
  Oxidizing agents, acids, or enzyme breakers yield non-damaging residues and act rapidly to minimize rig time with minimum damage to producing formations.
- **Compatibility with Other Oilfield Products**
  Proven additives for biocidal protection, corrosion inhibition, oxygen scavenging, defoaming, and fluid loss control are available for use with CELLOSIZE HEC-10.
- **Minimal Pollution**
  Disposal is simplified by the low concentrations required and by the low toxicity of the cellulose polymer base and its biodegradation products.
- **Shear Stable**
  CELLOSIZE HEC-10 solutions exhibit little or no degradation and viscosity loss when subjected to high-shear mixing devices.

The advantages of refined, water-soluble polymers, such as CELLOSIZE HEC-10, have been documented in the literature and proved by years of field experience. A landmark study[1] of HEC-based completion fluids drew the following conclusions:

- Breaking with hydrochloric acid is effective in restoring a high (> 90 percent) level of the original permeability in 500 millidarcy (md) sandstone cores saturated with fluid containing 1.5 pounds of HEC per barrel.

- Injection of HEC fragments, obtained by the acid-breaking method, resulted in 100 percent return permeability. Use of the enzyme-breaking method gave 93 percent return permeability.
- HEC-based completion fluid containing calcium carbonate was prepared with unfiltered bay water (136 ppm solids). After the filter cake was removed from the core face with acid, 98 percent of the original permeability was recovered. See Figure 1.

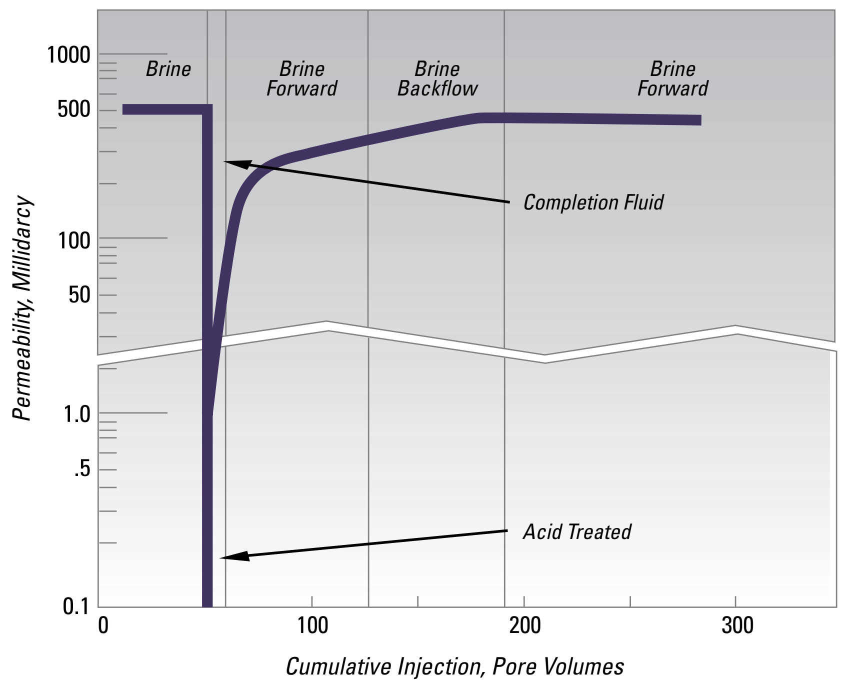
Superior Return Permeability

CELLOSIZE HEC-10, a competitive HEC and other water soluble polymers were tested for retained permeability after acid breaking in 150 – 200 millidarcy Berea sandstone cores. HEC-10 shows significantly better retained permeability than any of the alternative products. The testing was performed on acid broken solutions containing 2 ppb of the polymer and 2% KCl. The results are listed in Table 1.

The reported effectiveness of the polymer fluid in keeping suspended particles out of the formation, even when unfiltered bay water was used to make up the completion fluid, points up the role that CELLOSIZE HEC-10 plays in simplifying field operations. Compatibility with gypsum and cement further minimizes concern about downhole contaminants.

When weighted completion fluids are called for, the solubility of CELLOSIZE HEC-10 in a full range of brines provides unusual flexibility. Table 2 illustrates the exceptionally high thickening efficiency of CELLOSIZE HEC-10 in fresh water and in saturated sodium chloride, calcium chloride, and high-weight zinc bromide/ calcium bromide brines.

Figure 1 • Return Permeability of HEC Completion Fluid†



†**Composition of Completion Fluid:** Unfiltered bay water (136 ppm solids), 5 percent sodium chloride, 0.3 percent HEC, and 0.3 percent calcium carbonate after acidizing with hydrochloric acid.

Table 1 • Retained Permeability of Acid Broken Polymers

Polymer	% Retained Permeability[a]
CELLOSIZE HEC-10	83-95
Competitive HEC	58-77
Low Residue Guar	58-65
HP Guar	27-62
Xanthan	16-29

(a) The first value is the retained permeability in the first 0.75 inch of the core where the broken polymer solution was injected. This simulates the amount of damage to the formation, near the wellbore, due to gel particle filtration at the core face. The second value is the retained permeability in the deeper matrix of the core and simulates the amount of damage in the deeper matrix of the formation.

Fluids based on CELLOSIZE HEC-10 provide viscous transport of gravel during completion and workover. At about one to two pounds of CELLOSIZE HEC-10 per barrel, they lift the formation sand and rubble from the wellbore and provide good radial and vertical distribution of gravel pumped downhole. Subsequent breaking of the polymers simplified cleanup of the completion or workover fluid.

Occasionally, downhole conditions call for extreme corrective measures to prevent loss of circulation during drilling or workovers. In such cases, try lost circulation pills prepared from high concentrations of CELLOSIZE HEC-10 (see page 11). Isolate the required volume of water in a slugging pit or pill tank. Quickly mix three to seven pounds of HEC-10 per barrel and send it downhole. In extreme cases, concentrated pills as high as 50 pounds of HEC-10 per barrel have been made in diesel oil and pumped downhole where the slug slowly hydrates as it mixes with the formation waters.

Table 2 • Rheological Characteristics of Brine-Weighted Fluids Based on CELLOSIZE HEC-10

Weighting Brine	Density, lb/gal	Apparent Viscosity (AV), cP		Plastic Viscosity (PV), cP		Yield Point (YP), lb/100 ft²		10-Second Gel Strength lb/100 ft²	
		72°F	150°F	72°F	150°F	72°F	150°F	72°F	150°F
Fresh Water	8.33	16	7	10	5	12	3	2	1
Sodium Chloride	10.0	21	9	13	7	15	3	2	1
Calcium Chloride	11.5	60	27	35	21	38	11	6	1
Zinc Bromide/Calcium Bromide	17.2	74	39	42	23	50	24	4	3

NOTE: Concentration - One pound of HEC-10 per barrel. **Viscometer** - Fann VG Meter.

CELLOSIZE HEC-10 is compatible with additives typically used with completion and work-over fluids, including biocides, oxygen scavengers, fluid loss controllers, and foam control agents.

Cementing

CELLOSIZE HEC-10 performs a dual function in cementing operations. By reducing hydraulic friction of the slurry, lower pumping pressures and higher rates can be achieved. Also, the polymer provides fluid retention properties to the slurry, minimizing water loss to the formation and protecting the mechanical properties of the cement. Special low molecular weight grades of CELLOSIZE are recommended in cementing to minimize the viscosity increase of the slurry at the required concentrations.

Fracturing

CELLOSIZE HEC-10 provides sufficient viscosity and carrying capacity for transport of proppants in many hydraulic fracturing jobs. To circumvent viscosity loss at downhole temperatures, it is sometimes blended with the rapidly solvating type, HEC-25, which dissolves rapidly and provides needed topside viscosity. HEC-10, having been surface-treated to retard hydration under neutral or acidic conditions, does not yield until exposed to the higher temperature downhole, where it dissolves to provide additional viscosity and proppant-holding capacity. Its superior breaking properties and lack of pore-plugging residues facilitate cleanup after fracturing and permit unimpeded flow of oil through the fractures and into the wellbore.

Use in Drilling Fluids

While the value of CELLOSIZE HEC-10 was first recognized and used to maximum benefit for completion and workover fluids, it offers significant advantages in drilling fluids. The use of CELLOSIZE HEC-10 in drilling covers a range of fluid types:

- **Low-solids fluids…** for hard rock drilling.
- **Potassium chloride-inhibited, low-solids fluids…** for heaving or sloughing shale formations. Higher-weight brines may be used in pressured formations.
- **Spudding fluids…** for top-hole or large-hole drilling.
- **Foam stabilizers…** to extend performance range of foam muds.

Thus, CELLOSIZE HEC-10 can be used in any drilling area where the low-solids drilling fluid concept has shown advantages over conventional muds. Drilling through salt beds, anhydrite, dolomite, and Zechstein salt attests to its tolerance to an exceptional range of downhole environments.

The pluses offered by CELLOSIZE HEC-10 in drilling fluids combine to give a favorable performance/cost ratio compared to conventional drilling muds. The following performance features are noteworthy:

- Higher drilling rates
- Increased oil production
- Longer bit life
- Tolerance for a wide variety of electrolytes and fluid additives
- Allows same fluid for drilling and completion
- Easier fluid disposal
- Reduced dependence on dispersants, thinners, pH control agents
- Lower transportation and storage costs
- More gauge hole

Because HEC-10 is efficient and compatible in a range of chemical environments, it can be used under many circumstances. Small quantities often replace large quantities of costly auxiliaries needed to maintain stable operating conditions with conventional muds. Properly employed, bags of CELLOSIZE HEC-10 can be more productive than tons of “cheaper” conventional mud thickeners.

Additives and procedures are available for controlling lost circulation, excessive fluid loss, unusual pressures, heaving and sloughing shale, and other immediate, short-term problems that may be encountered in drilling operations.

The advantages of drilling fluids based on CELLOSIZE HEC-10 result in substantial savings. Higher drilling rate, longer bit life, and easier maintenance of fluids based on CELLOSIZE HEC-10 outweigh the lower unit cost of the conventional mud, yielding net savings as high as 30 percent. Central to achieving best results with CELLOSIZE HEC-10 is good solids control equipment that maintains drilled solids below a maximum level of about two percent.

Brine Tolerance

CELLOSIZE HEC-10 will viscosify a variety of monovalent and divalent brines. It is a nonionic material that is compatible with a range of ionic materials. Its use simplifies the preparation of fluids and provides performance in different ionic environments encountered in drilling. See Figures 2 and 3. Because of these attributes, HEC-10 is a prime component in drilling fluids based on polymer blends.

Shales, gypsum, and cement cause serious problems when they contaminate conventional bentonite muds. Use of CELLOSIZE HEC-10 eliminates the costs associated with soda ash, sodium bicarbonate, SAPP (sodium acid pyrophosphate), and other additives. *See Table 3* for the effect of contaminants on CELLOSIZE HEC-10.

Polymer Fluid Rheology

The superior drilling rates obtainable with CELLOSIZE HEC-10 under appropriate conditions stem from its shear thinning or pseudoplastic flow behavior. The viscosity of solutions of CELLOSIZE HEC-10 varies markedly over the range of shear rates experienced downhole. See Figure 4. At the very high shear rates encountered at the bit, the viscosity of fluids based on CELLOSIZE HEC-10 approaches that of water, a feature reflected in high penetration rates and excellent hole-cleaning. The relatively high viscosity in the annulus and in quiescent zones encountered at enlarged hole sections gives a low "sink" rate to the cuttings and a faster lifting of cuttings to the surface than conventional bentonite muds of the same Marsh Funnel viscosity and specific gravity. Lack of appreciable gel strength in fluids based on CELLOSIZE HEC-10 eliminates potentially damaging pressure surges when resuming circulation after a shutdown. The high shear rate and resultant low fluid viscosity at the shale shaker facilitate efficient solids removal from fluids based on CELLOSIZE HEC-10.

Figure 2 • Thickening efficiency of CELLOSIZE HEC-10

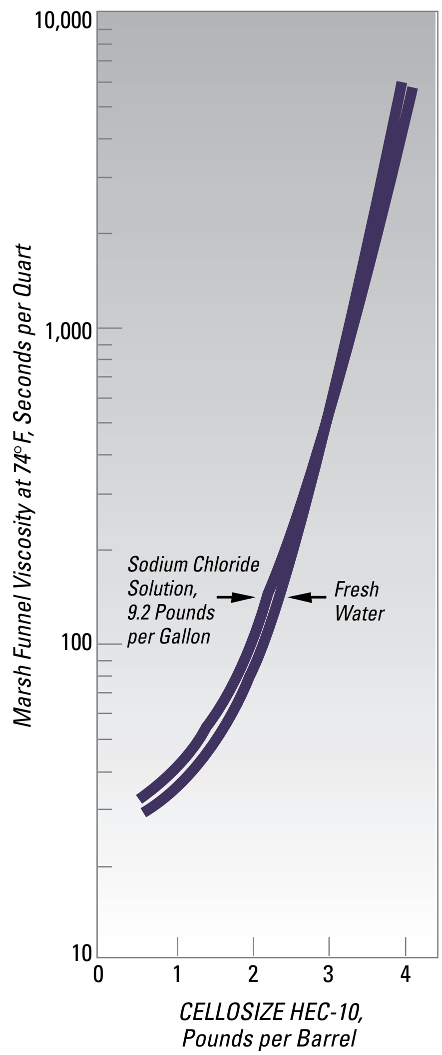
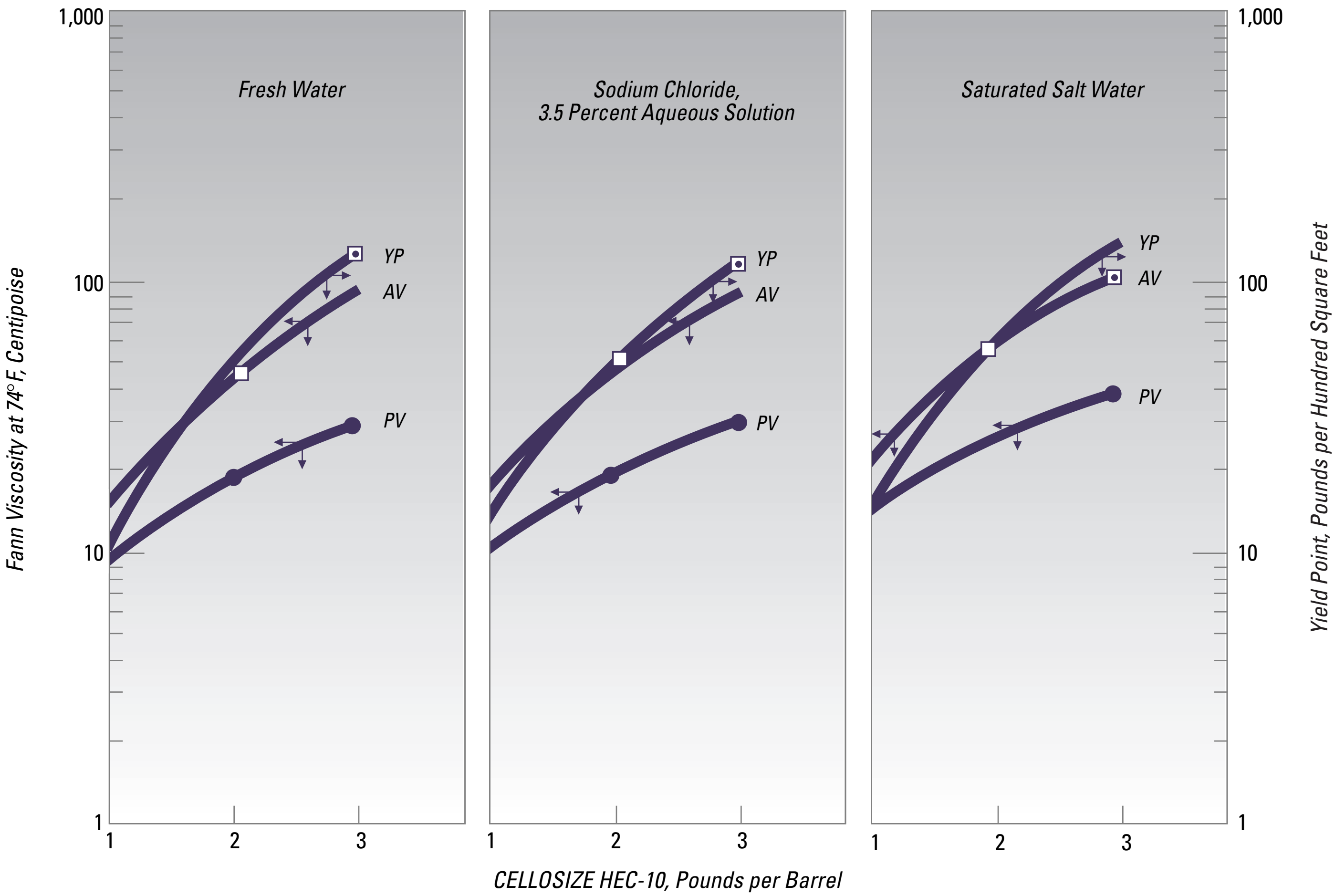


Table 3 • Effect of shale, cement, and gypsum on drilling fluid properties of CELLOSIZE HEC-10 in fresh water

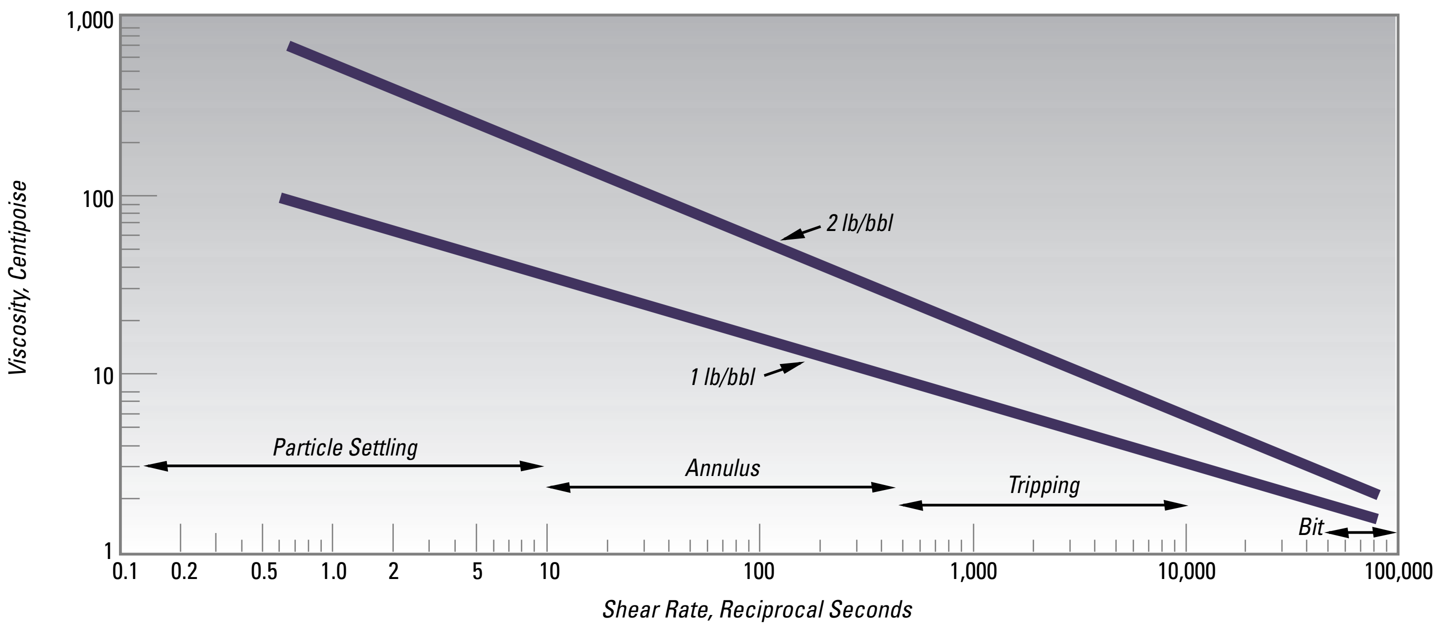
	A	B	C	D
Fresh Water, bbl	1.0	1.0	1.0	1.0
CELLOSIZE HEC-10 Polymer, lb	2	2	2	2
Cement, lb	3	–	–	–
Gypsum, lb	–	3	–	–
Glen Rose Shale, lb	–	–	100	–
Hot-Rolled for 16 hours at 150°F				
Apparent Viscosity (AV), cP	38	46	32	43.5
Plastic Viscosity (PV), cP	19	20	18	20
Yield Point (YP), lb/100 ft^2	37	52	28	47
10-Second/10-Minute Gel Strength, lb/100 ft^2	3/3	6/6	2/3	6/6
pH	2.4	8.0	7.9	7.0
API Fluid Loss, ml	300	150	11.0	300

Figure 3 • Effect of sodium chloride on rheological properties of CELLOSIZE HEC-10



NOTE: Hot rolled for 16 hours at 150°F. Cooled to room temperature and measured API-RP13B.
AV = Apparent Viscosity **YP** = Yield Point **PV** = Plastic Viscosity

Figure 4 • Viscosity vs. shear rate of CELLOSIZE HEC-10 in fresh water

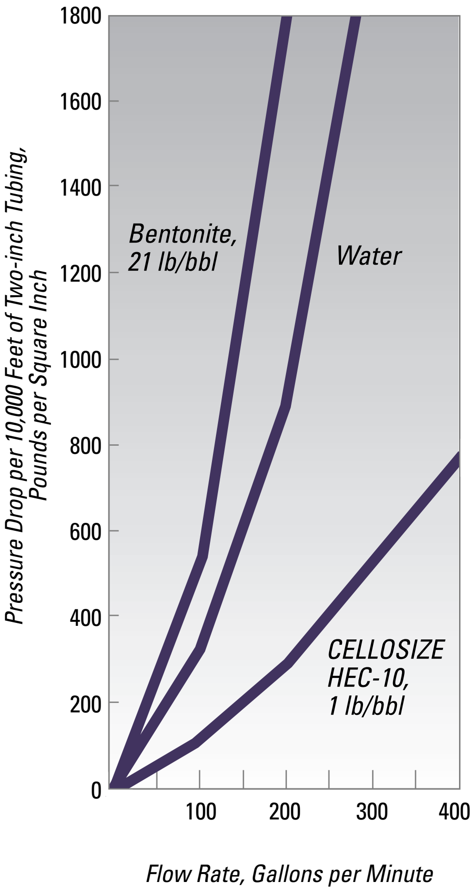


NOTE: Measured with a Ferranti-Shirley Cone/Plate Viscometer. For background, see R. McKennell and K. Watkin, ***Rheologica Acta*** 1,545, 1961.

Table 4 • Rheological Properties of Solutions of CELLOSIZE HEC-10

CELLOSIZE HEC-10, lb/bbl	Apparent Viscosity (AV), cP	Plastic Viscosity (PV), cP	Yield Point (YP), lb/100 ft²	Power Law Constants at 200 rpm to 100 rpm n	K	at 30 rpm to 15 rpm n′	K′	Effective Viscosity at 50 seconds⁻¹, based on n′ & K′, cP
Fresh Water								
1.0	15.5	9.5	12	0.58	0.74	0.41	1.46	71
1.5	29	15	28	0.49	2.73	0.64	1.60	186
2.0	46.5	20	53	0.40	7.46	0.48	5.37	343
3.0	92.5	31	123	0.30	27.42	0.25	31.05	807
4.0	160	52	216	0.26	60.82	0.20	70.17	1512
Sodium Chloride Solution, 9.2 lb/gal								
1.0	17	11	12	0.58	0.81	0.58	0.82	77
1.5	31.5	16	31	0.48	3.10	0.45	3.27	181
2.0	49	21	56	0.41	7.90	0.51	5.21	374
3.0	94.5	33	123	0.30	28.55	0.39	20.17	888
4.0	164	48	232	0.26	65.49	0.26	60.48	1596

Figure 5 • Hydrodynamic Friction Reduction with CELLOSIZE HEC-10



Power Law Constants

Rheological behavior of drilling fluids is nonlinear and is best represented by the Power Law Equation:

Shear Stress = K (Shear Rate)^n

The values of K [reflecting the effective viscosity of the fluid at low (l second-1) shear rate] and n (inversely related to the degree of shear thinning) are useful to mud engineers in calculating effective fluid viscosity under downhole conditions. Values determined at moderate (100 to 200 rpm) and low (15 to 30 rpm) shear rates are given in Table 4 for fluids prepared over a range of concentrations in fresh water and in brine weighted to 9.2 pounds per gallon with sodium chloride.

Hydraulic Friction Reduction

The pressure required to circulate a fluid at a particular flow rate depends largely on viscosity. However, certain polymer fluids reduce pumping pressure below that of conventional muds by reducing the hydrodynamic friction. This effect is particularly dramatic for fluids based on CELLOSIZE HEC-10, as shown in Figure 5. The practical benefit of this phenomenon is a lowering of the circulating pressure, thereby reducing the susceptibility to lost circulation. Also, this feature, coupled with the low gel strength of HEC fluids, reduces the starting torque when resuming circulation after a shutdown.

Shale Stabilization

The clay stabilizing ability of CELLOSIZE HEC-10 in conjunction with potassium chloride solution is shown in Figure 6. Drilling with such a fluid improves borehole stability, stabilizes against heaving and sloughing shales, yields more gauge holes, and may reduce the requirements for casing. A further advantage is the improved transport of cuttings to the surface with minimum dispersion. The beneficial effect of the polymer in maintaining the integrity of cuttings is illustrated in Table 5, where 50 pounds per barrel of crude, sized, simulated cuttings (calcium bentonite) were rolled six hours at 150°F in fresh water, 10 percent potassium chloride solution, and 10 percent potassium chloride solution plus one and two pounds per barrel solutions of CELLOSIZE HEC-10. Under these severe test conditions, the presence of the polymer increased the recovery of integral simulated cuttings from nil (potassium chloride alone) to 37 percent and 64 percent (one pound per barrel and two pounds per barrel CELLOSIZE HEC-10, respectively).

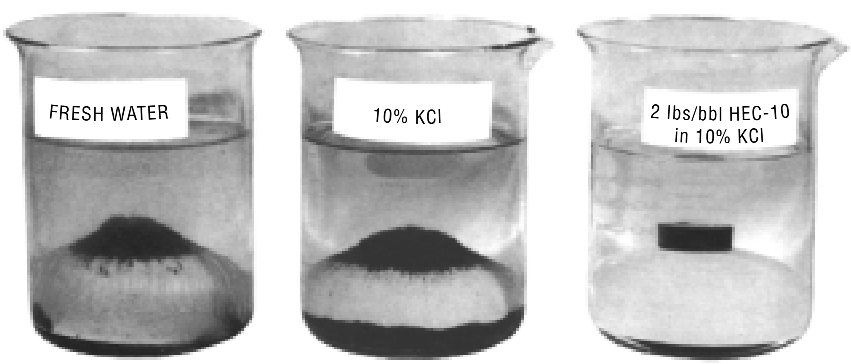
This stabilizing action, coupled with the shear-thinning properties of HEC-10 fluids, facilitates solids removal at the shale shaker, so vital in maintaining low-solids polymer fluid performance. The clay affinity of HEC-10 causes it to be depleted and requires periodic replenishment for fluid maintenance.

Table 5 • Relative disintegration rate of simulated clay cuttings† in 10 percent potassium chloride solution with CELLOSIZE HEC-10 in fresh water

	A	B	C	D
Potassium Chloride, 10% Aqueous Solution, bbl	Fresh Water	1.0	1.0	1.0
CELLOSIZE HEC-10 Polymer, lb/bbl	0	0	1	2
Adjusted to pH 9. Hot-rolled for 16 hours at 150°F				
Apparent Viscosity (AV), cP	1	1	12.5	40
Plastic Viscosity (PV), cP	1	1	9	19
Yield Point (YP), lb/100 ft^2	1	1	7	42
10-Second/10-Minute Gel Strength lb/100 ft^2	1/1	1/1	1/1	5/5
Added Calcium Bentonite, lb/bbl	50	50	50	50
Hot-rolled for six hours at 150°F				
Calcium Bentonite Recovery, % + 10 Mesh Screen	0	0.4	37	64
Properties of Screened Mud				
Apparent Viscosity (AV), cP	3	3	14.5	42
Plastic Viscosity (PV), cP	3	3	14	20
Yield Point (YP), lb/100 ft^2	0	0	1	44
10-Second/10-Minute Gel Strength lb/100 ft^2	1/1	1/1	1/1	4/4

†Crude calcium bentonite - 1/4-inch, 10 mesh.

Figure 6 • Clay Stabilizing Ability of CELLOSIZE HEC-10



Additive for Nondispersed Muds

CELLOSIZE HEC-10 can be used as an additive to nondispersed salt water bentonite muds for lowering fluid loss and increasing viscosity without increasing the gel strength. Table 6 illustrates the effect of adding CELLOSIZE HEC-10 to hydrated seawater mud containing 120 pounds per barrel of western bentonite and kaolinite clays. The feasibility of this approach is further indicated by the compatibility of CELLOSIZE HEC-10 with barite and calcium carbonate weighting materials at intermediate levels, up to weights of about 12 pounds per barrel. See "Weightability."

Fluid Loss Control

Clear fluids made with CELLOSIZE HEC-10, lacking the suspended solids present in conventional muds that rapidly build a filter cake, show anomalous behavior in the standard API Filter Loss Test. A high initial fluid loss (spurt loss) is observed until drilled solids (suspended in the fluid) build a cake, after which the filter rate shows the normal dependence on the square root of the filtration time. In practice, the normal level of drill solids (finely-divided clays, shales, or limestone) suspended in the fluid quickly reaches a level sufficient to bring the API fluid loss to satisfactory levels; the typical range is 5 to 15 mL. However, the initial spurt loss contributes to the high drilling rates reported with fluids based on CELLOSIZE HEC-10. At the same time, polymer filtrate that penetrates unconsolidated formations (unlike the aqueous filtrate from bentonite muds) will stabilize and inhibit clay swelling and, thus, help to maintain hole integrity. This mechanism of hole stabilization is particularly advantageous in near-surface, large-hole drilling or spudding.

In formations of high permeability, the use of particulate filter loss additives, such as calcium carbonate, sized hydrocarbon resins[2], or sized water-soluble salt particles[3] has proven effective. In severe cases, the flow of fluid deep into the formation has been prevented with fluids containing high concentrations of CELLOSIZE HEC-10 polymer (three to seven pounds per barrel).

Table 6 • Effect of CELLOSIZE HEC-10 on a nondispersed sea water mud

	A	B	C
Base Mud†, bbl	1.0	1.0	1.0
CELLOSIZE HEC-10 Polymer, lb	–	1	2
Apparent Viscosity (AV), cP	7	13.5	34
Plastic Viscosity (PV), cP	4	10	22
Yield Point (YP), lb/100 ft^2	6	7	24
10-Second/10-Minute Gel Strength, lb/100 ft^2	4/7	1/3	3/4
API Fluid Loss, ml	85	48	8.2

†**Base Mud Preparation** - Synthetic sea water • Wyoming bentonite, 20 lb/bbl • Martin #5 Ball Clay, 100 lb/bbl • Caustic soda to pH 9 • Prepare base mud • Age base mud 72 hours before adding CELLOSIZE HEC-10 • Add CELLOSIZE HEC-10 in stated concentration to base mud • If necessary, readjust pH to 9 • Stir 15 minutes at high speed • Roll 16 hours to 150°F • Cool to room temperature and test.

Weightability

Low-solids drilling fluids prepared with CELLOSIZE HEC-10 possess little or no gel strength, and weighting is normally achieved with soluble salts. Weighting to intermediate densities can be achieved with insoluble minerals, such as calcium carbonate or barite. Insoluble weighting materials should only be used when drill solids are present to build gel strength, and weighting is generally limited to about 12 pounds per gallon.

Brine Fluid Thickening

Clear brine solutions, consisting of mixtures of sodium, calcium, and zinc chlorides or bromides, are sometimes employed for drilling and completions in sensitive formations. These solids-free solutions can be thickened with CELLOSIZE HEC-10, one of the few water-soluble polymers to maintain its gel-free solubility and thickening power over a full range of brine concentrations and weights.[4] With suitable filtration equipment for solids removal, brine fluids will prevent formation damage and, therefore, increase the quantity of oil produced, compared to nearby wells drilled with conventional muds. Faster drilling rates and more gauge hole have also been reported. Rheological properties of brine-weighted fluids thickened in CELLOSIZE HEC-10 are presented in Table 1, page 4.

High-shear devices can be used to enable CELLOSIZE HEC-10 to hydrate more completely in brines with little or no change in rheological properties of the fluids.[5] These viscous solutions can be subsequently filtered through cartridges or diatomaceous earth to further reduce potential formation damage.

Large-Hole Drilling

CELLOSIZE HEC-10 is particularly suited for drilling large holes, such as top holes for platform supports, for spudding, and for specialty drilling near the surface. Such drilling often encounters unconsolidated clastics varying from soft hydrated clays to loose gravel beds. Fluids based on CELLOSIZE HEC-10 help meet the three major challenges facing large hole drillers:

1. **Keeping the Hole Clean** — Pseudoplastic flow behavior gives plug flow, minimizing shear stress at the hole wall while maintaining lift where fluid velocity is low.
2. **Preventing Formation Breakdown** — In large-diameter, near-surface drilling, all factors that increase the hydraulic pressure against the formation must be minimized and all factors that relieve pressure must be maximized. Fluids based on CELLOSIZE HEC-10 minimize pressure by their low specific gravity, by their hydraulic friction-reducing property, and by the absence of gel strength and the resultant pressure surges encountered when restarting circulation of conventional muds.
3. **Maintaining Hole Integrity** — It is not immediately apparent that a clear fluid based on CELLOSIZE HEC-10 will effectively support the sides of a hole. In contrast, the ability of a thick conventional mud to do so is rarely doubted. Actually, the reverse is often true. The filtrate of a dispersed bentonite mud can be highly disruptive of the loosely consolidated formations that are frequently encountered in near-surface drillings. On the other hand, CELLOSIZE HEC-10 inhibits clay swelling, which causes breakdown of cohesive strata. Furthermore, the shear-thinning behavior of fluids based on CELLOSIZE HEC-10 minimizes erosion of the formation opposite collars where fluid velocity is highest.

These features, along with the absence of major toxicity and disposal problems associated with conventional drilling muds, make large-hole, near-surface drilling with CELLOSIZE HEC-10 particularly attractive in light of today's ecological concerns.

Preparation of Fluids

A key feature of CELLOSIZE HEC-10 is its delayed viscosity build, or yield, when added to water that is slightly acidic. The time required for thickening to start (hydration time) with HEC-10 facilitates the preparation of lump-and gel-free solutions. Once the polymer is dispersed, it can be agitated until thickening is complete; alternatively, the pH can be adjusted to basic (pH 9 to 10) and thickening will be complete in less than 15 minutes. Increasing the temperature of the fluid also increases the rate at which HEC-10 dissolves.

Normally, HEC-10 fluids are made up batch-wise in the mixing tanks by addition through the mud hopper (eductor-type funnel) at neutral to slightly acidic pH. While keeping the polymer dispersed, an immediate yield can be obtained by the addition of caustic soda. If mud guns are used, the nozzles should be below the surface to prevent foaming.

If the viscosity of an existing fluid must be increased under basic conditions, add HEC-10 very slowly with good agitation, or, before adding, pre-wet it in diesel oil, organic solvent, or water that is neutral to slightly acidic. Pre-wetting the polymer in this manner will produce a lump-free, gel-free fluid.

Normal Fluids

1. Clean tanks, pits, and mixing equipment of any extraneous solids.
2. At one to three pounds per barrel concentration, mix HEC-10 in the desired volume of water at neutral to slightly acidic pH. Addition rate should be no faster than 15 minutes per sack.
3. Raise the fluid to pH 9 using sodium hydroxide (caustic soda). Do not, however, raise the pH of calcium chloride or calcium bromide brines; if the pH is raised, low solubility hydroxides will precipitate.
4. The viscosity may be increased by adding small amounts of HEC-10. The viscosity may be reduced by adding water.

Lost Circulation Pills

1. Isolate the desired volume of water in a slugging pit or pill tank.
2. Quickly mix three to seven pounds of CELLOSIZE HEC-10 per barrel of water.
3. Pump the mixture with minimum waiting time on the surface. Do not wait for viscosity to develop before pumping.

Six Important Points for Optimum Performance

1 Maintain agitation while adding CELLOSIZE HEC-10. Do not stop circulation until full viscosity has been obtained.

2 Remember that water properties influence dissolving time. Time for complete hydration decreases as either the pH or temperature is increased.

3 Add the polymer slowly (15 minutes per bag) via the mud hopper.

4 Do not raise the pH of the water until all of the polymer is dispersed. After dispersion, the pH can be increased to speed up dissolution.

5 Add an effective preservative to prevent enzymatic degradation.

6 To prevent absorption of moisture during storage, keep partially empty containers of CELLOSIZE HEC-10 tightly closed.

Protection from Bacteria and Enzymes

CELLOSIZE HEC-10 is supplied as a dry powder. In its original sealed package, under normal storage conditions, CELLOSIZE HEC-10 shows excellent stability over long periods of time. Contamination can occur, however, when solutions of the polymer are prepared and stored. Then, like other cellulosics, CELLOSIZE HEC-10 polymer is subject to enzymatic degradation and loss of viscosity. This property is utilized to advantage with breakers for use in workovers and completions. It is not, however, desirable in drilling and other applications.

At the time solutions are prepared, treat them with an effective biocide such as UCARCIDE™ 125 Antimicrobial or one of the other Dow biocides approved for oilfield use. Once bacterial degradation has started, the enzymes formed can degrade HEC-10 long after the bacteria are killed.

Avoid preparation of HEC-10 solutions with surface runoff water. Enzymes that may be present in runoff water can break HEC-10 solutions nearly as fast as the polymer hydrates; that is, in 45 minutes to two hours.

Packaging of CELLOSIZE HEC-10

CELLOSIZE HEC-10 is packaged in 50-lb bags that are easy to palletize. These moisture-resistant bags are extra strong, can be opened easily, and save valuable storage space. Polyethylene film is stretched around a loaded pallet, providing a protective covering that keeps the bags dry, positions them firmly, and protects them from damage in transit.

Table 7 • Typical properties of aqueous fluids of CELLOSIZE HEC-10†

Refractive Index at 20°C(a)	1.336
Specific Gravity at 20/20°C(a)	1.003
Color(a), Pt-Co	40
pH(a)	6 to 7
Freezing Point(a), °C (°F)	0 (32)
Surface Tension at 25°C, dynes/cm	
at 0.01% aqueous solution	66.1
at 0.1% aqueous solution	65.4
at 1.0% aqueous solution	66.3
Apparent Viscosity(b) (AV), cP	47
Viscosity(c), Brookfield LVF, cP	4400 to 6500

†Typical properties, not specifications.
(a) At two percent aqueous solution.
(b) Apparent Viscosity (AV) at concentration of 2 lb/bbl using Fann Viscometer, deflection at 600 RPM/2, fresh water at 72°F (22°C).
(c) Brookfield LVF at 25°C, No. 4 spindle at 30 RPM, one percent by weight on dry basis, adjusted to compensate for volatiles.

Table 8 • SI Metric Conversion Factors

bbl x 1.589 873 E - 01	= m^3
cP x 1.0† E - 03	= Pa•s
dynes/cm x 1.0† E + 00	= mN/m
(°F-32)/1.8	= °C
gallons x 3.785 412 E - 03	= m^3
in x 2.54† E + 00	= cm
lb x 4.535 924 E - 01	= kg
lb/bbl x 2.853 010 E + 00	= kg/m^3
lb/100 ft^2 x 4.882 428E - 02	= kg/m^2
lb/gal x 1.198 264 E + 02	= kg/m^3
psi x 6.894 757 E + 00	= kPa

†Conversion factor is exact

CELLOSIZE HEC-25

A General-Purpose Viscosifier for Use in Liquid Slurries

CELLOSIZE HEC-25 is a general-purpose viscosifier for low-solids fluids. This special grade of hydroxyethyl cellulose was developed specifically for use in liquid slurries. Products formulated with HEC-25 in a hydrocarbon solvent are easily dispersed in fresh water or brine and are fast yielding. Thus, drilling, fracturing, flow diversion, completion or workover fluids can be made-up or polymer additions made to existing fluids without concern for pH or prewetting the polymer, and it can be done with a minimum of agitation. The liquid system eliminates the development of "fish eyes", which may occur when dry HEC is not used properly.

Features and Benefits

CELLOSIZE HEC-25 offers many important advantages in a wide variety of oilfield applications:

- Non-damaging
- Fast yielding
- Easy to pour and easily dispersed
- Stable suspension
- Soluble in fresh water, saturated NaCl and $CaCl_2$ brines
- Nonsensitive to pH
- High thickening efficiency
- Good hole stability
- Good cutting removal
- Faster drilling rates

Table 9 • Typical Properties of CELLOSIZE HEC-25†

Ash Content as Na_2CO_3, % by wt	4
Bulk Density, lb/ft^3	31
Color	Cream to white
Decomposition Temperature, °C (°F)	About 205 (400)
Softening Point, °C (°F)	>140 (285)
Specific Gravity at 20/20°C	1.38 to 1.40
Volatile Matter, % by wt	4

†The physical property data listed are considered to be typical properties, not specifications.

Performance

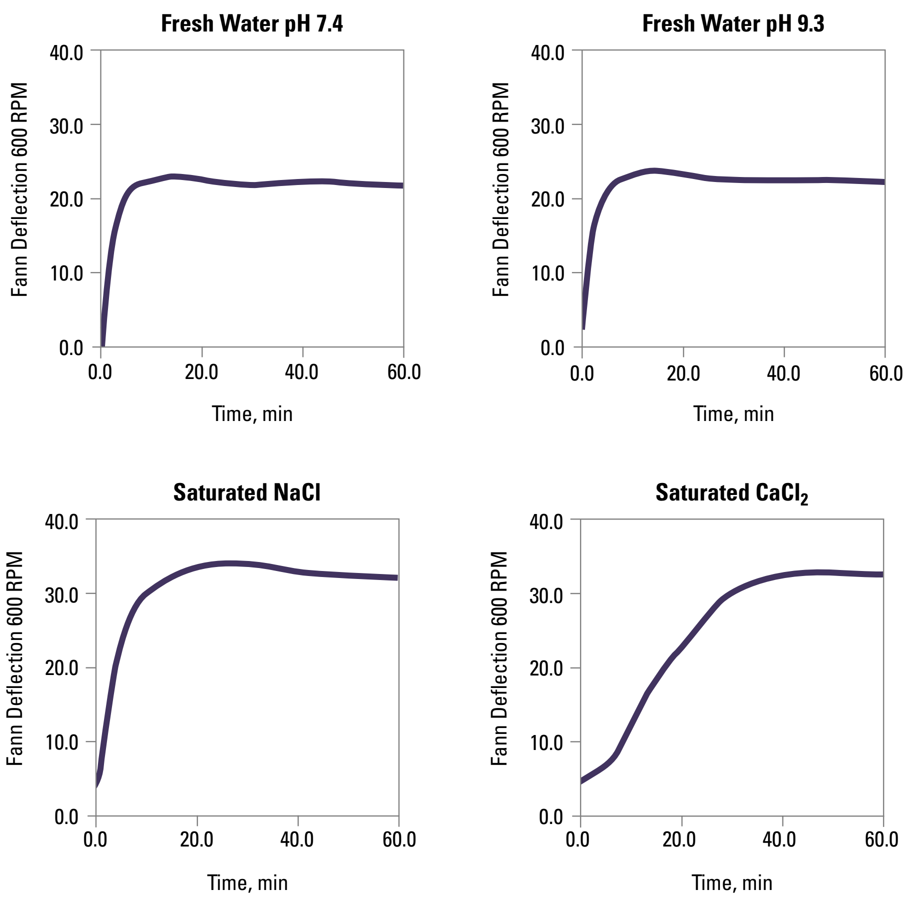
Thickening times of a CELLOSIZE HEC-25 slurry in fresh water and in brines are shown in the following graphs. As the data show, fully yielded, homogeneous solutions of HEC-25 can be achieved in 20 minutes or less in fresh water or brine while being sheared at 600 rpm (1022 sec^{-1}) on a Fann Model 35 viscometer. The viscometer was run continuously for the first 60 minutes with regular readings.

Laboratory-prepared slurries of CELLOSIZE HEC-25 remain easily pourable after one month storage.

Packaging of CELLOSIZE HEC-25

CELLOSIZE HEC-25 is packaged in 50-lb bags that are easy to palletize. These moisture-resistant bags are extra strong, can be opened easily, and save valuable storage space. Polyethylene film is stretched around a loaded pallet, providing a protective covering that keeps the bags dry, positions them firmly, and protects them from damage in transit.

Figure 6 • Thickening Response Times of Liquid Slurries Made from CELLOSIZE HEC-25



CELLOSIZE HEC-10HV and HEC-25HV

CELLOSIZE HEC-10HV and HEC-25HV are higher viscosity versions of CELLOSIZE HEC-10 and HEC-25. Their higher viscosity allows users to formulate with lower polymer concentrations, which further reduces the potential of formation damage and can also be more economical. HEC-25HV is designed for use in liquid slurry systems and has the same advantages as HEC-25 in these systems, including fast yield, non-damaging to the formation, good solubility in NaCl and $CaCl_2$ brines and insensitivity to pH. Typical properties of HEC-10HV and HEC-25HV are listed in Table 10.

Table 10 • Typical Properties of HEC-10HV and HEC-25HV

Property	HEC-10HV	HEC-25HV
Viscosity[a], Brookfield LVF, cP	>6000	>6000
Ash Content as Na_2CO_3, % by wt	3	3
Volatile Matter, % by wt	4	4
Bulk Density, lb/ft^3	30	30

(a) Brookfield LVF at 25°C, No. 4 spindle at 30 rpm, one percent solution on a dry basis, adjusted for volatiles

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For pricing and availability, please contact your service company.

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Published February 2004

Printed in U.S.A.

Form No. 325-00005-0204 AMS