ASTM Permeability: Drilling Brine Permeants

TEST REPORT #14
ASTM (D5084) Hydraulic Conductivity of Product Formulations for Brine from Drilling Operations

Background and Purpose of Testing

To limit and manage the potential leakage and/or failure of flexible membrane or concrete liner-based containment systems, low permeability materials can be used for either secondary containment below a liner, as a means of sealing penetrations through liners, or in other structural applications to control potential off-site migration of contaminants.

Sodium bentonite has been used in many traditional fresh water sealing applications, such as landfills and in well applications. However, the material is known to have sensitivity to high ionic-strength waters such as the brine which may be a characteristic of the flow-back water resulting from a hydro-fracking operation used to develop petroleum and gas fields. Bentonite resistance to highly saline or chemically aggressive waters in an initially dispersed slurry wall system, for example, can result in clay flocculation, increased permeability and, in extreme cases, wall failure (Day 1994).

Other types of clay minerals display a much lower sensitivity to high ionic-strength waters or to changes in water chemistry over time. One such mineral is attapulgite (a.k.a. palygorskite). Attapulgite has a needle-like structure, a relatively high but minimally charged surface area, and a lower affinity for water – attributes that result in this mineral displaying minimal flocculation or swelling potential, regardless of the chemistry or salinity level of the hydrating water (e.g. Tobin and Wild 1986; Shackleford 1994).

The goal of this testing is to determine hydraulic conductivity measurements for three (3) variations of bentonite based AquaBlok products using a hyper-saline drilling brine permeant. It is known that hydraulic conductivity of sodium bentonite-based materials to saline conditions can be significantly lower in the short term if the material is first hydrated with freshwater (Lin and Benson, 2000; Shackelford, 1994). To confirm this phenomena with an AquaBlok product, the product is first hydrated with fresh water then subjected to a permeability test using brine water taken from an actual drilling operation.

Table 1

Brine Produced Water Data					
	% Salt	mg/L Sodium	mg/L Clorides	mg/L Strontium	Density
Brine #1	13.0	34400	79100	2150	-
Brine #2	35.5	95500	215560	3900	10.01

Methods

Representative samples of selected freshwater (FW) and saline (SW) formulations (n = 1 for each formulation) were permeated with brine waters of different chemical and salinity levels in the laboratory using flexible-wall permeameters (constant head).

Testing was conducted in general conformance with ASTM Method D5084, as was freshwater product testing (see Test Report No. 3). Cell pressures during testing were approximately 35 psi and hydraulic gradients were held between approximately 5 cm/cm to slightly over 30 cm/cm.

Samples tested included a number of selected FW or SW formulations manufactured using different clay types (sodium bentonite, attapulgite, or a clay blend); at approximate clay to aggregate weight ratios of 30% (3070). Additional testing details are provided in Tables 1 and 2.

The chemical profile of the two permeant (input) solutions is provided in Table 1. The salinity values are high enough to be expressed in percent rather than traditional parts per thousand, ppt measurement. (36 ppt is equivalent to that of typical undiluted, or full-strength, seawater).

Results

Flexible-wall permeameter values for three selected FW and SW product formulations permeated with waters of different chemical and salinity levels are presented in Table 2.

Results of the testing indicate that all three clay formulations provided very low hydraulic conductivity (low permeability) and good short-term resistance to the two tested brine samples. It is important to note that these tests do not represent the long-term performance of these low-permeability clay formulations if exposed to these brine waters. It is anticipated that the high sodium levels in the water would gradually cause an increase in permeability as demonstrated by continued permeameter testing of different FW and SW formulations using permeants of variable input salinity over time.

Observations and Conclusions

ASTM hydraulic conductivity measurements for three variations of bentonite-based AquaBlok products using a hypersaline drilling brine permeant are given in table 2. All three clay formulations showed a very low permeability and good short-term resistance to the two tested brine samples. This illustrates that they can be used for either secondary containment below liners or as a means of sealing penetrations through liners or in other structural applications (trench dams, pond liners, anti-seep collars, etc.) to control potential off-site migration of contaminants

Table 2

AquaBlok - Clay Type Permeability			
	3070 FW	3070 SW	BKCR
Brine #1	8.8E-09	2.1E-08	-
Brine #2	1.6E-08	1.8E-08	5.97E-09

References

Day, S. R., 1994. The Compatibility of Slurry Cutoff Wall Materials with Contaminated Groundwater. In: Hydraulic Conductivity and Waste Contaminant Transport in Soils. ASTM STP 1142. D. Daniel and S. Trautwein (eds.), American Society for Testing and Materials, Philadelphia, PA., pp. 284-299.

Shackleford, C. D., 1994. Waste-Soil Interactions that Alter Hydraulic Conductivity, In: Hydraulic Conductivity and Waste Contaminant Transport in Soils. ASTM STP 1142. D. Daniel and S. Trautwein (eds.), American Society for Testing and Materials, Philadelphia, PA., pp. 111-168.

Tobin, W. R. and Wild, P. R., 1986. Attapulgite: A clay liner Solution?, *Civil Engineering*, ASCE, Vol. 56, No. 2, pp. 56-58.

AquaBlok® Composite Particle System

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