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; Shackelford 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 freshwater then subjected to a permeability test using brine water taken from an actual drilling operation.

<table>
<thead>
<tr>
<th>Brine Produced Water Data</th>
<th>mg/L</th>
<th>mg/L</th>
<th>mg/L</th>
</tr>
</thead>
<tbody>
<tr>
<td>% Salt</td>
<td>Sodium</td>
<td>Chlorides</td>
<td>Strontium</td>
</tr>
<tr>
<td>Brine #1</td>
<td>13.0</td>
<td>34400</td>
<td>79100</td>
</tr>
<tr>
<td>Brine #2</td>
<td>35.5</td>
<td>95500</td>
<td>215560</td>
</tr>
</tbody>
</table>

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

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