Baroid Industrial Drilling Products

Product Service Line, Halliburton

Bentonite Grouting and Sealing Materials

HOLEPLUG® **(ANSI/NSF Standard 60 Certified)**

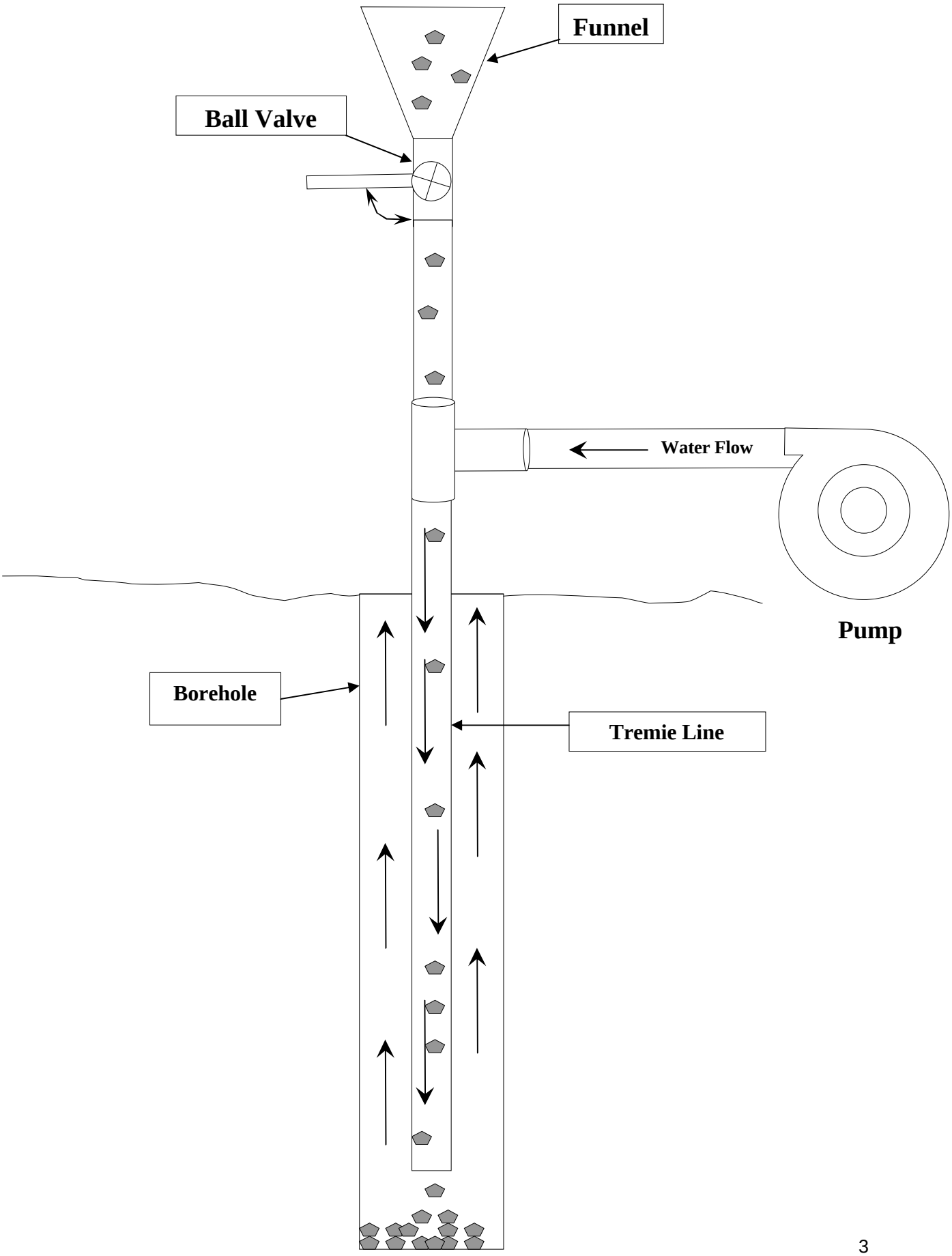
HOLEPLUG is a high quality sodium montmorillonite available in 3/8" or 3/4" chips packaged in 50-lb (22.7 kg) multi-layer bags containing approximately 0.69 ft^3 of material per 50-lb bag. When correctly applied HOLEPLUG develops one of the highest quality sodium bentonite seals available.

The HOLEPLUG material as seen in the bag is essentially unaltered from its natural state. The production of HOLEPLUG consists of mining of the selective ore and placing the material on drying beds to be ambiently dried to approximately 15%-17% moisture. The bentonite material is then crushed and screened into 3/8" or 3/4" inch chips and bagged for shipment. Therefore, the resulting material has not been physically or chemically altered and the inherent structural properties remain intact. The HOLEPLUG material is not starved for water and since the natural permeability and porosity remain the resulting hydration of the chip material occurs slowly and completely. When HOLEPLUG is used as a sealing agent, a calculation is made to determine the volume of the annular space or the respective borehole. These calculations are based on gauge hole values and assume concentric orientation of the casing. When the volume calculation is completed this gives the user the ability to place an equivalent volume of high quality sodium bentonite in the form of 3/8" or 3/4" inch chips for an equivalent volume of annular space or borehole volume. The HOLEPLUG is placed into the area of concern and the hydration of the sodium bentonite takes place in-situ thereby enhancing the quality of the resulting seal. The process results in a seal composed of high quality sodium bentonite at a solids concentration approaching 70% with permeability values less than 1.0 x 10^{-8} cm/sec, high degrees of structural integrity and expansion pressure due to the resulting hydration of the sodium bentonite in-situ.

HOLEPLUG can be effectively used in a variety of environments and in conjunction with steel, fiberglass, acrylic or PVC casing. HOLEPLUG is the product of choice for applications in the vadose zone or in geologic conditions consisting of permeable and/or fractured environments. The physical size of the material, high swell potential, percent solids and reduced surface area make HOLEPLUG the optimum choice for a sealing agent in these problematic environments. The physical size of the chips reduces and/or eliminates loss of material to the formation. The high swell potential, percent solids and reduced surface area enhance the quality of the resultant seal by reducing the potential for desiccation and makes the material less susceptible to contaminants.

The limiting factor for the use of HOLEPLUG is the amount of annular space, potential for bridging and placement method.

It is recommended that a minimum annular space of 2 inches be present to allow for the application of HOLEPLUG. The use of HOLEPLUG is always a viable option in open boreholes when applied properly. There are two basic methods for the application of HOLEPLUG, the pouring method and tremie method.
The pouring method is effective means of application when a few simple guidelines are followed.
Calculate the volume of the annular space or borehole and determine the minimum amount of HOLEPLUG necessary to fill the borehole to the desired elevation. The calculations are based on gauge hole diameters and will result in the minimum amount of material necessary to abandon the well. Acquire enough 1/4" square mesh screen to assemble a v-shaped trough or similar design. Prior to entry into the borehole, the HOLEPLUG should be poured across the square mesh screen at an application rate not less than 2 minutes per 50-lb sack. The physical screening of the chip material removes "fines" that have developed during transportation. If the "fines" are not removed prior to entry to the borehole the fine material may accumulate at the static water level thereby increasing the potential of a bridge forming at that point.
The material will be applied into the annular space or open borehole through fresh standing water. In the event that water is no longer standing in the remaining borehole once the HOLEPLUG column reaches the static water level then additional water should be added prior to subsequent HOLEPLUG additions. This situation is rare but the minimum water added should be equal to approximately 5 gallons of freshwater per sack of HOLEPLUG. This will insure that initial hydration of HOLEPLUG occurs and a functional seal is established.
Physically tag the material with a depth indicator tape, wireline or other method that will indicate the measured depth of the HOLEPLUG material. This depth should correlate with the calculated depth reduction or be less due to potential washouts in the borehole itself. The tagging process should be done periodically to insure that bridging has not occurred. The problems associated with the pouring of chip sodium bentonite predominately occur when placing the material into narrow annular spaces or small diameter boreholes at excessive rates of application without the material being screened prior to entrance into the annular space or open borehole. These factors combined with contractors not physically tagging the material to insure that the depth of contact correlates with the calculated depth reduction as a result of placing the HOLEPLUG into the borehole.
The second method of application is the tremie method. This method allows for the chip sodium bentonite material to be placed into the annular space or open borehole through a 1 1/2 inch or greater pipe (tremie) carried in a circulating medium of water. This method insures adequate volumes of material are used, bridging does not occur and water is present for the initial hydration of the sodium bentonite to take place. This insures that a functional seal is established.
The following diagram illustrates the method of HOLEPLUG placement via the tremie method.


Funnel
Ball Valve
Water Flow
Pump
Borehole
Tremie Line

The tremie method is carried out by installation of the tremie pipe into the annular space or open borehole at the bottom of the respective interval. When completing sealing operations within the annular space a minimum of 2 inches of annular space is necessary to facilitate the placement of the HOLEPLUG material and to allow for the entry of a tremie pipe large enough to carry out the job. This requires a tremie pipe with a minimum inside diameter of 1 1/4 inches. The process is initiated by breaking circulation with water through the tremie pipe with the ball valve to the funnel closed. Once fluid returns are present to the surface the ball valve below the funnel is then opened and the HOLEPLUG material is trickled into the hopper at an application rate of approximately 2 minutes per 50-lb sack. The tremie pipe must be retracted as the annular space or borehole is filled. Calculations should be done prior to the beginning of sealing operations to determine the amount of annular space or open borehole that will be filled by each sack of HOLEPLUG. The tremie pipe serves as a means of physically tagging the HOLEPLUG column to insure that bridging has not occurred. In the event that the tremie line appears to be plugging the addition of HOLEPLUG should be stopped and the ball valve below the hopper closed. This will allow for the tremie line to clear and the application of material to continue. The process is continued until the annular space or borehole is filled to the required elevation. A second tremie method for the placement of HOLEPLUG puts the chip bentonite material into the suction side of the pump. This method requires specific equipment and practice. The bentonitic material is positively displaced into the annular space or open hole ultimately providing effective placement and a high quality seal.

Baroid Bentonite Pellets

Baroid Bentonite Pellets are non-coated, high quality sodium bentonite that is compressed and formed into 1/4", 3/8", or 1/2" inch sized pellets. The material is packaged in 50-lb buckets that contain approximately 0.7 ft^3 per bucket. Baroid Bentonite Pellets provide a resultant seal with high structural integrity and permeability values of less than 1.0×10^{-8} cm/sec. The pelletized bentonite is an excellent sealing agent for annular spaces or open borehole applications. The pellets can be poured or tremied in the same manner as HOLEPLUG to facilitate the complete filling of the annular space or open hole and eliminate the potential for bridging to occur. The pelletized material can be used in the vadose zone or in highly permeable or fractured environments. The physical size of the pellet, high swell potential, percent solids and high shear strength of the resultant seal makes the pellets an excellent choice for sealing operations. To utilize Baroid Bentonite Pellets calculate the volume of the annular space or borehole and determine the minimum amount of pellets necessary to fill the space to the desired elevation. The calculations are based on gauge hole diameters and will result in the minimum amount of material necessary to abandon the well or fill the respective annular space. The use of bentonite pellets is limited by the amount of

annular space, rate of application and effective placement methods. The tendency of pellets to hydrate rapidly causes adherence and increases the potential to form a bridge. Therefore the pellet column should be physically tagged periodically to insure that bridging has not occurred. These guidelines allow for the effective use and placement of Baroid Bentonite Pellets to produce high quality seal for multiple applications.

BENSEAL/EZ-MUD **(ANSI/NSF Standard 60 Certified)**

The BENSEAL/EZ-MUD slurry combines two widely used Baroid products into a patented technique that provides a simple, economical method to seal and grout boreholes, well casings and earthen structures. The BENSEAL/EZ-MUD slurry provides a high quality pumpable grout combined with excellent structural integrity and low permeability that can be placed at solids percentages from 15-20 percent by weight. BENSEAL is a uniform, # 8 mesh granular sodium bentonite that provides a resultant seal with excellent shear strength and low permeability. The BENSEAL/EZ-MUD process utilizes a highly reactive sodium bentonite and retards the hydration of that material through the encapsulating mechanism of the EZ-MUD polymer. The hydration of the bentonite material is delayed just long enough to allow for the placement of the bentonite grout slurry into the annular space or open borehole. This allows the hydration process to occur in-situ where it is most beneficial to the quality of the resultant seal. The inherent properties of the base clay have not been altered and result in high shear strength and expansion pressure as a result of the in-situ swelling of the BENSEAL material. These superior physical properties allow the BENSEAL/EZ-MUD slurry to be used in a variety of geologic conditions such as permeable and fractured formations; thereby, reducing the potential for subsidence through its high shear strength and in-situ swelling capability. Pumpable grouts are not the best sealing materials for placement in the vadose zone. It is always preferable to place HOLEPLUG or Baroid Bentonite Pellets in this section of the annular space or open borehole because of the physical size of the material, percent solids and corresponding structural integrity. BENSEAL/EZ-MUD is a highly reactive bentonite grout thus limiting its use as a result of limited working time, depth of application, grouting equipment and placement methods. The mixing and placement methods for the use of BENSEAL/EZ-MUD are simple but require strict adherence to insure proper mixing and performance. To pump BENSEAL/EZ-MUD slurry, use a piston, diaphragm or gear-type pump. **Do not use a centrifugal pump**. The use of progressive cavity pumps is not suggested for placement of bentonite grouts. As the stator progresses forward withing the housing the granular BENSEAL is crushed into smaller and smaller pieces. This crushing action creates additional surface area thereby resulting in premature hydration and plugging of the progressive cavity pump. It is recommended that the mixing process be carried out with paddle type mixing equipment to facilitate a low shear environment. The respective pump should be used solely for displacement purposes. In the event high shear mixers are used this will shear

the bentonite exposing more surface area of the clay to water thereby speeding up the rate of hydration and reducing working time.
The make-up water should be freshwater with a total hardness of less than or equal to 100 ppm. Elevated water temperature can result in reduced working time of the BENSEAL/EZ-MUD slurry. To each 30 gallons (U.S.) add 8-10 ounces of EZ-MUD liquid polymer and mix well. Once the EZ-MUD has been dispersed add 50-lb (1 sack) of BENSEAL to the grouter's mixing tank. This mixture results in a slurry with a density of 9.3 lb/gal, 16.6 % solids (by weight) and a finished slurry volume of 32.3 gallons. It is recommended that the material be mixed at low shear and no longer than is necessary to gain suspension of the granular bentonite. Once suspension is achieved the material should be immediately pumped through the tremie line into the annular space or open hole. The tremie should always be kept within the grout column as displacement is carried out. Active pumping of the grout should continue UNTIL COMPETENT GROUT IS PRESENT AT THE SURFACE. It should be noted that active pumping should continue as the tremie pipe is extracted from the annular space or open hole to insure effective displacement. The objective is to get the resulting BENSEAL/EZ-MUD slurry into the annular space or open hole in as near un-yielded form as possible. This allows for in-situ hydration of the sodium bentonite material thereby improving the quality of the resultant seal. The entire displacement procedure should be completed within 15 minutes from the time the BENSEAL is added. It is recommended that the size of the respective batches be limited to 1 sack at a time. This will insure that the specified amount of water for each batch is consistent and the material can be mixed and pumped quickly reducing the potential for placement problems. Consistency of the grout insures the quality of the resulting seal.

EZ-SEAL **(ANSI/NSF Standard 60 Certified)**

EZ-SEAL is a patented, one-sack, easily mixed granular bentonite product intended for use as a grouting and plugging material. EZ-SEAL is packaged in 50-lb (22.7-kg) multi-wall paper bags, containing 0.7-ft^3 (0.02 m^3). EZ-SEAL is a new generation product that takes the two-step inhibitive process of the BENSEAL/EZ-MUD slurry and incorporates it into a one step system. The granular sodium bentonite consisting of a range of specific particle size distribution is coated with a specially formulated liquid polymer thereby eliminating the need for EZ-MUD. The coating process gives the end-user the flexibility to work with varying percentages of solids from 15% - 23% (by weight) and increased working time. EZ-SEAL provides a high quality pumpable grout combined with high structural integrity and low permeability. The hydration of the bentonite material is delayed long enough to allow for the placement of the bentonite grout slurry into the annular space or open borehole. This allows the hydration process to occur in-situ where it is most beneficial to the quality of the resultant seal. The inherent properties of the base clay have not been altered which results in high shear strength and expansion pressure as a result of the in-

situ swelling of the granular sodium bentonite material. The superior physical properties allow the EZ-SEAL slurry to be used in a variety of geologic conditions such as permeable and fractured formations thereby reducing the potential for subsidence through its high shear strength and in-situ swelling capability. Pumpable grouts are not the best sealing materials for placement in the vadose zone. It is always preferable to place HOLEPLUG or Baroid Bentonite Pellets in this section of the annular space or open borehole because of the physical size of the material, percent solids and corresponding structural integrity. To pump the EZ-SEAL slurry, use a piston, diaphragm or gear-type pump.
Do not use a centrifugal pump. The use of progressive cavity pumps is not suggested for placement of bentonite grouts. As the stator progresses forward withing the housing the granular EZ-SEAL is crushed into smaller and smaller pieces. This crushing action creates additional surface area thereby resulting in premature hydration and plugging of the progressive cavity pump. It is recommended that the mixing process be carried out with paddle type mixing equipment to facilitate a low shear environment. The respective pump should be used solely for displacement purposes. In the event high shear mixers are used, this will shear the bentonite exposing more surface area of the clay to water thereby speeding up the rate of hydration and reducing working time.
The make-up water should be freshwater with a total hardness of less than or equal to 100 ppm. Elevated water temperature can result in reduced working time of the EZ-SEAL slurry. To develop a 20% solids (by weight) grout start with 24 gallons (U.S. gallons) and add one sack (50-lbs) of EZ-SEAL to the grouter's mix tank. This mixture results in a slurry density of 9.5 lb/gal, and a finished slurry volume of 26.3 gallons. It is recommended that the material be mixed at low shear and no longer than is necessary to gain suspension of the granular bentonite. Once suspension is achieved the material should be immediately pumped through the tremie line into the annular space or open hole. The tremie should always be kept within the grout column as displacement is carried out. Active pumping of the grout should continue UNTIL COMPETENT GROUT IS PRESENT AT THE SURFACE. It should be noted that active pumping should continue as the tremie pipe is extracted from the annular space or open hole to insure effective displacement. The objective is to get the resulting EZ-SEAL slurry into the annular space or open hole in as near un-yielded form as possible. This allows for in-situ hydration of the sodium bentonite material thereby improving the quality of the resultant seal. It is recommended that the size of the respective batches be limited to 1 sack at a time. This will insure that the specified amount of water for each batch is consistent and the material can be mixed and pumped quickly reducing the potential for placement problems. Consistency of the grout insures the quality of the resulting seal.

QUIK-GROUT (ANSI/NSF Standard 60 Certified)

QUIK-GROUT is a single-sack, easy-to-use, sodium bentonite grout designed for grouting water wells, monitoring wells, and for plugging boreholes. QUIK-GROUT

does not contain any organic additives or polymers. QUIK-GROUT is a pumpable grout designed to meet industry requests for a 20% solids bentonite grout with extended working time. QUIK-GROUT is packaged in 50-lb (22.7-kg) multi-wall paper bags, containing 0.7-ft^3 (0.02 m^3). QUIK-GROUT provides a competent seal with low permeability and is capable of being placed with a variety of grouting equipment. The hydration of the bentonite material is delayed to allow for the placement of the bentonite grout slurry into the annular space or open borehole. This allows the hydration process to occur in-situ where it is most beneficial to the quality of the resultant seal. QUIK-GROUT is best suited for use in competent geologic conditions, due to the reduced shear strength of QUIK-GROUT versus that of BENSEAL/EZ-MUD or EZ-SEAL, as there is a higher potential for subsidence with dispersed type grouts such as QUIK-GROUT in highly permeable and fractured geologic environments. The mixing and placement methods for the use of QUIK-GROUT are simple but require strict adherence to insure proper mixing and performance. Pumpable grouts are not the best sealing materials for placement in the vadose zone. It is always preferable to place HOLEPLUG or Baroid Bentonite Pellets in this section of the annular space or open borehole because of the physical size of the material, percent solids and corresponding structural integrity. To pump the QUIK-GROUT slurry, use a piston, diaphragm or gear-type pump.

Do not use a centrifugal pump. The use of progressive cavity pumps is not suggested for placement of bentonite grouts. As the stator progresses forward withing the housing the granular QUIK-GROUT is crushed into smaller and smaller pieces. This crushing action creates additional surface area thereby resulting in premature hydration and plugging of the progressive cavity pump. It is recommended that the mixing process be carried out with paddle type mixing equipment to facilitate a low shear environment. The respective pump should be used solely for displacement purposes. In the event high shear mixers are used this will shear the bentonite exposing more surface area of the clay to water thereby speeding up the rate of hydration and reducing working time. The make-up water should be freshwater with a total hardness of less than or equal to 100 ppm. Elevated water temperature can result in reduced working time of the QUIK-GROUT slurry. To develop a 20% solids (by weight) grout start with 24 gallons (U.S. gallons) and add one sack (50-lbs) of QUIK-GROUT to the mix tank of the grouter. This mixture results in a slurry with a density of 9.4 lb/gal, and a finished slurry volume of 26.3 gallons. It is recommended that the material be mixed at low shear and no longer than is necessary to gain suspension of the granular bentonite. Once suspension is achieved the material should be immediately pumped through the tremie line into the annular space or open hole. The tremie should always be kept within the grout column as displacement is carried out. Active pumping of the grout should continue UNTIL COMPETENT GROUT IS PRESENT AT THE SURFACE. It should be noted that active pumping should continue as the tremie pipe is extracted from the annular space or open hole to insure effective displacement. The objective is to get the resulting QUIK-GROUT slurry into the annular space or open hole in as near un-yielded form as possible. This allows for in-situ hydration of the sodium bentonite

material thereby improving the quality of the resultant seal. It is recommended that the size of the respective batches be limited to 1 sack at a time. This will insure that the specified amount of water for each batch is consistent and the material can be mixed and pumped quickly reducing the potential for placement problems. Consistency of the grout insures the quality of the resulting seal.

AQUAGUARD (ANSI/NSF Standard 60 Certified)

AQUAGUARD is a single-sack grout containing granular Wyoming sodium bentonite blended with inorganic additives. AQUAGUARD is packaged in 50-lb (22.7-kg) multi-wall paper bags containing 0.7-ft^3 (0.02 m^3). The grout is designed for sealing the annular space around monitor or water well casing. AQUAGUARD grout mixes with freshwater to produce a pumpable, 30% solids (by weight) grouting slurry with extended working time. AQUAGUARD provides a competent seal with low permeability. The hydration of the bentonite material is delayed to allow for the placement of the bentonite grout slurry into the annular space or open borehole. This allows the hydration process to occur in-situ where it is most beneficial to the quality of the resultant seal. AQUAGUARD is best suited for use in competent geologic conditions, due to the reduced shear strength of AQUAGUARD versus that of BENSEAL/EZ-MUD or EZ-SEAL, as there is a higher potential for subsidence with dispersed type grouts such as AQUAGUARD in highly permeable and fractured geologic environments. The mixing and placement methods for the use of AQUAGUARD are simple but require strict adherence to insure proper mixing and performance. Pumpable grouts are not the best sealing materials for placement in the vadose zone. It is always preferable to place HOLEPLUG or Baroid Bentonite Pellets in this section of the annular space or open borehole because of the physical size of the material, percent solids and corresponding structural integrity. To pump the AQUAGUARD slurry, use a piston, diaphragm or gear-type pump. **Do not use a centrifugal pump**. The use of progressive cavity pumps is not suggested for placement of bentonite grouts. As the stator progresses forward withing the housing the granular AQUAGUARD is crushed into smaller and smaller pieces. This crushing action creates additional surface area thereby resulting in premature hydration and plugging of the progressive cavity pump. It is recommended that the mixing process be carried out with paddle type mixing equipment to facilitate a low shear environment. The respective pump should be used solely for displacement purposes. In the event high shear mixers are used this will shear the bentonite exposing more surface area of the clay to water thereby speeding up the rate of hydration and reducing working time. The make-up water should be freshwater with a total hardness of less than or equal to 100 ppm. Elevated water temperature can result in reduced working time of the AQUAGUARD slurry. To develop a 30% solids (by weight) grout start with 14 gallons (U.S. gallons) and add one sack (50-lbs) of AQUAGUARD to the mix tank of the grouter. This mixture results in a slurry with a density of 10.2 lb/gal, and a finished slurry volume of 16.3 gallons. It is recommended that the material be

mixed at low shear and no longer than is necessary to gain suspension of the granular bentonite. Once suspension is achieved the material should be immediately pumped through the tremie line into the annular space or open hole. The tremie should always be kept within the grout column as displacement is carried out. Active pumping of the grout should continue UNTIL COMPETENT GROUT IS PRESENT AT THE SURFACE. It should be noted that active pumping should continue as the tremie pipe is extracted from the annular space or open hole to insure effective displacement. The objective is to get the resulting AQUAGUARD slurry into the annular space or open hole in as near un-yielded form as possible. This allows for in-situ hydration of the sodium bentonite material thereby improving the quality of the resultant seal. It is recommended that the size of the respective batches be limited to 1 sack at a time. This will insure that the specified amount of water for each batch is consistent and the material can be mixed and pumped quickly reducing the potential for placement problems. Consistency of the grout insures the quality of the resulting seal.

Note

The grouting method selected will depend upon, and you should carefully consider, all prevailing geological and hydrological factors and any existing regulatory requirements. The grouting process may not be complete until the grout is static at the desired level.

It is essential that the make-up water used for development of sodium bentonite grouts is fresh. The total hardness should always be less than 100 ppm. The best method for pre-treatment of make-up water is to use Soda Ash at 1-2 lb/100 gallons added to the water tank when filling. This insures that the water used for development of drilling fluid and make-up water for grouting is addressed. The resultant grout seal must last for the life of the well so it essential that development and placement of the respective grout are done correctly the first time. The subsurface environment that the respective bentonite sealing material or grout is to be placed into should always be taken into consideration when selecting the appropriate material to compose the well seal. If the formation water chemistry has a total hardness of greater than or equal to 500 ppm and/or a chloride content of greater than or equal to 1500 ppm the use of a bentonite material may not be appropriate for this environment. In the event that questions regarding subsurface environments arise it is always best to consult your local Baroid IDP representative to determine if the Baroid product of choice is appropriate for the given conditions.

The aforementioned grouting materials are not recommended for use as cement additives. The American Petroleum Institute (API) recommends the use of un-beneficiated sodium bentonite with cement. The appropriate Baroid IDP product for use with cement is AQUA-GEL® GOLDSEAL.

Product data sheets, material safety data sheets or technical information is available through local Baroid IDP sales representatives or Baroid IDP Technical Service in Houston, TX

Baroid Industrial Drilling Products
A Product and Service Line of Halliburton Energy Services, Inc.
3000 N. Sam Houston Pkwy E.
Houston, TX 77032

Customer Service	(800) 735-6075 Toll Free	(281) 871-4612
Technical Service	(877) 379-7412 Toll Free	(281) 871-4613