Designation: D6724/D6724M – 16

Standard Guide for Installation of Direct Push Groundwater Monitoring Wells[1]

This standard is issued under the fixed designation D6724/D6724M; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope*

1.1 This guide describes various direct push groundwater monitoring wells and provides guidance on their selection and installation for obtaining representative groundwater samples and monitoring water table elevations. Direct push wells are used extensively for monitoring groundwater quality in unconsolidated formations. This guide also includes discussion of some groundwater sampling devices which can be permanently emplaced as monitoring wells.

1.2 This guide does not address the single event sampling of groundwater using direct push water samplers as presented in Guide D6001. The methods in this guide are often used with other tests such as direct push soil sampling (Guide D6282) and the cone penetrometer test (Guide D6067). The guide does not address the installation of monitoring wells by rotary drilling or sonic drilling methods such as those presented in Practice D5092. Techniques for obtaining groundwater samples from monitoring wells are covered in Guides D4448, D7929, and Practice D6771. Practice D6725 addresses direct push wells using pre-packed screens.

1.3 The installation of direct push groundwater monitoring wells is limited to unconsolidated soils and sediments including clays, silts, sands, and some gravels and cobbles. Penetration may be limited, or damage may occur to equipment, in certain subsurface conditions; some of which are discussed in 5.5. Information in this guide is limited to groundwater monitoring in the saturated zone.

1.4 The values stated in either inch-pound units or SI units presented in brackets are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in nonconformance with the standard.

1.5 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026, unless superseded by this standard.

1.6 This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgement. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

1.6.1 This guide does not purport to comprehensively address all of the methods and issues associated with monitoring well installation. Users should seek input from qualified professionals for the selection of proper equipment and methods that would be the most successful for their site conditions. Other methods may be available for monitoring well installation, and qualified professionals should have flexibility to exercise judgement concerning alternatives not covered in this guide. The practice described in this guide is current at the time of issue; however, new, alternative, and innovative methods may become available prior to revisions. Therefore, users should consult with manufacturers or producers prior to specifying program requirements.

1.7 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory requirements prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D4448 Guide for Sampling Ground-Water Monitoring Wells

[1] This guide is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Groundwater and Vadose Zone Investigations.

Current edition approved July 1, 2016. Published July 2016. Originally approved in 2001. Last previous editon approved in 2010 as D6724–04(2010). DOI: 10.1520/D6724_D6724M-16.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For Annual Book of ASTM Standards volume information, refer to the standard's Document Summary page on the ASTM website.

***A Summary of Changes section appears at the end of this standard**

D4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitoring Well (Observation Well) (Withdrawn 2010)[3]
D5088 Practice for Decontamination of Field Equipment Used at Waste Sites
D5092 Practice for Design and Installation of Groundwater Monitoring Wells
D5254 Practice for Minimum Set of Data Elements to Identify a Ground-Water Site
D5299 Guide for Decommissioning of Groundwater Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities
D5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
D5474 Guide for Selection of Data Elements for Groundwater Investigations
D5521 Guide for Development of Groundwater Monitoring Wells in Granular Aquifers
D5730 Guide for Site Characterization for Environmental Purposes With Emphasis on Soil, Rock, the Vadose Zone and Groundwater (Withdrawn 2013)[3]
D5978 Guide for Maintenance and Rehabilitation of Groundwater Monitoring Wells
D6001 Guide for Direct-Push Groundwater Sampling for Environmental Site Characterization
D6026 Practice for Using Significant Digits in Geotechnical Data
D6067 Practice for Using the Electronic Piezocone Penetrometer Tests for Environmental Site Characterization
D6282 Guide for Direct Push Soil Sampling for Environmental Site Characterizations
D6286 Guide for Selection of Drilling Methods for Environmental Site Characterization
D6452 Guide for Purging Methods for Wells Used for Groundwater Quality Investigations
D6564 Guide for Field Filtration of Groundwater Samples
D6634 Guide for Selection of Purging and Sampling Devices for Groundwater Monitoring Wells
D6725 Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers
D6771 Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations (Withdrawn 2011)[3]
D6914 Practice for Sonic Drilling for Site Characterization and the Installation of Subsurface Monitoring Devices
D7242 Practice for Field Pneumatic Slug (Instantaneous Change in Head) Tests to Determine Hydraulic Properties of Aquifers with Direct Push Groundwater Samplers
D7352 Practice for Direct Push Technology for Volatile Contaminant Logging with the Membrane Interface Probe (MIP)
D7929 Guide for Selection of Passive Techniques for Sampling Groundwater Monitoring Wells

[3] The last approved version of this historical standard is referenced on www.astm.org.

3. Terminology

3.1 *Definitions*—For common definitions of terms in this standard, refer to Terminology D653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *dual tube systems, n*—a system whereby inner and outer tubes are advanced independently or simultaneously into the subsurface strata.

3.2.1.1 *Discussion*—The outer casing tube is used for borehole stabilization. The inner tube for is used sampler recovery and insertion of other devices. In Practice D6282, direct push soil sampling the dual tube system takes soil samples with a sampler fixed to the inner rods.

4. Summary of Guide

4.1 This guide provides information to be used by experienced groundwater professionals for exploration of the subsurface and ambient groundwater conditions.

4.2 This guide outlines a variety of field methods for installing direct push groundwater monitoring wells. Installation methods include: (*1*) soil probing using combinations of dynamic (percussion or vibratory) driving with, or without, additions of static (constant) force; (*2*) static force from the surface using hydraulic penetrometer or drilling equipment; and (*3*) incremental drilling combined with direct push methods. Methods for installation of annular seals and annular grouts are also discussed as well as abandonment grouting.

4.3 This guide addresses considerations for selection and use of direct push well systems and installation techniques that may be classified into two main categories; exposed screen techniques and protected screen techniques. In exposed screen techniques, the screened casing may serve as the drive rod, or may surround a drive rod that is removed following installation. In protected screen techniques, the well may be advanced along with a protective outer casing, or may be lowered into a driven casing that is subsequently removed. Alternatively, the screen, riser, and a retractable shield may be driven simultaneously and all remain in the ground.

4.4 The interval to be tested is determined in advance by prior exploration, or by soil or water sampling during direct push driving. A screen section, either protected or unprotected, is connected to riser pipes and either driven on the outside of, or placed inside of direct push rods. With some monitoring well designs, it may be necessary to add sand pack and seals to isolate the screened test zone as the rods are retracted. The top of the installation is usually completed in a manner consistent with regulatory requirements. The well can be developed to remove mobile sediments. Water levels can be measured, and water samples are taken as required in the sampling plan.

5. Significance and Use

5.1 The direct push ground method is a rapid and economical procedure for installing groundwater monitoring wells to obtain representative groundwater samples and location-specific hydrogeologic measurements. Direct push installations may offer an advantage over conventional rotary drilled monitoring wells (Practice D5092) for groundwater explorations in unconsolidated formations because they reduce disturbance to the formation, and eliminate or minimize drill cuttings. At facilities where contaminated soils are present, this can reduce hazard exposure for operators, local personnel, and the environment, and can reduce investigative derived wastes. Additionally, smaller equipment can be used for installation, providing better access to constricted locations.

5.2 Direct push monitoring wells are typically smaller in diameter than drilled wells, thereby reducing purge water volumes, sampling time, and investigative derived wastes. Practice D5092 monitoring wells are used when larger diameters and/or sample volumes are required, or at depths or in geologic formations to where it is difficult to install direct push wells. Direct push monitoring wells should be viable for monitoring for many years.

5.3 Prior to construction and installation of a direct push well or any other type of groundwater well the reader should consult appropriate local agencies regarding regulatory requirements for well construction. A regulatory variance may be required for installation of direct push monitoring wells.

5.4 To date, published comparison studies between drilled monitoring wells and direct push monitoring wells have shown comparability (**1-10**)[4]. However, selection of direct push monitoring wells over conventional rotary drilled wells should be based on several criteria, such as site accessibility and penetrability, stratigraphic structure, depth to groundwater, and aquifer transmissivity.

5.5 Typical penetration depths for installation of groundwater monitoring wells with direct push equipment depend on many variables. Some of the variables are the size and type of the driving system, diameter of the drive rods and monitoring well, and the resistance of the earth materials being penetrated. Some direct push systems are capable of installing groundwater monitoring wells to depths in excess of 100 ft [30 m], and larger direct push equipment can reach depths of several hundred feet. However, installation depths of 10 to 50 ft [5 to 15 m] are most common. Direct push methods cannot be used to install monitoring wells in consolidated bedrock (for example, granite, limestone, gneiss), but are intended for installation in unconsolidated materials such as clays, silts, sands, and some gravels. Additionally, deposits containing significant cobbles and boulders (for example, some glacial deposits), or strongly cemented materials (for example, caliche) are likely to hinder or prevent penetration to the desired monitoring depth.

5.6 For direct push methods to provide accurate groundwater monitoring results, precautions must be taken to ensure that cross-contamination by "smearing" or "drag-down" (that is, driving shallow contamination to deeper levels) does not occur, and that hydraulic connections between otherwise isolated water bearing strata are not created. Similar precautions as those applied during conventional rotary drilling operations (Guide D6286) should be followed.

[4] The boldface numbers in parentheses refer to a list of references at the end of this standard.

5.7 There have been no conclusive comparisons of effectiveness of sealing between drilled monitoring wells and direct push monitoring wells. As with drilled monitoring wells, sealing methods must be carefully applied to be effective. Research on well sealing (**11**) has shown that bentonite seals are not effective above the water table and that if used bentonite grout requires a minimum of 20 % solids.

5.8 Selection of direct push monitoring wells versus conventional rotary drilled monitoring wells should be based on many issues. The advantages and disadvantages of the many available types of driving equipment and well systems must be considered with regard to the specific site conditions. Specific well systems and components, as well as direct push driving equipment, are described in Section 7.

5.9 *Advantages:*

5.9.1 Minimally intrusive and less disturbance of the natural formation conditions than many conventional drilling techniques.

5.9.2 Rapid and economical.

5.9.3 Smaller equipment with easier access to many locations.

5.9.4 Use of shorter screens can eliminate connections between multiple aquifers providing better vertical definition of water quality than long well screens. Shorter screens are also more effective at identifying contaminated zones in heterogeneous formation conditions.

5.9.5 Generates little or potentially no contaminated drill cuttings.

5.9.6 Less labor intensive than most conventional drilling techniques.

5.10 *Disadvantages:*

5.10.1 Cannot be used to install monitoring devices in consolidated bedrock and deposits containing significant cobbles and boulders.

5.10.2 Small diameter risers and screens limit the selection of useable down-hole equipment for purging and sampling.

5.10.3 Difficulty installing sand pack in small annular space if gravity installation of sand pack is used.

5.10.4 Difficulty installing grout in same annular space unless appropriately designed equipment is used.

NOTE 1—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/inspection/etc. Users of this standard are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

Practice D3740 was developed for agencies engaged in the laboratory testing and/or inspection of soils and rock. As such, it is not totally applicable to agencies performing this field practice. However, user of this practice should recognize that the framework of Practice D3740 is appropriate for evaluating the quality of an agency performing this practice. Currently there is no known qualifying national authority that inspects agencies that perform this practice.

6. Pre-Installation Considerations

6.1 *Site Characterization*—Successful installation of direct push groundwater monitoring wells must be preceded by appropriate site characterization activities. These activities may include reconnaissance, research, conceptual model development, exploratory field investigations, and confirmation and re-evaluation of any existing flow models.

6.2 For the installation to be successful, it is imperative that the target aquifer be located accurately. As with any well installation, the geologic conditions must be understood and the stratigraphy must be known. Although direct push wells can monitor thinner aquifers, with more precision, they may be ineffective is incorrectly placed. In thicker aquifers, and when seeking dense non-aqueous phase liquids, screens may need to be located in the bottom of the water-bearing stratum. Wells placed without determination of nearby geologic conditions can be ineffective and possibly dangerous. Geologic investigations should look for perched aquifers and use installation methods which will avoid any cross contamination of the unit.

6.3 Environmental site characterization approaches are described in Guide D5730. Proper site characterization for monitoring well placement is reviewed in Practice D5092 on Monitoring Well Design.

6.3.1 *Characterization Tools*—In geologic settings amenable to the use of direct push groundwater monitoring wells, other direct push methods and tools can likely also be used to effectively characterize the site. For example, the Cone Penetrometer Test (CPT) (Guide D6067) is an effective tool for mapping stratigraphy and locating target layers. The Hydraulic Profiling tool is a method to map formation permeability and may be used to guide well placement. The membrane interface probe (Practice D7352) may be used to identify zones of volatile organic contamination to guide screen placement. Other sensors, such as electrical conductivity and optical detectors have been placed on CPT and other direct push systems. Direct push soil sampling (Guide D6282) and water sampling (Guide D6001) can be used in advance to locate strata of concern. Direct push characterization experience at a site can guide the user in well design or device selection.

6.3.2 *Sampling During Installation*—Many direct push systems can take soil or water samples as part of the well installation process. For example, two-tube systems described in direct push soil sampling Guide D6282 can be used to collect soil samples while driving. When the target aquifer is reached, the well screen system can be installed in the casing. Sampling data taken prior to well installation can confirm the target stratum has been reached.

6.3.3 *Sampling Systems*—There is a wide variety of direct push groundwater sampling systems which can also be used for groundwater monitoring. Direct push water sampling Guide D6001 describes exposed screen versus protected screen samplers. Guide D6282 describes the differences in two-tube and single-rod direct push soil sampling systems.

6.4 *Access and Clearances*—The selection of driving equipment should consider the accessability of the installation site. The site should be surveyed for accessibility. Utility clearances may be required. Certain driving methods are incompatible with nearby hazards (for example, flammables). Also check for overhead utility lines during the site survey.

6.5 *Well Size Selection*—Driving resistance can govern the selection of an appropriate well diameter. Driving resistance can be evaluated by direct push testing on the site prior to well installation. Larger diameter monitoring wells may be easy to install on soft or loose ground sites. Smaller diameter monitoring wells may facilitate deeper installation on sites that are more resistant to penetration, but also present additional considerations for use as discussed below.

6.5.1 The availability of appropriate well development and sampling equipment for use in small-diameter monitoring wells may be limited. Many conventional down-hole pumps for purging and sampling are too large for use in small-diameter screens and risers. However, simple inertial pumps are robust and generally effective for developing smaller DP wells installed in coarse grained formations.

6.5.2 Small diameter monitoring wells, because they are generally less rigid than larger diameter monitoring wells, require special attention during backfilling to maintain vertical alignment. This may include the use of centralizers.

7. Direct Push Wells Systems and Components

7.1 *Drive Rod and Casing*—Rod systems can be single rods or casing tubes or dual tube systems (Practice D6282) specifically designed for direct push hammers. In some instances with single tube system the well itself may serve as the drive rod. Direct push drive rod is typically constructed of steel in threaded sections. Lengths of 5 ft [1 m] are common. The diameter selected will depend on the driving resistance of the soil and well size considerations. Consult experienced area contractors or qualified manufacturers to select the appropriate diameters for the site. Drive rods used inside of dual tube casings range from 0.5 to 1.25 in. [15 to 30 mm] in diameter. Outer drive casings of up to 4.5-in. [10 mm] diameter have been used at relatively soft or loose soil sites allowing installation of 2-in. [50 mm] screen/riser assemblies. The most common casing sizes are 2 to 3 in. [50 to 75 mm]. Large drive rods can be advanced with large vibratory drills (Guide D6286). Threaded sections can be outfitted with o-ring seals or polytetrafluoroethylene (PFTE) tape to reduce groundwater infiltration. Drive casings are equipped with expendable steel or aluminum drive points that are left in the bottom of the well. Depending on well design, the bottom of the casing may be advanced from a few inches [75 mm] to few feet deeper [1 m] than the bottom of the desired screen interval to separate the expendable point from the well if desired. Alternately, dual tube systems may use an inner rod equipped with an attached drive point that is removed before well insertion. An expendable cutting shoe is often used with these systems and the shoe is left in place as the casing is retracted to set the well.

7.2 *Well Screen and Riser Pipe*—Slotted PVC with flush-joint riser pipe is commonly used in the installation of direct push monitoring wells. Sizes range from ½ in. to 2 in. (Schedules 40 and 80) [15 to 50 mm]. Other riser screen and riser materials such as stainless steel, polyethylene, or PTFE may be used. PVC is preferred due to its low cost and because it is relatively inert. Selection of well material should consider possible material interactions with the contaminant being monitored. While PVC and stainless steel are commonly used in most monitoring wells without any problem, there are extreme environmental conditions that could lead to failure of these materials. PVC should not be exposed to neat organic solvents (that is, pure products) that are PVC solvents or swelling agents or to extremely high concentrations of these chemicals (approaching a saturated solution) (**5, 12-16**). Although there is very little data on the expected life of steel well casings (**17**), stainless steel is reported to perform well in most environments (**17-19**). Stainless steel should be avoided in extremely corrosive conditions, which may include water high in chlorides, low in pH, high in dissolved solids or high in dissolved oxygen (**20-23**). As screen and riser pipe may contain chemical residue from manufacturing, the screen and riser should be cleaned prior to installation. Most manufacturers supply pre-cleaned riser pipe. Threaded joints of the riser pipe can be sealed with O-rings or by using PTFE tape.

7.2.1 Slotted (PVC) or wire-wrapped (steel) well screen is normally supplied with slot widths of 0.01 or 0.02 in. [0.25 to 0.50 mm]. The screen can be wrapped with stainless steel wire mesh of 0.006 in. [0.15 mm] opening. The selection of slot size depends on the formation grain size distribution and if a sand pack will be needed to reduce turbidity. Practice D5092 provides slot size and sand pack selection criteria.

7.2.2 A sediment trap may be specified. If the riser is lifted and needs to be pushed back into place, pointed sediment traps are useful.

7.3 *Sand Pack*—The use of sand packs assists in reducing turbidity and the amount of well development required to obtain low turbidity samples. Monitoring wells without sand packs will likely yield more turbid water, which may impact the results of some chemical analyses. However, a filter can be as thin as several grain diameters to be effective. Improving well yield is not the purpose of the sand pack; yield is controlled by the formation. For monitoring of metals, filtering of samples (Guide D6564) may be required for samples with elevated turbidity levels.

7.3.1 *Sand Pack Selection and Size Range*—Formations of clean sands and gravels (that is, less than 5 % fines) may not require a sand pack. For soil containing appreciable fines, use of a sand pack should be considered. The gradation requirement depends on the particle size distribution in the target aquifer. Refer to Practice D5092 for criteria on sand pack design.

7.3.2 *Pre-packed Screens*—Pre-packed screen systems are intended to ease the installation of sand in direct push cased monitoring wells by carrying it with the casing. The prepack sections use hollow stainless steel screen casings to accommodate the slotted riser. A screen opening of 0.006 in. [0.15 mm] is typical. Pre-packed screen systems addressed in Practice D6725 are used in two tube systems and allow for better control of placement of well screen filter pack and top seal and allow for placement of fine sand filters needed for fine grained formations (Practice D5092).

7.4 *Seals*—In addition to the sand pack, a seal above the screen is needed. Current local agency regulations and environmental guidance documents (**7, 10, 24-26**) require the installation of annular seals and grouting of the well annulus to prevent potential cross contamination along the well bore and the possibility of surface water or chemical spills from contaminating the monitored aquifer(s). Sealing is necessary to prevent infiltration of surface runoff and to maintain the hydraulic integrity of confining layers. The sealing required depends on the formation, well type, and installation technique (Section 8). Several methods can be used to assure a seal above the screened zone. Most completion methods with cased systems use tremie grout placed as the casing is withdrawn. The grout can be bentonite or cement similar to that specified in Guides D6001, D6282, and Practice D5092. A typical well completion diagram is shown on Fig. 1. A grout barrier of fine to medium sand is used to protect the sand pack or screened interval from infiltration of grout, which can change the local water chemistry. Practice D5092 addresses this subject.

7.4.1 Mechanical techniques can also be used to create an effective seal. For example, Fig. 2 depicts a solid metal sleeve left in the ground, and Fig. 3 shows modular expandable foam and bentonite sleeves used above the screened interval. Rubber wiper seal may also be used. Whether this barrier is formed by the addition of fine to medium sand, by collapse of the surrounding formation, or mechanically, the materials employed must be chosen to be compatible with the local groundwater conditions and contaminants of interest.

7.5 *Modular Well Systems*—The most recent developments have been towards the use of modular components for placing sand pack and seals. Pre-packed screens can be used with most drive systems. The screens are stainless steel wire mesh filled with sand of different gradations. Fig. 1 and Fig. 3 show the use of these modular sand packs.

7.6 *Other Variations*—Numerous innovations have been developed for groundwater monitoring through direct push well systems. For example, multiple screened sections can be completed in one installation, using Continuous Multichannel Tubing (CMT) and sampling of multiple zones can be performed by using packers or sampling ports for groundwater extraction (**28, 29**). This system shown in Fig. 4 and is normally installed in rotary drilling operations, but can be

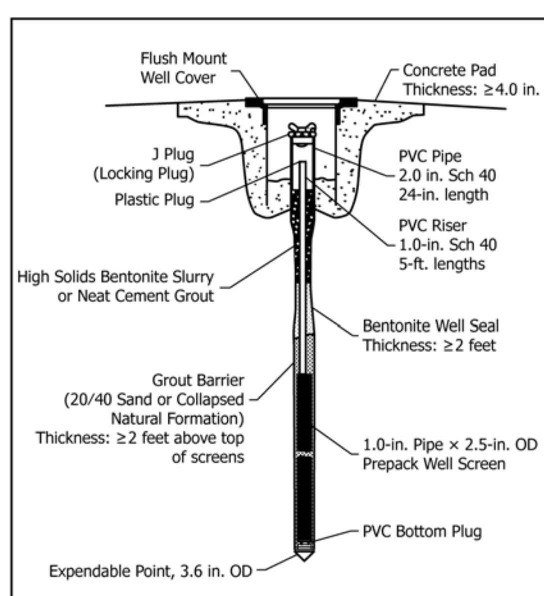

FIG. 1 Example of a Completed Direct Push Monitoring Well (27)

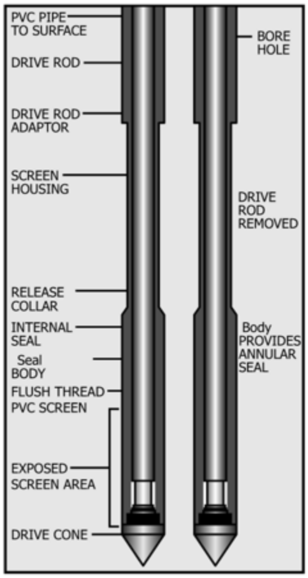

FIG. 2 Example of a Steel Seal Body Above the Screen

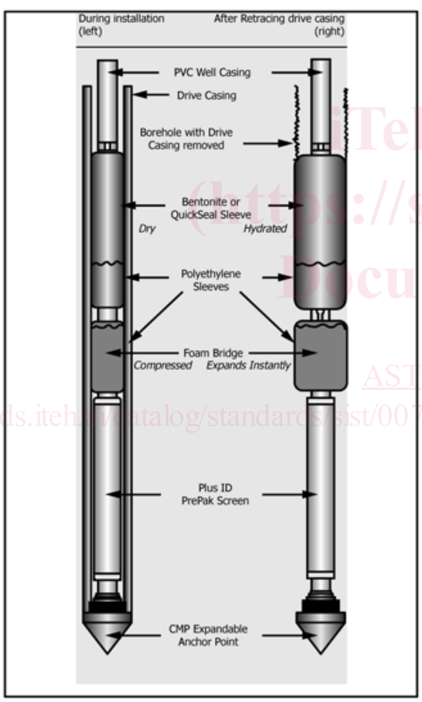

FIG. 3 Direct Push Well with Modular Sealing Components

installed in large diameter direct push casing tubes. The multichannel HDPE tube is equipped with prepack sand packs and bentonite sealing systems to isolate zones for testing. Another recent development has been the use of an everting flexible liner system to seal the borehole and isolate contaminated zones and water sampling intervals (**30**).

8. Installation Techniques

8.1 There are several techniques for installing direct push monitoring wells. Techniques can be broadly classifieds into two categories: exposed screen techniques, and protected screen techniques. Each of the systems described hereafter may require a unique installation procedure. Regardless of the choice of techniques and systems, a written operating procedure should be developed which allows some flexibility in response to field conditions. Project sampling plans and standard operating procedures should be consulted prior to installation.

8.2 *Direct Push Driving Equipment*—Direct push Guides D6001 and D6282 describe typical driving systems. Some systems are manual (slam bar, hand held electric or pneumatic hammers), static weight (cone penetrometers), percussion (hydraulic hammers, air hammers, electric hammers), and vibratory systems. In some cases, direct push monitoring wells may be installed in combination with rotary drilling.

8.3 *Exposed Screen Techniques*—One method of installing direct push wells is to advance a screen and riser of constant diameter that remain in direct contact with the formation during installation. The riser may be driven either alone or by using a mandrel rod inside the screen and riser (Fig. 5). Because the well screen is exposed to soil during driving, development by surging or jetting will be necessary to remove sediment from the screen slots (see Guide D5521 for well development methods). When installing exposed screen monitoring wells the slotted screens may become clogged with fine-grained materials if any are present in the penetrated formation. If the zone penetrated with the slotted screens is contaminated the materials trapped in the screens may be contaminated and result in cross contamination of the screened interval. Additional development may be required to remove the material clogged in the screens. Failure to remove such material may bias sample quality.

8.3.1 *Driven or Jetted Wellpoints*—As is commonly practiced in other hydrology applications (for example, construction site dewatering), well points can be jetted or driven (hammer or vibration) through sands. Fig. 5 shows this simple type of installation. At many saturated sand sites, the well point can be quickly driven using vibrators or vibratory hammers. Well points are generally 2 to 3 in. [50 to 75 mm] diameter and constructed of slotted or wire-wrapped steel or stainless steel. Slot widths of 0.01 to 0.02 in. [0.25 to 0.50 mm] are typical. These monitoring wells perform well in clean, coarse to medium sand deposits, but they do not have a sand pack and will yield sediment in soils containing fines. The use of jetting will reduce effective sealing above the screen. Installation by jetting with water or other fluids is not recommended for environmental water quality monitoring wells, as injection of large volumes of fluids into the local formation will result in significant alteration of the local groundwater geochemistry.

8.3.2 *Mandrel-Driven Screen and Riser*—Fig. 6 shows a section of poly vinyl chloride (PVC) screen and riser that is driven using inner steel CPT rods. A drive tip slightly overreams the hole to reduce friction on the riser pipes. Through experience, the drive tip diameter can be optimized to assure good sealing above the screen. With this type of installation, rigorous development to remove possible cross-contamination must be performed. A combination of mechanical surging and continuous withdrawal of the well water is effective for this purpose. This well installation method is often used on cone