Designation: D6725/D6725M – 16

Standard Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers[1]

This standard is issued under the fixed designation D6725/D6725M; 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 practice is based on recognized methods by which direct push monitoring wells may be designed and installed for the purpose of detecting the presence or absence of a contaminant, and collecting representative groundwater quality data. The design standards and installation procedures herein are applicable to both detection and assessment monitoring programs for facilities.

1.2 The recommended monitoring well design, as presented in this practice, is based on the assumption that the objective of the program is to obtain representative groundwater information and water quality samples from aquifers. Monitoring wells constructed following this practice should produce relatively turbidity-free samples for granular aquifer materials ranging from gravels to silty sand.

1.3 Direct push procedures are not applicable for monitoring well installation under all geologic and soil conditions (for example, installation in bedrock). Other rotary drilling procedures are available for penetration of these consolidated materials for well construction purposes (Guide D5092). Additionally, under some geologic conditions it may be appropriate to install monitoring wells without a filter pack (**1, 2**)[2]. Guide D6724 may be referred to for additional information on these and other methods for the direct push installation of groundwater monitoring wells.

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 non-conformance 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values shall conform to the guidelines for significant digits and rounding established in Practice D6026, unless superseded by this standard.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 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 limitations prior to use.*

1.7 *This practice offers a set of instructions for performing one or more specific operations. This document cannot replace education or experience and should be used in conjunction with professional judgement. Not all aspects of this practice 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 the 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.*

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D653 Terminology Relating to Soil, Rock, and Contained Fluids
D1586 Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4043 Guide for Selection of Aquifer Test Method in Determining Hydraulic Properties by Well Techniques
D4044 Test Method for (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers
D4104 Test Method (Analytical Procedure) for Determining Transmissivity of Nonleaky Confined Aquifers by Overdamped Well Response to Instantaneous Change in Head (Slug Tests)
D4448 Guide for Sampling Ground-Water Monitoring Wells

[1] This practice 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.

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

[3] 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)[4]
D5088 Practice for Decontamination of Field Equipment Used at Waste Sites
D5092 Practice for Design and Installation of Groundwater Monitoring Wells
D5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
D5521 Guide for Development of Groundwater Monitoring Wells in Granular Aquifers
D5785 Test Method for (Analytical Procedure) for Determining Transmissivity of Confined Nonleaky Aquifers by Underdamped Well Response to Instantaneous Change in Head (Slug Test)
D5786 Practice for (Field Procedure) for Constant Drawdown Tests in Flowing Wells for Determining Hydraulic Properties of Aquifer Systems
D5787 Practice for Monitoring Well Protection
D5881 Test Method for (Analytical Procedure) Determining Transmissivity of Confined Nonleaky Aquifers by Critically Damped Well Response to Instantaneous Change in Head (Slug)
D5912 Test Method for (Analytical Procedure) Determining Hydraulic Conductivity of an Unconfined Aquifer by Overdamped Well Response to Instantaneous Change in Head (Slug) (Withdrawn 2013)[4]
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
D6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
D6282 Guide for Direct Push Soil Sampling for Environmental Site Characterizations
D6285 Guide for Locating Abandoned Wells
D6286 Guide for Selection of Drilling Methods for Environmental Site Characterization
D6542 Practice for Tonnage Calculation of Coal in a Stockpile
D6634 Guide for Selection of Purging and Sampling Devices for Groundwater Monitoring Wells
D6724 Guide for Installation of Direct Push Groundwater Monitoring Wells
D6771 Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations (Withdrawn 2011)[4]
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. Terminology

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

3.2 *Definitions:*

3.2.1 *tremie pipe, n*—in wells, a small-diameter pipe or tube that is used to transport filter pack materials and annular seal materials from the ground surface into an annular space. (D5092).

3.3 *Definitions of Terms Specific to This Standard:*

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

3.3.1.1 *Discussion*—The outer casing tube is used for borehole stabilization. The inner rod system is used for sampler recovery and insertion of other devices.

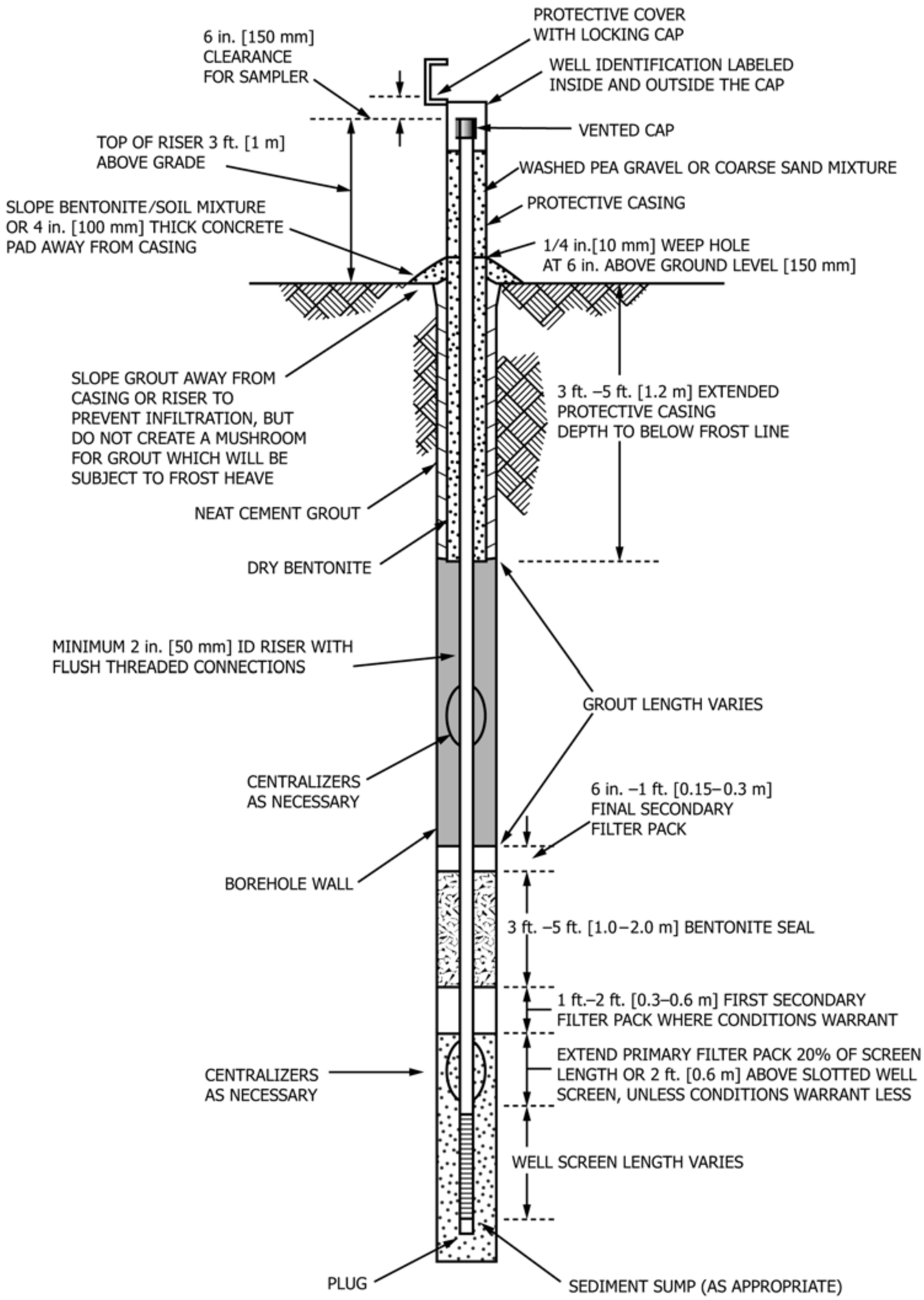
3.3.2 *prepacked screen*—a manufactured well screen that is assembled with a slotted inner casing and an external filter media support. The external filter media support may be constructed of a stainless steel wire mesh screen or slotted PVC that retains filter media in place against the inner screen. The filter media is usually composed of graded silica sand.

4. Summary of Practice

4.1 This practice provides information for installing a prepacked screen monitoring well using direct push techniques. When constructed following this Standard Practice the direct push installed monitoring wells can meet most local regulations and environmental guidelines (**2-5**) for well construction (Fig. 1) and protection of the aquifer and groundwater resources.

4.2 Initially the outer casing tube of the dual tube system is advanced to depth using direct push methods. The monitoring well is constructed inside the casing with prepacked well screens and riser pipe. The casing tube is retracted to set the well at the desired depth in the formation. Bottom up tremie installation of the annular seal and grout is conducted through the outer casing as it is retracted. This grouting method is advised to obtain the highest integrity well construction. Commonly available types of above ground or flush mount well protection are installed to physically protect the well and prevent tampering (D5787). The small diameter wells may be developed using bailers, peristaltic pumps, bladder pumps or an inertial check valve system (D6542). The inertial check valve and tubing system is especially effective when used for development in medium to coarse-grained aquifers. This development method simultaneously surges and purges fines from the screen interval. Slug testing of the wells (D7242) can be conducted to determine local aquifer properties and verify that development has been successful. Low flow (D6771) and other sampling techniques (D4448, D7929) may be used to obtain representative water quality samples. Clear and accurate documentation of the well construction is advised.

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



NOTE 1—This well design is consistent with most regulatory requirements promulgated prior to development of direct push techniques (after Practice D5092)

FIG. 1 Specifications for Conventional Monitoring Wells Installed with Rotary Drilling Methods.

5. Significance and Use

5.1 This practice is intended to provide the user with information on the appropriate methods and procedures for installing prepacked screen monitoring wells by direct push methods. The monitoring wells may be used to obtain representative water quality samples for aqueous phase contaminants or other analytes of interest, either organic or inorganic (**3**, **6-8**). The monitoring wells may also be used to obtain information on the potentiometric surface of the local aquifer and properties of the formation such as hydraulic conductivity or transmissivity.

5.2 Use of direct push methods to install monitoring wells can significantly reduce the amount of potentially hazardous drill cuttings generated during well installation at contaminated sites. This may significantly reduce cost of an environmental site investigation and groundwater monitoring program. Minimizing generation of hazardous waste also reduces the exposure hazards to site workers, local residents, and the environment.

5.3 Direct push methods for monitoring well installation are limited to use in unconsolidated formations such as alluvial/stream sediments, glacial deposits, and beach type sediments. Direct push methods are generally successful at penetrating clays, silts, sands and some gravel. Deposits such as soils with thick caliche layers, or glacial tills with large cobbles or boulders may be difficult or impossible to penetrate to the desired depth. Direct push methods are not designed for penetration of consolidated bedrock such as limestone, granite or gneiss.

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. Site Characterization and Well Placement

6.1 *Characterization*—Understanding the project goals as well as the subsurface geology, hydrogeology, and contaminant distribution at a site is necessary before installation of monitoring wells can be completed successfully. Steps in a site characterization program may include investigating site history, literature search, site reconnaissance, and field investigation and sampling efforts. The field investigation may include completion of borings to collect soil and groundwater samples and to determine the groundwater flow direction. Geophysical methods may also be applied to obtain an understanding of the subsurface geology. Several ASTM standards are available for use in conducting the site characterization and sampling efforts; these include water sampling Guide D6001, soil sampling Guide D6282, cone penetrometer Practice D6067, slug testing Test Method D4044 and Practice D7242, standard penetration Test Method D1586, and membrane interface probe (D7352). Other important sources of information include local agencies having responsibilities for groundwater protection and regulation. A list of geological surveys are included in Guide D6285. Depending on site conditions, when direct push methods are used for site characterization (for example, D6001 and D6282) it may be possible to complete the site characterization and monitoring well installation activities in one mobilization. Practice D5092 provides further details on site characterization necessary for successful installation of monitoring wells and development of a site conceptual model.

6.2 *Well Placement*—The well location, depth and length of screen interval should be based on project requirements, information obtained during the site characterization activities and background research. In general at least one well is placed at a depth and location considered to represent undisturbed background water quality conditions. The length and depth of the screened interval for the background well(s) should reflect those of the wells installed hydraulically down gradient of the site. Information obtained during site characterization regarding local hydrogeology, water level(s), contaminant distribution, and groundwater flow direction should be used to determine appropriate well placement. If multiple aquifers separated by aquitards are present beneath the site monitoring wells with screened intervals at multiple depths may be needed at each location. The purpose for installation should be considered in selecting the locations of the monitoring wells. Purposes may include detection monitoring, long term monitoring, or data collection to determine the presence, extent, and concentrations of potential contaminants. Guidance on selection of well locations, screen lengths and intervals are found m several references, some of which are: (**1, 3-5, 9-15**).

7. Monitoring Well Construction Materials

7.1 *General*—The materials that are used in the construction of a prepacked screen monitoring well should not measurably alter the chemistry of the groundwater sample(s) to be collected when appropriate sample collection methods are used. Ideally, PVC should not be used when monitoring for neat organic solvents that are PVC solvents (**16**). While conventional steel materials (for example, carbon steel or galvanized steel) are not suitable for use under most groundwater monitoring conditions stainless steel has been found to perform well in most corrosive environments, particularly under oxidizing conditions (**11**). In most cases Type 304 stainless steel will perform satisfactorily for many years (**17, 18**). Under highly corrosive and reducing conditions Type 316 stainless steel will perform better than Type 304 stainless steel (**11**). The prepacked screens and well casing used in the well construction should be delivered from the manufacturer to the field site in a clean state sealed in protective wrapping. Any other equipment used in the well construction process (for example, casing, measuring tapes, grout hoses, other down hole tools) that could impact the resultant water quality should be cleaned and decontaminated following appropriate methods (Practice D5088) prior to use in the well installation. Additional guidance and information on well construction practices can be obtained from Practice D5092. Always verify compliance with local regulations by contacting the appropriate regulating agency or organizations.

7.2 *Water*—In general, little water is used in the construction of direct push installed prepacked screen wells other than in preparation of annular seal and grout mixtures. However, there are situations that may require addition of water to the well or borehole during installation. One of the most common situations that may require addition of water is under drilling conditions where formation blow-in may occur. Under these conditions (most often saturated sands) water must be added to the boring to prevent blow-in and assure that the well is properly installed at the desired depth. When water is used in the well installation and construction process (to prevent blow-in, or mix grout) water of known quality (generally potable water) that will not adversely affect the sample must be used to ensure that the sample integrity will not be compromised. The volume of water added to each well must be documented.

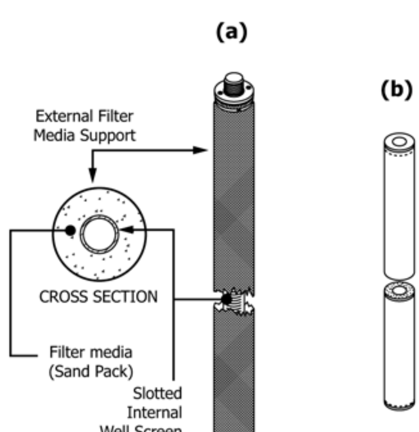
7.3 *Prepacked Screen*—There are three primary components of the prepacked well screen (Fig. 2). These are the internal well screen, the external filter media support, and the contained filter media (sand pack). Some prepack screens are assembled with the internal PVC screen as an integral part of the assembly (Fig. 2a). Alternatively, some prepack screens are available as sleeves or jackets (Fig. 2b) that may be installed over factory available casing. The components used in construction of the prepacked well screen must not adversely affect the groundwater quality so that representative samples may be acquired. Subsurface conditions, including but not limited to site geology, geohydrology, groundwater chemistry, and the analytes to be monitored must be considered to assure that the prepacked well screens are compatible with the system to be monitored. A sump may be attached to the base of the screen to capture any fines entering the well. The bottom of the screen or sump must be sealed with a plug constructed of compatible material. The prepacked well screen must be of sufficient strength to withstand the forces and stress of installation and development without being damaged or otherwise compromised. Some of the prepacked well screens are packed with filter media by the manufacturer. Other prepacked screens are shipped without filter media and are packed in the field with acceptable filter media materials just prior to installation.

7.3.1 *Internal Well Screen*—The most common material used for construction of this component is polyvinyl chloride (PVC). Other materials (for example, stainless steel or fluoropolymers) may be used where and when appropriate. Routinely used internal well screen diameters include nominal 0.5-in., 0.75-in., and 1.0-in. [15, 25, 50 mm] PVC. For optimum performance of the well the screen slot size should be determined relative to the grain size analysis of the stratum to be monitored and the gradation of the filter pack material. For further details on the selection of screen slot size refer to Practice D5092. The most widely available slot size is 10 slot, 0.010-in. [0.25 mm] in the prepacked well screens. The slot size used for the internal well screen should retain at least 90 % of the filter media.

7.3.2 *External Filter Media Support*—The purpose of the external filter media support is twofold. The primary purpose is to retain the filter media around the internal well screen as the screen is being placed in the boring. Additionally the external filter media support assures accurate and complete placement of the filter pack media in the desired screen interval. Emplacement of the filter media in this fashion eliminates problems with formation collapse against bare screen or bridging and creation of voids around the bare screen as when gravity installation of the filter media is conducted. One of the most common materials used for construction of this screen component is a stainless steel wire mesh. Slotted PVC, fluoropolymers or other compatible materials may be used for construction of this screen component when and where appropriate. The external diameter of the prepacked screen ranges from about 1.4- to 3.0-in. [35 to 75 mm], depending on the inner well screen diameter and the inside diameter of the probe rods used to advance the boring.

7.3.3 *Filter Media*—The filter media or gravel pack most commonly consists of uniformly graded siliceous particles washed and screened to have the appropriate particle size distribution. Refer to Practice D5092 for details on the selection of appropriate grain size distribution for the filter media. One of the most widely used grain size distributions for prepacked screen well filter media is 20-40 grade silica sand. However, finer grained formations may require finer sand gradation (see Practice D5092).

7.3.4 *Sump*—The sump is usually constructed of a length of well casing material ranging from a few inches in length to several feet [1 m] in length depending on the well design and formation characteristics. It is attached to the base of the well screen and is plugged at the bottom. The sump provides a space



NOTE 1—The internal well screen is usually constructed of Schedule 40 or 80 PVC (a) with a factory cut 0.010 in. slots while some are available with 0.25 slots. The external filter media support is usually constructed with stainless steel wire cloth with pore size of approximately 0.011 in. and graded silica sand or equivalent material is used for the filter media. Some prepacked screens are available as sleeves or jackets (b) that slide over factory available slotted PVC.

FIG. 2 Typical Prepacked Well Screens.

for fine sediments entering the well to settle without obstructing a portion of the screen interval and interfering with recharge or sampling activities. The sump also allows for the collection of dense nonaqueous phase fluids (DNAPLs) at locations where they are present.

7.4 *Casing or Riser*—The well casing should be made of clean, new materials that will not alter the quality of the water samples being collected. Most casing or riser is made of PVC but other materials (for example, stainless steel, fluoropolymers, etc.) may be appropriate in some situations. The inside diameter and wall thickness of the casing should match that of the internal well screen of the prepacked well. Threaded and flush jointed casing fitted with o-rings of appropriate material are generally recommended for the casing. Glued or solvent welded joints are not recommended as the glues and solvents generally contain hazardous chemicals that can cause contamination of the groundwater to be sampled. The casing and casing joints must be of sufficient strength to withstand the forces of installation and development. Further information on the selection of appropriate casing materials can be found in Practice D5092 and (**1, 10-12, 15, 17-21**).

7.5 *Grout Barrier*—The grout barrier serves to prevent the annular sealants from entering into the screen interval resulting in the alteration of the water chemistry, because common annular sealants and grouts (for example, bentonite and Portland cement) can have a significant impact on the local groundwater chemistry a grout barrier is emplaced immediately above the screened interval. The grout barrier may be constructed by gravity or tremie installation of fine sand or by installation of a mechanical or modular barrier.

7.5.1 *Gravity or Tremie Installation*—The grout barrier may be constructed with silica sand having the same or finer gradation than the materials used in the filter media. When the filter media is course-grained use of a finer grained grout barrier is recommended. The grout barrier usually extends 1 to 2 ft [1 m] above the top of the screened interval. The granular material used for the grout barrier may be poured through the annular space in the well for installation or placed through a tremie tube if conditions permit (see 9.4.1).

NOTE 2—Slowly add the barrier material to prevent bridging and to allow time for the material to settle through the water column.

7.5.2 *Modular Barriers*—Some direct push well systems offer the option of installing a modular grout barrier (see 9.4.1). This modular barrier is assembled with the screen and casing and lowered into the well annulus. When the outer casing is retracted this modular barrier expands and creates a seal above the prepacked screen. These modular barriers are constructed with polyurethane foam covered with a polyethylene sleeve. These modular barriers are not recommended for use below the water table because of potential for absorption and desorption of some contaminants.

7.6 *Annular Seal and Grout*—The annular seal and grout are prepared of materials that will eliminate or at least reduce the potential for surface or up-hole water (or fluids) from moving down the well annulus. This is important because these fluids could significantly alter the water quality or cause cross contamination in the zone being monitored.

7.6.1 *Annular Seal*—Regulations may recommend the use of sodium bentonite in construction of the annular seal immediately above the grout barrier. Recent research on sealing methods shows that bentonite seals are not effective above the water table and that a minimum of 20 % solids mix should be used for grouting (Practice D5092). Different sealants may be needed when subsurface geology, chemistry of the groundwater, or high concentrations of contaminants are present. When present in high concentrations, some organic contaminants can cause desiccation and cracking of bentonite seals resulting in cross contamination of the well and potential migration of contaminants to a previously clean aquifer. Efforts should be taken in the site characterization program to determine if these conditions may exist at the site. Annular seals may be installed by gravity or tremie methods and modular seals are available for some prepacked well systems.

7.6.1.1 *Gravity and Tremie Installations*—Bentonite chips, granules, or pellets may be used to construct the annular seal when the field conditions and size of the well annulus permit. Gravity or tremie installation of these dry bentonite materials is most successful when the top of well screen is at or near the water table. Use of a small diameter tremie tube and grout pump with bentonite slurries may provide the most reliable method of placing the annular seal (Fig. 4). Bentonite slurries ranging from 20 to 30 % solids by weight are required. Check the local regulations to verify compliance. A side port tremie tube may be used to reduce the jetting of the slurry into the grout barrier.

7.6.1.2 *Modular Seals*—These seals are constructed with paper sleeves containing bentonite attached to a segment of blank casing. This modular seal (Fig. 3) is placed above the grout barrier (modular) and prepacked screens to provide an annular seal.

7.6.2 *Grout*—There are two primary types of grout slurry used in monitoring well construction. These are bentonite grouts and cement grouts. The grout slurries should be mixed until smooth to prevent clogging of the tremie tube. Local regulations for grout compositions and density vary considerably and these regulations should be reviewed to assure compliance. Additional information on grouting requirements is provided in Practice D5092 and (**22**).

7.6.2.1 *Bentonite Grout*—Some bentonite powders contain additives to accelerate the gelling of the slurry and increase viscosity. For the smaller diameter direct push installed monitoring wells where a small well annulus may require the use of small diameter tremie tubes these additives may cause clogging of the tremie tube. The use of bentonite powders (200 mesh) without additives is commonly used for grout when small diameter tremie tubes are advised. In general bentonite slurry densities of 20 to 30 % solids by weight are required by regulation. A 20 % solids by weight bentonite slurry may be prepared by adding 2.0 lb [0.9 kg] of bentonite powder to 1 gal [3.8 L] of clean water (D5092). Bentonite grouts are recommended for use only in the saturated zone as dessication may occur in the unsaturated zone compromising the integrity of the seal (**22**). Additional information on grout mixtures is provided in Practice D5092 and regulations should be consulted.

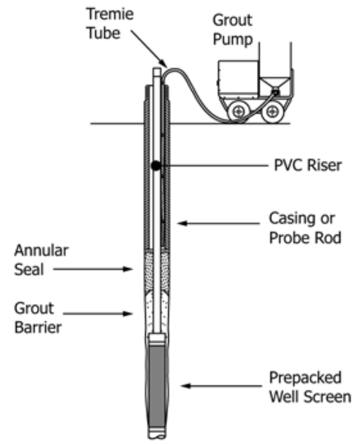


FIG. 4 Another option for installation of the annular well seal is with a side-port tremie tube and grout pump. This may be the most effective option when the screen is below the water table.

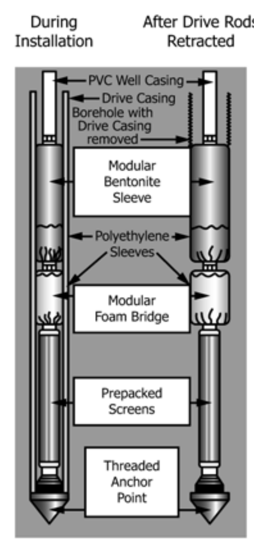


FIG. 3 Some direct push prepacked well systems use modular grout barriers and modular annular seals attached to the well casing. The modular foam barrier, used primarily above the water table, expands when the drive casing is retracted. The modular annular seal with polyethylene barrier is used below the water table. The bentonite in the modular seal is hydrated by the groundwater and expands to seal the annulus prior to grouting.

7.6.2.2 *Cement Grout*—Cements containing additives to accelerate the setting process are not recommended for use in grouting. These additives may prematurely cause thickening of the slurry and result in clogging of the tremie tube used for bottom up installation. Additionally, these additives may leach from the grout and alter the local water chemistry. In most cases neat cement should be used for grouting. Cement grout is typically mixed by adding one 94-lb [50-kg] bag of Type I portland cement to 6 to 7 gal [22-27 L] of clean water, check local regulations to verify compliance. When small diameter tremie tubes are required it is best to use fresh cement so that lumps of hardened cement will not clog the tremie tube. Additional information on grout mixtures is provided in Practice D5092 and applicable local regulations should be consulted. Research **(22)** as shown that in the unsaturated zone cement shrinks away from the casing and this problem can be alleviated by using a metal riser in that section or non-shrink cement (D5092).

7.7 *Well Protection*—There are two primary types of well protection commonly used for monitoring wells, these are above-ground and flush mount well protectors. The above ground protector is used in locations where vehicular traffic is not a concern. The above ground protection is also more widely approved because of its ability to eliminate or at least reduce the potential for surface runoff to enter the well head and thus contaminate the local aquifer. Flush mount well protection is used in areas where vehicular traffic is a concern. Most agencies require a regulatory variance for use of this well protection design because of the increase in potential for cross contamination of the local aquifer by infiltration from surface runoff waters or chemical spills. Check local regulations before using flush mount protection and obtain the necessary variance(s) where needed. Further specifications on well protection are available in Practice D5787.

8. Direct Push Methods

8.1 *General*—There are three basic methods for advancing direct push tools into the subsurface. Traditionally, cone penetration testing (CPT) equipment (D6067) has used the static weight of the vehicle (15 to 30 tons), sometimes coupled with anchors, to advance tools down hole. Smaller and lighter weight direct push vehicles rely on percussion methods together with vehicle weight to advance tools. Another method for advancing tools or casing into the subsurface is sonic or resonance drilling (D6914). This method uses high frequency percussion combined with rotary action to advance tools and casing into the subsurface. A review of the local geologic conditions and any available records of previous sampling by direct push or rotary drilling methods should be conducted prior to mobilization to determine which direct push method should be applied for well installation at the site under consideration. If site specific conditions are not amenable to direct push methods other rotary drilling methods (D6286) may be reviewed for potential use.

8.1.1 *Percussion Methods*—Advancement of tools or casing into the subsurface with percussion methods can be completed with hydraulic, pneumatic and mechanically operated hammers. These hammers are used in conjunction with hydraulic slides and vehicle weight to advance tools. Typical DP units may be mounted in trucks or other vehicles (Fig. 5) to facilitate site access. The percussion procedures are some of the most widely used direct push methods. These methods are generally capable of penetrating clays, silts, sands, and some gravel as commonly encountered in alluvial and glacial deposits. Monitoring wells are routinely installed at depths of 20 to 50 ft [10 to 15 m] with percussion methods, and may be installed at depths exceeding 200 ft [60 m] in amenable geologic conditions. Densely packed glacial deposits, deposits with cobbles or boulders, or thick zones of caliche may make penetration with percussion methods difficult or impossible. Some percussion-type direct push units are also equipped with rotary drilling capabilities. These capabilities make it possible for direct push methods to be used where a significant gravel, cobble, or caliche layer may have previously limited their use.

8.1.2 *Static Weight Methods*—Cone penetration (CPT) systems are the most commonly used static weight method for advancing tools and installing monitoring wells (D6067). Hydraulic rams are used to advance the tool string into the subsurface using the static force of the vehicle weight. Large CPT trucks (Fig. 6) may use anchors or add ballast to the vehicles (tanks of water, or lead blocks) to increase vehicle weight and depth of penetration. Capabilities and limitations of the static weight method are similar to those of the percussion methods.

8.1.3 *Sonic or Resonance Drilling Methods*—These are generally more powerful drilling methods that combine high frequency sonic or resonance with rotary action to advance tools into the subsurface (D6914). These methods can generally penetrate to greater depths than percussion or static methods and have been used to penetrate difficult formations such as cobble rich glacial till.

8.1.4 *Rotary Drilling*—Some conventional rotary drilling methods can be combined with direct push methods for sampling and well installation (D6286). Hollow stem augers (Fig. 6) (D6151) are sometimes advanced to depth and then the hydraulic hammer generally used for standard penetration testing (Test Method D1586) may be used to advance tools or casing ahead of the augers. Occasionally, the manual cathead-and-rope method is used to advance tools or casing ahead of the augers to facilitate sampling or well installation.

8.2 *Advantages and Limitations*—Direct push methods have some advantages and limitations when compared to rotary drilling methods. One of the primary advantages of direct push methods is that essentially no waste cuttings are generated as the tool string or casing is advanced into the subsurface. At locations where hazardous contaminants may be present this significantly reduces the handling, drumming, storage, sampling, testing, transportation, and disposal of contaminated cuttings. Elimination of these waste handling and disposal activities will not only reduce cost but also reduce potential exposure hazards for site workers, local residents and the environment. Direct push methods are generally limited to unconsolidated formations composed of clays, silts, sands and some gravel. Conventional rotary drilling methods will be required for penetration of consolidated bedrock (for example, limestone, granite, gneiss) and some very dense unconsolidated formations or formations with an abundance of cobbles or boulders.

9. Monitoring Well Installation

9.1 *General*—Several of the procedures described below are similar to those used for installation of monitoring wells by rotary drilling techniques and Practice D5092 may be referenced for additional information or guidance as needed. Manufacturer's standard operating procedures for installing

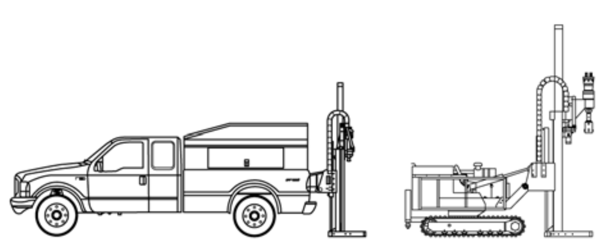


FIG. 5 Typical percussion type direct push units are often mounted in conventional pick-up trucks or more rugged track vehicles for access to difficult locations. Some percussion-type units, such as the track unit shown here, are fitted with optional auger heads.

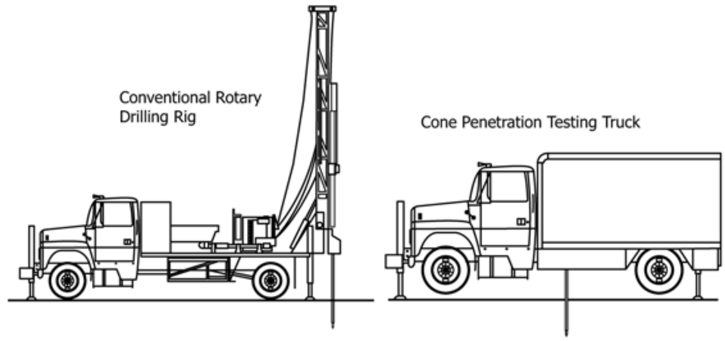
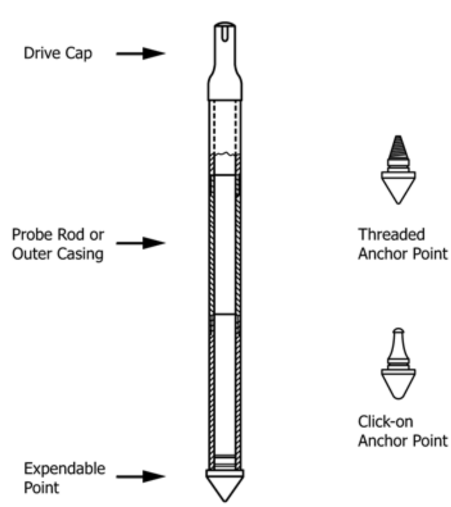


FIG. 6 Hydraulics and SPT hammers on rotary drilling rigs may be used to advance direct push tools under some conditions. CPT units may weigh from 15 to 30 tons. These vehicles have been used to install monitoring wells by direct push methods at many locations.

direct push prepacked screen monitoring wells (**23-25**) may also provide additional information on installation techniques. Installation of monitoring wells in an open/uncased borehole is not recommended for direct push or rotary drilling procedures. Installation of a monitoring well through an open borehole may result in slough of potentially contaminated material down the well bore either prior to or during the well installation procedure. This can lead to cross contamination and water quality samples that are biased and inaccurate and ultimately abandonment and replacement of the incorrectly installed well. While open hole installation of temporary piezomenters for water level monitoring in uncontaminated formations may be acceptable this is not an acceptable installation method for monitoring wells to be used for water quality sampling.

9.2 *Installation of Drive Casing*—The direct push method (percussion, static, sonic) which is selected based on site conditions is used to advance the drive casing to the desired depth. Use of O-rings or Teflon tape on casing joints is recommended to eliminate the potential for cross contamination as the tools are advanced to depth.

9.2.1 *Advance Casing*—Information from the site characterization is used to determine the appropriate depth and screen length for each well. The direct push unit is set up over the proposed well location and leveled. Depending on the specific well construction and casing advancement procedures to be used either an expendable point, anchor point, or expendable cutting shoe is installed on the lead casing section. If the dual tube casing is to be advanced without sampling either an expendable point or expendable anchor point (Fig. 7) is placed in the lead casing section. If continuous or targeted dual tube soil sampling (see Guide D6282) is to be conducted as the casing is advanced an expendable cutting shoe (Fig. 8) can be installed on the lead casing section to permit well installation after sampling is completed. The appropriate drive cap (Fig. 7) is used to advance the tool string to depth. New sections of casing are added incrementally as needed to achieve the desired depth. To prevent the infiltration of potentially contaminated formation water as the casing is advanced o-rings or other acceptable materials (for example, PTFE tape) may be used to seal each casing joint. A water level indicator should be



NOTE 1—Some prepack well systems are available with expendable anchor points with either a thread or click on mechanism to anchor the screens in position.

FIG. 7 Advanced Direct Push Casing (or probe rod) to Depth with an Expendable Point to Prepare for Installation of a Prepacked Screen Monitoring Well.

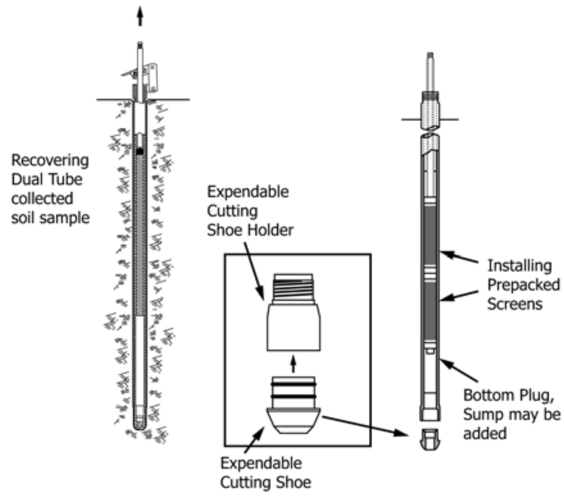
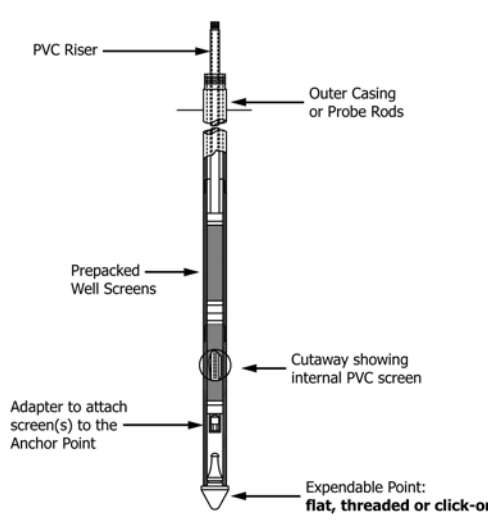


FIG. 8 When an expendable cutting shoe is used during dual tube soil sampling prepacked screens may be installed after sampling is completed. In saturated noncohesive formation (sands) it may be necessary to add water to the probe rods to prevent blow-in during sample collection activities.

used to check the bore of the rods prior to installation of the prepacked screens to determine if water is present (D4750). If potentially contaminated water is present in the drive rods it should be evacuated before continuing with the well installation.

9.2.2 *Assembly and Installation of Screen and Riser*—The well screens to be installed may have been prepacked by the manufacturer prior to shipping, or may require addition of the filter media in the field before installation. Follow the manufacturer's specifications for adding the filter media to prepack the screens. If an expendable point or cutting shoe is used in the installation then the lower end of the screen or sump will require a bottom plug (Fig. 8). A threaded anchor point may be used and in this situation the base of the screen or sump is threaded directly onto this point to seal the bottom of the well (Fig. 9). If an expendable anchor point is to be used to anchor the well screen(s) in the formation an adapter (Fig. 9) may have to be installed in the base of the screen or sump. Then the screen section or sections are assembled and riser added as the screen(s) is (are) lowered through the casing (Fig. 9). Sufficient PVC riser is added to the assembly so that the final piece of riser extends above the drive casing. If an expendable anchor point is used the adapter on the base of the screen is attached to the anchor point. If a threaded anchor point is used, the screen attaches directly to the point by threading the base of the PVC onto the anchor point.

9.3 *Retraction of Drive Casing*—To deploy the assembled prepacked well screen and risers the direct push casing must be retracted. A rod retraction system that allows for access to the open ID of the casing is recommended. Such a system will enable the operator to confirm that the well screen(s) and riser stay at the required depth as the casing is retracted. The unit hydraulics are used with the retraction tools to retract the casing above the top of the screened interval. If the casing is advanced well below the static water level of the aquifer in a



NOTE 1—A simple plug may be added to the base of the well screens and a sump may be used. A special adapter may be used if the screens are attached to an expendable anchor point. Some threaded anchor points make it possible to thread the PVC screen directly to the point.

FIG. 9 Lowering Assembled Prepacked Screens Through the Casing as PVC Riser is Added to the Well Assembly.

cohesionless formation it may be necessary to add water (of known quality) to the annulus of the rods prior to retracting the screen to prevent flow of formation materials between the screen and casing. If flow-in occurs the prepacked screen can become lodged inside the casing. If for any reason the prepacked screen becomes lodged inside the casing as it is retracted small diameter extension rods may be lowered into the open bore of the well (Fig. 10). The extension rods are used to gently push or tap on the base of the screen to dislodge it from the casing. Adding water to the casing can increase the hydraulic head inside the well relative to the formation helping to dislodge the screen from the casing. (**Warning—**Excessive force used to dislodge the screen from the casing can result in damage and possible loss of the well.)

9.4 *Emplacing Grout Barrier*—The grout barrier may be installed by gravity or tremie methods, or a modular system may be used. Alternatively, collapse of the natural formation may be used to create a natural barrier when the formation material is of appropriate grain size and cohesion.

9.4.1 *Gravity or Tremie Methods*—If project specifications require that an artificial grout barrier be installed above the prepacked screen(s) the rods should be retracted no more than 2 to 4 in. [50-100 mm] above the top of the prepacked screens. Then medium to fine grained sand can be slowly poured though the well annulus (Fig. 11) as the casing is retracted to build the grout barrier. If the top of the screen is several feet [1 m] below the static water level the sand should be poured slowly to prevent bridging. Periodic monitoring of the annular depth should be conducted with a weighted tape to verify that bridging does not occur. If bridging does occur clean water can be pumped by a tremie tube to jet out the bridge. The grout barrier should generally be extended 2 ft [0.5 m] above the top of the prepacked screen to assure that annular sealants do not penetrate into the screened interval. Local regulations vary on the thickness requirements for the grout barrier. Verify local regulations to maintain compliance.

9.4.2 *Modular Grout Barrier*—There are at least two types of barriers that fall in this category. The first is a seal comprised of a polyurethane foam and the second is a combination of a modular bentonite annular seal with a polyethylene sleeve barrier (Fig. 3). The foam seal may be threaded onto the casing string immediately above the prepacked screen (Fig. 3). Alternatively, the modular seal and polyethylene sleeve-barrier may be used alone (below water table) or in conjunction with the foam seal. Once the barrier is in place PVC riser is added to the assembly as it is lowered down the drive casing. Depending on the length of the modular grout barrier multiple units may be needed in sequence to meet local regulatory requirements for length of the barrier. Verify local regulations to maintain compliance.

9.4.3 *Natural Grout Barrier*—In poorly cohesive materials natural collapse of the formation may occur as the casing is retracted above the screen. Under these conditions it may be possible to use the natural formation collapse as the grout barrier. Samples of the formation should be examined to determine if the material would provide an effective barrier to the movement of annular sealants into the well screen interval. Coarse-grained sands or gravels may not sufficiently impede the migration of annular sealants and under these formation conditions an artificial or modular grout barrier should be emplaced. Review local regulations to verify that use of a natural grout barrier is acceptable. The natural grout barrier should be a minimum of 2 ft [1 m] in length and monitoring with a weighted tape should be used to verify the amount of formation collapse.

9.5 *Annular Seal:*

9.5.1 *Gravity Installation*—If the top of the sand barrier is near or above the static water level it may be possible to pour in fine chips or pellets of bentonite to construct the annular seal. Use chips or pellets not more than one-fifth the width of the open annulus to reduce the potential for bridging and formation of voids in the seal. Incrementally retract the drive

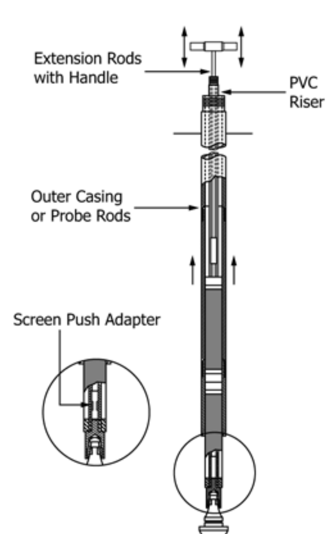


FIG. 10 Small diameter extension rods equipped with an adapter may be used to free the prepacked screens if they become lodged inside the casing. Care must be used to prevent damage to the well.

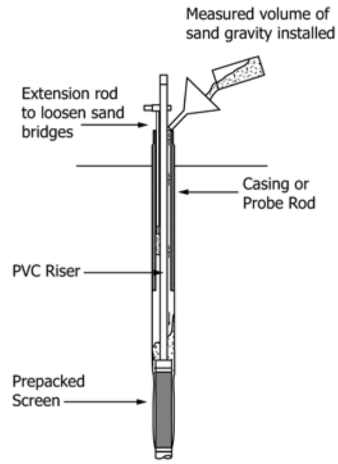


FIG. 11 One method to construct the grout barrier is by pouring medium to fine grained sand through the casing annulus. If any bridging occurs an extension rod or jetting with water may be used to re-open the well annulus.

casing as bentonite is poured down the well annulus. Use of a weighted tape to verify the length of the seal is necessary. The weighted tape also may be used to detect any bridging of the bentonite material during installation. Bridges must be removed and length of the seal reviewed. Generally the length of the annular seal should be at least 2 ft [1 m]. Verify local regulations on requirements for length of the annular seal to maintain compliance.

9.5.2 *Tremie Installation*—For the highest integrity annular seal, especially in deeper wells and where the static water level is several feet [1 m] above the grout barrier, it will be necessary to use bottom-up tremie installation of the seal (Fig. 4). Because of the small well annulus on most direct push wells smaller diameter tremie tubes 0.25- to 0.5-in. [10 to 15 mm] inside diameter will be required to pump bentonite slurries down hole. Because of the viscosity of the 20 to 30 % solids bentonite slurries used for annular seals a high pressure grout pump will be required to pump the slurry down hole through the small ID tremie tubes. Piston operated or other positive displacement pumps are often the best for pumping the viscous slurries through the small ID tremie tubes. To prevent intrusion of the slurry into the grout barrier and screen interval it is recommended that a side port tremie be used for installing the annular seal slurries. The annular seal should be emplaced slowly as the casing is retracted and should usually extend 2 ft [1 m] above the top of the grout barrier. Local regulations may vary as to the composition and thickness of the annular seal. Check applicable regulations to maintain compliance.

9.5.3 *Modular Installation*—When modular annular seals (bentonite sleeves) are used they are assembled on the well casing above the prepacked well screen(s) (Fig. 3). Additional well casing is added to this assembly as it is lowered down the bore of the drive casing. The drive casing is then retracted just above the top of the modular seal. An adequate amount of water is added to the well bore to hydrate the bentonite. Sufficient time is allowed for hydration of the bentonite in the modular seal before grouting can commence Use of a weighted tape is necessary to verify the modular seal has hydrated and plugged the well bore. Local regulations may vary as to the composition and length of the annular seal. Check applicable regulations to maintain compliance.

9.6 *Grouting*—The bottom-up tremie method of grout installation (Fig. 4) will provide the highest integrity annular seal for most field conditions. The appropriate grout slurry (see 7.6.2) should be emplaced slowly as the casing is retracted. For best results the grout is pumped into the well annulus until undiluted grout is observed flowing from the top of the casing. Then the casing is slowly retracted as additional grout is pumped into the annulus to replace the void created as casing is removed. Care should be taken to keep several ft [1 m] of grout up inside the casing so that the potential for formation collapse against the casing or the presence of voids in the grout are eliminated, or at least reduced. Annular grout usually extends from the well seal to within 2 to 4 ft [1 m] of ground surface. Review local regulations for the recommended grout mixture and depth to grout below ground surface. It is recommended that bentonite grout be used only in the saturated zone because of potential for dessication and loss of integrity in the unsaturated zone. Cement based grouts may provide a better seal in the unsaturated zone.

9.7 *Well Protection*—Above ground or flush mount well protection should be installed to protect the well from physical damage or tampering (Fig. 12). Concrete is used to set the well protection in place and usually extends below the frost line (where applicable) to prevent frost heave from damaging the well head. A concrete pad 2 to 3 ft [1 m] in diameter and 4 in. [100 mm] thick is usually constructed around the well head. The pad is sloped away from the well head to encourage storm water runoff. Check local regulations for detailed requirements for well protection and construction. For smaller diameter riser an outer protective casing may be needed to provide a locking well cap. Generally a 2-in. [50-mm] PVC casing can be installed over the well riser extending 3 to 4 ft [1 to 2 m] below grade. Locking well caps are commercially available for 2-in. [50-mm] diameter PVC pipe. An inner cap or plug is recommended for use on the small diameter casing to assure protection of water quality. When a flush mount protector is

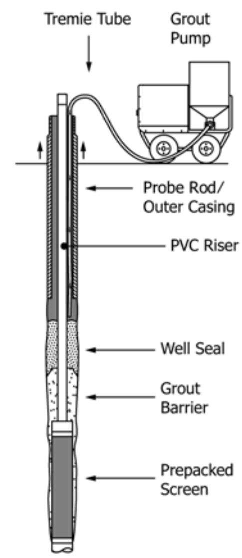


FIG. 12 The casing is filled with grout by a bottom up tremie tube before retraction of the casing continues.

used in areas with vehicle traffic it should meet state and Dept. of Transportation requirements for weight loading rate. It may be necessary to install posts or traffic bumpers when above ground protectors are used in some locations. Further information on well protection may be found in Practice D5092, D5787, (**1**, **2**, **5**, **11**, **12**, **17**, **18**).

10. Post Installation Activities

10.1 *Development*—Direct-push monitoring wells can be developed using mechanical surging, pumping and backwashing, hydraulic jetting, or inertial lift pumps. The first three methods are described in detail in Practice D5092, D5521 Inertial-lift pumps (also referred to as tubing check valve pumps) are operated by oscillating a piece of rigid or semi-rigid tubing, with a simple ball check valve on the down-hole end, in the water column within the well screen. The tubing and check valve act like a surge block, alternately forcing water to flow into the well (on the upstroke) and out of the well (on the downstroke), and significantly agitating the water column in the well and the water contained within the filter pack and the adjacent formation materials. The downstroke causes a backwashing action to loosen bridges in the formation and filter pack, and fills the tubing with water and suspended sediment brought into the well during the upstroke. The upstroke pulls dislodged fine-grained material into the well and causes water in the tubing to move upward under inertia, as the tubing is pushed back into the well. This oscillation of the tubing is repeated until water and suspended sediment are discharged from the tubing at the surface; development is complete when the water being discharged is free of suspended sediment. Additional purging with a pumping method that does not surge the well (peristaltic, bladder, etc.) may be needed to achieve low turbidity levels advised for some analytes. Information on different monitoring well development and purging devices is available in Guide D6634. Details on development methods may be found in Practice D5092, D5521, (**1-3**, **5**, **and 11**).

10.1.1 In predominantly fine-grained formation materials (with a high silt and clay content), attempts to develop direct-push wells may not improve well yield and may result in increases in suspended sediment, clogging of the well screen and filter pack, or damage to the screen or filter pack. Pumping the well at a low flow rate, to the point at which pump discharge is free of suspended sediment (using a peristaltic pump, bladder pump, or gas-displacement pump), is often an effective development method for wells installed in fine-grained formations.

10.1.2 Well development should be done either after the well casing, screen and filter pack have been installed and the drive casing has been pulled back to just above the top of the screen (that is, prior to installation of annular seal materials), or after the entire well has been completed. In the latter case, it is necessary to wait until the annular seal materials have set or cured, typically 48 to 72 h after well installation

10.2 *Survey*—It is recommended that a survey be conducted to accurately determine the location and elevation of a reference point on the well. This information can be used to determine the elevation of static groundwater level in the well. If multiple wells are installed the location and elevation data can be used to determine the groundwater flow direction and possibly to construct a potentiometric surface map. A reference point should be permanently marked on the riser pipe.

10.3 *Sampling*—Purging a direct-push monitoring well is generally required prior to sampling the well. The types of devices appropriate for use in purging and sampling a direct-push monitoring well, and the procedures for using them, are described in detail in Guide D6634. Because of the smaller inside diameter of most direct-push wells, the selection of devices is more limited than it is for wells 2 in. [50 mm] nominal diameter and larger. Bladder pumps, gas-displacement pumps, peristaltic pumps, bailers, and inertial-lift (tubing check valve) pumps may all be used for both purging and sampling. Guide D6634 should be consulted to determine the conditions and analytes for which each device is appropriate. Additional information on sampling equipment, methods and procedures can be found in Guide D4448, (**1**, **4**, **11-13**). Information on decontamination of sampling equipment is provided in Practice D5088 and (**26**). In wells in which low-flow purging and sampling methods (Practice D6771) are to be used, or from which low-turbidity samples are required, bailers and inertial-lift pumps are not appropriate devices. Bladder pumps are now available in sizes as small as ½ in. [15 mm] diameter and are well suited for low flow sampling (**27**). Low flow purging and sampling (Practice D6771) is highly recommended when sampling for metals in groundwater or other parameters that are affected by elevated turbidity, as well as sampling VOC's. Passive sampling techniques (Guide D7929) can also be used or sampling although some systems may be limited to larger diameter wells.

10.4 *Aquifer Testing*—Recent studies (**28-33**) have found that small diameter direct push installed groundwater sampling tools can be used for aquifer testing procedures. Tests in an alluvial aquifer have shown that the direct push installed tools can be used as observation wells during pumping tests. Side by side comparisons of the direct push installed devices and conventional designed monitoring wells indicate that the direct push tools provide the same results as conventional observation wells during pump tests. Field comparisons have also shown that direct push installed devices can be used to obtain accurate measurement of formation hydraulic conductivity from slug tests (**28**, **31**, **33**, **and 34**). Modifications of conventional slug testing methods for use in smaller diameter wells can be successfully applied (**30**). Further information on slug testing procedures can be found in Practice D7242 and Test Methods D4044, D5881, D5912, D5785, D4104, Guide D4043, and (**1**, **9**, **and 29**).

11. Report: Test Data Sheet(s)/Form(s)

11.1 The methodology used to specify how data are recorded on the test data sheet(s)/form(s), as given below, is covered in 1.5.

11.2 Record as a minimum the following general information: Documentation of the direct push installed prepacked screen monitoring well should be completed to provide clear and precise information on the well installation and construction procedures. An example well construction diagram (Fig. 13) provides guidance on the information that should be documented during well construction. Accurate documentation of the volumes of materials such as grout, bentonite, and sand used in the well construction should be maintained. Additional, and or different information may be required for documentation depending on the purpose and uses of the prepacked screen well installation.

11.2.1 Record and report information as required in the sampling plan and as noted in Section 8 on the well installation. An example of a well completion report form is shown on Fig. 13.

11.2.2 Report any subsurface investigation exploration data that are required in the sampling plan and consult Guide D5434 on logging of subsurface investigations. All records must be dated and include the names of those performing the work.

11.2.3 Report all survey data including location of the well and well markers.

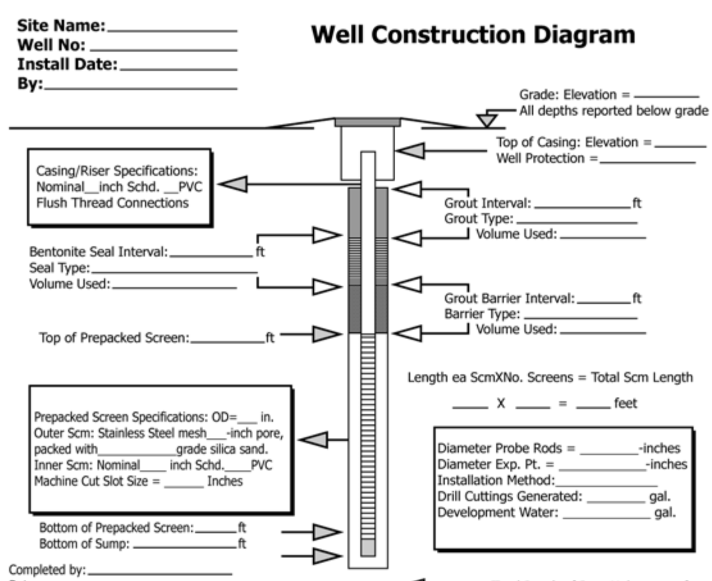


FIG. 13 Example well construction diagram for use in documenting well specifications in in.-lb units. Additional information may be required.

11.2.4 Well development events may require a separate report of monitored groundwater conditions during development.

11.2.5 A field notebook should be kept to document all activities relevant to the work plan. Activities include sampling events and conditions that occur during installation, development, and sampling as part of a quality assurance program.

11.2.6 If samples are obtained during the installation, as with two-tube soil sampling Guide D6282, record and report the sample intervals and the data that are required.

11.2.7 If water samples are acquired during the push (Guide D6001), record the purge water volumes and any monitored water quality indicators.

11.2.8 Record and report the depth of the push, and details such as effective screen length, effective seal lengths, backfilling and sealing methods. As the well is completed, ensure that all necessary installation information is recorded.

11.3 Record as a minimum the following data:

11.3.1 Record all drilling depths, and installation depths and lengths, the nearest 0.1 ft [0.03 m] or better on well completion diagrams used in 11.2.

11.3.2 Record all quantities and volumes for filter pack, grout, and backfill to two significant digits.

12. Keywords

12.1 aquifer; direct push; groundwater; monitoring well; prepacked screen; water quality

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SUMMARY OF CHANGES

In accordance with Committee D18 policy, this section identifies the location of changes to this standard since the last edition (2010) that may impact the use of this standard. (July 15, 2016)

(1) Changed units to in.-lb with rationalized SI units.
(2) Added significant digits statement.
(3) Updated technical references on national well standards and guides.
(4) Added information on grouting in vadose zone.
(5) Changed the report section to meet D18 requirements