TEST REPORT #2 HB HOLEBLOK+™ GROUT CHEMICAL REACTIVITY WITH GROUNDWATER IN MONITORING WELL

Technology Overview

AquaBlok® is a patented, composite-aggregate technology resembling small stones and typically comprised of a dense aggregate core, clay or clay sized materials, and polymers (Figure 1). For typical formulations, AquaBlok's clay (sealant) component consists largely of bentonite clay. However, other clay minerals can be incorporated to meet specific needs. Other technology parameters (particle size, relative clay content, etc.) can also be modified, as appropriate.

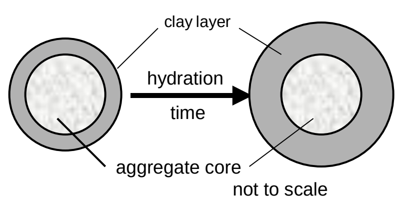

Figure 1. Configuration of Typical AquaBlok Particle.

AquaBlok particles expand when hydrated, with the degree of net vertical expansion determined largely by the formulation, application thickness, and the hardness and salinity of the hydrating water. When a mass of particles is hydrated, the mass coalesces into a continuous body of material. Once developed, the hydrated AquaBlok can act as an effective physical, hydraulic, and chemical barrier by virtue of its relatively cohesive and homogeneous character, and low permeability to water.

Problem Statement

In construction of an environmental monitoring well, a low-permeability, hydraulic seal is required to minimize the potential for vertical transfer of contaminated ground water or oil along the well's annular space. Often standard bentonite grout materials will absorb low levels of contaminants, only to release these constituents later. This can result in false positive readings causing significant added expense and time to monitoring programs. In addition, creating and maintaining a positive seal above the sand/screen interval is important to prevent transfer of contaminants such that pollutant migration does not contaminate adjacent aquifers.

Approach

Current practice for creating a hydraulic seal above a well's screened interval generally involves installation of a low-permeability grout material directly over a well screen sand pack or other granular material previously placed into the well's annular space, adjacent to the well screen (Figure 2). The seal is typically created by pouring an adequate quantity of pure, dry bentonite pellets or chips down the annular space and across the surface of the granular component.

Water present in the formation hydrates the pellets, thus affecting material expansion and sealing of the annular space. Finally, the bentonite chips or concrete/bentonite grout slurry (typically characterized by a low bearing capacity) is tremie-piped over the top of the semi-solid cap. Well construction is then typically completed through application of a surficial concrete cap.

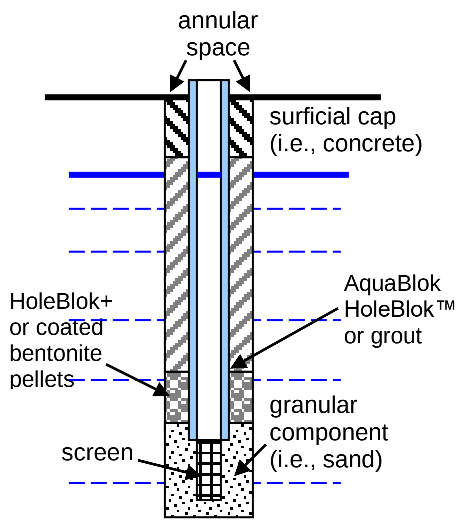

Figure 2. Schematic of common well construction.

Figure 3. Hole Size Application Rates.
D1 = Bore Hole Diameter (Inches)
V1 = Entire Bore Hole Volume (Cu.Ft.)
LF1 = Linear Feet per 50# of HoleBlok
D2 = Well Casing Diameter (Inches)
V2 = Annular Space Volume (Cu.Ft.)
LF2 = Linear Feet per 50# of HoleBlok

D_1	V_1	LF_1	D_2	V_2	LF_2
24	3.142	0.20	16	1.745	0.36
			12	2.356	0.27
18	1.767	0.35	8	1.418	0.44
			6	1.571	0.40
16	1.396	0.45	8	1.047	0.60
			6	1.200	0.52
			4	1.309	0.48
14	1.069	0.58	8	0.720	0.87
			6	0.873	0.72
			4	0.982	0.64
12	0.785	0.80	6	0.589	1.06
			4	0.698	0.90
10	0.545	1.15	4	0.458	1.36
			2	0.524	1.19
8	0.349	1.79	2	0.327	1.91
7	0.267	2.34	2	0.245	2.55
6	0.196	3.18	2	0.175	3.58
			1	0.191	3.27
4	0.087	7.16	2	0.065	9.55
			1	0.082	7.64
3	0.049	12.73	1 1/2	0.037	16.98
			1	0.044	14.32
2	0.022	28.65	1 1/2	0.010	65.48
			1	0.016	38.20
			3/4	0.019	33.34
1 3/4	0.017	37.42	1 1/4	0.008	76.39
1 1/2	0.012	50.93	1	0.007	91.67
1 1/4	0.009	73.34	1	0.003	203.72
1	0.005	114.59	3/4	0.002	261.92

Construction of an effective bentonite seal directly over the top of (and contiguous with) the underlying granular unit can be complicated by a phenomenon known as "bridging." Bridging generally involves a "clogging" of bentonite material within upper reaches of the annular space during its application and descent through the annular space, and can result in gaps.

Such a hydraulic gap could create pathways for release or the uncontrolled transfer of contaminated ground waters from one aquifer to another.

In addition, the potential for direct contact between the bentonite seal and contaminated groundwater below creates the need for both a very low hydraulic conductivity barrier and also a material that will not react or re-release contaminants once contact is made.

Why HoleBlok+ Is Better

Two important advantages are provided by the use of AquaBlok's unique HoleBlok+ product. First, the more dense, bentonite-bearing particle has both a greater mass and a delayed hydration time to minimize bridging during descent through the annular space, enabling more effective placement of the reactive bentonite component directly overtop the sand unit – thus resulting in formation of a continuous and effective well seal. The settling velocity of dry AquaBlok particles through a water column within the annular space equals that of coated bentonite pellets and is faster than that of pure chips (see Figure 6, page 2).

Second, the reactive material contained in the HoleBlok+ will both minimize the potential for contaminant rebound within an environmental monitoring well, but also provide some level of pollution prevention as described further below.

Figure 4. AquaBlok HoleBlok™ and HoleBlok+™ grout particles are easy to handle and place. No mixing or special equipment is required.

AquaBlok HoleBlok+ Reactive Sealant for Pollution Prevention

By adding reactive media or catalysts to AquaBlok, such as Zero Valent Iron, hydrated composite particles quickly form subsurface seals around targeted objects such as well casings, piping, or other structures and provide treatment of residual pollution. The reactive nature of the amended sealant is such that organic compounds that partition into the sealant can be destroyed. Inorganic compounds, which tend to migrate along the preferred path of the boreholes or engineered structures, will also be effectively sequestered, thereby minimizing extended or cross-contamination of sub-aqueous environments. AquaBlok HoleBlok+ helps minimize cross contamination of aquifers during site investigation, delineation and remedial actions. In addition, the potential for rebound of contaminants of concern, which may be attributed to the sorptive nature of conventional sealants, can be minimized (PATENTS PENDING).

Impact/Reactivity of HoleBlok+ with Groundwater

Independent lab tests were performed to access potential impact on groundwater chemistry from the use of HoleBlok+ or standard HoleBlok products. Leachability in a simulated well/annular environment was tested. Comparison was made to control, where no sealant was used. This study provides additional data beyond prior tests which were performed to compare AquaBlok to other currently commercially available well sealant products.

The below table presents a selected, partial summary of key analytical results:

Indicator, Major Ions, Metals	Drinking Water Stds	Control	Bentonite	HP+
Specific Conductance	--	2160	2480	2430
pH	6.5-8.5	7.28	7.22	7.29
Calcium	--	328000	315000	330000
Chloride	250	74	80	72
Iron	300	4910	1380	3750
Potassium	--	3810	7230	6720
Magnesium	--	147000	135000	145000
Sodium	--	57200	153000	113000
Sulfate	250	1240	1320	1280
Arsenic	10	<3.0	<3.0	<3.0
Copper	1300	<5.0	<5.0	<5.0
Lead	15	<1.0	1.54	1.7

HoleBlok+ did not materially affect analytical groundwater data. Also, previous studies indicate that non-reactive HoleBlok is an effective alternative to traditional annular sealant, which compares favorably from a chemical perspective. This additional data now indicates that HoleBlok+ performs as well as non-reactive HoleBlok and may offer additional protective measures to further assure the accuracy of ground water samples by minimizing the potential impact of organic pollutant rebound issues.

Settling Characteristics

To obtain a comparison of the rate of descent of AquaBlok to alternative products, two formulas of AquaBlok were used: a 4060 No. 9 AquaBlok HoleBlok, having an average particle size of ~1/4"; and a 4060 uniform No. 8 AquaBlok HoleBlok, having an average particle size of ~3/8". The two formulations of AquaBlok were compared to bentonite chips, 1/4" coated tablets, and 3/8" coated tablets. To perform the comparison, an 8.5'x11"x11" acrylic testing apparatus was used. The 8.5- foot column was filled to six-inches from the top of the column to obtain an eight-foot water column. A dropping apparatus was then utilized to consistently drop approximately 200 cm^3 of each product. The rate of descent was timed from the moment of opening the dropping apparatus until the majority of the product had reached the floor of the testing column. A total of ten repetitions were completed for each product. As shown on Figure 5, the average drop rates for the AquaBlok HoleBlok grout particles are equivalent to the coated bentonite pellets.

Permeability

Representative samples of freshwater AquaBlok (4060 FW) were used to determine saturated hydraulic conductivity in general conformance with ASTM Method D 5084.

AquaBlok HoleBlok Formulation	Hydraulic Conductivity Values (cm/sec)
4060 FW	3.94×10^{-9}

Figure 5. Comparative Drop Test Results.

TEST #	Bentonite Chips	1/4" Coated Bentonite Pellets	AquaBlok 4060 No.9's	3/8" Coated Bentonite Pellets	AquaBlok 4060 No. 8's
	Time (sec)	Time (sec)	Time (sec)	Time (sec)	Time (sec)
AVG	*11.46*	*10.44*	*10.46*	*8.22*	*8.31*

Additional Application Data

The following additional data is provided for better understanding of the physical and application characteristics of HoleBlok and HoleBlok+ products.

Figure 6. Mean Moisture Content

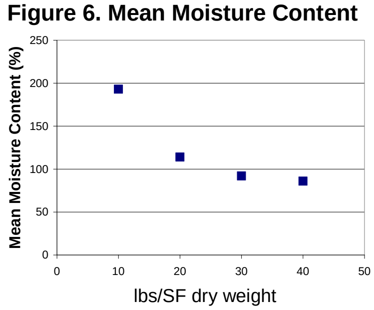

Figure 7. Mean Moisture Content

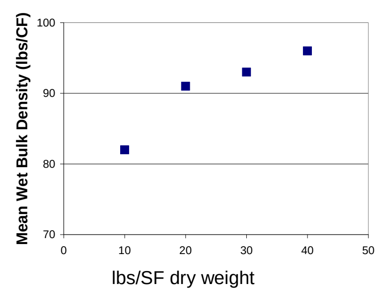

Figure 8. Typical Dry Bulk Density for AquaBlok HoleBlok+

Product Formulation	Aggregate Core	Dry Bulk Density, Typical Range (lbs/ft^3) 75 80 85
4060 FW	No. 8	

For more information, call AquaBlok, Ltd. at (419) 825-1325, or email us at services@aquablok.com.

The test reports are also available on our web site at: www.aquablok.com.

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AquaBlok® Composite Particle System