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Standard Guide for Use of Dual-Wall Reverse-Circulation Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices[1]

This standard is issued under the fixed designation D 5781; 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 covers how dual-wall reverse-circulation drilling may be used for geoenvironmental exploration and installation of subsurface water-quality monitoring devices.

NOTE 1—The term *reverse circulation* with respect to dual-wall drilling in this guide indicates that the circulating fluid is forced down the annular space between the double-wall drill pipe and transports soil and rock particles to the surface through the inner pipe.

NOTE 2—This guide does not include considerations for geotechnical site characterizations that are addressed in a separate guide.

1.2 Dual-wall reverse-circulation for geoenvironmental exploration and monitoring-device installations will often involve safety planning, administration, and documentation. This guide does not purport to specifically address exploration and site safety.

1.3 The values stated in SI units are to be regarded as the standard. The inch-pound units given in parentheses are for information only.

1.4 *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.*

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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 judgment. 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.*

2. Referenced Documents

2.1 *ASTM Standards:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[2]
D 1452 Practice for Soil Investigation and Sampling by Auger Borings[2]
D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils[2]
D 1587 Test Method for Thin-Walled Tube Sampling of Soils[2]
D 2487 Classification of Soils for Engineering Purposes[2]
D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]
D 4428/D4428M Test Method for Crosshole Seismic Testing[2]
D 5088 Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites[3]
D 5092 Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers[3]
D 5099 Test Method for Rubber—Measurement of Processing Properties Using Capillary Rheometry[4]
D 5254 Practice for Minimum Set of Data Elements to Identify a Ground-Water Site[3]
D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock[3]

3. Terminology

3.1 *Definitions:*

3.1.1 Terminology used within this guide is in accordance with Terminology D 653. Definitions of additional terms may be found in Terminology D 653.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bentonite*—common name for drilling-fluid additives and well-construction products consisting mostly of naturally-occurring montmorillonite. Some bentonite products have chemical additives that may affect water-quality analyses.

3.2.2 *bentonite granules and chips*—irregularly-shaped particles of bentonite (free from additives) that have been dried and separated into a specific size range.

3.2.3 *bentonite pellets*—roughly spherical- or disc-shaped

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[2] *Annual Book of ASTM Standards*, Vol 04.08.

[3] *Annual Book of ASTM Standards*, Vol 04.09.

[4] *Annual Book of ASTM Standards*, Vol 09.01.

units of compressed bentonite powder (some pellet manufacturers coat the bentonite with chemicals that may affect the water quality analysis).

3.2.4 *coefficient of uniformity*— C_u *(D)*, the ratio D_{60}/D_{10}, where D_{60} is the particle diameter corresponding to 60 % finer on the cumulative particle-size distribution curve, and D_{10} is the particle diameter corresponding to 10 % finer on the cumulative particle-size distribution curve.

3.2.5 *drawworks*—a power-driven winch, or several winches, usually equipped with a clutch and brake system(s) for hoisting or lowering a drilling string.

3.2.6 *drill hole*—a cylindrical hole advanced into the subsurface by mechanical means. Also known as a borehole or boring.

3.2.7 *filter pack*—also known as a gravel pack or a primary filter pack in the practice of monitoring-well installations. The gravel pack is usually granular material, having selected grain size characteristics, that is placed between a monitoring device and the borehole wall. The basic purpose of the filter pack or gravel envelope is to act as: (*1*) a non-clogging filter when the aquifer is not suited to natural development or, (*2*) act as a formation stabilizer when the aquifer is suitable for natural development.

3.2.7.1 *Discussion*—Under most circumstances a clean, quartz sand or gravel should be used. In some cases a pre-packed screen may be used.

3.2.8 *hoisting line*—or drilling line, is wire rope used on the drawworks to hoist and lower the drill string.

3.2.9 *in-situ testing devices*—sensors or probes, used for obtaining mechanical or chemical-test data, that are typically pushed, rotated or driven below the bottom of a borehole following completion of an increment of drilling. However, some in-situ testing devices (such as electronic pressure transducers, gas-lift samplers, tensiometers, and etc.) may require lowering and setting of the device(s) in a pre-existing borehole by means of a suspension line or a string of lowering rods or pipe. Centralizers may be required to correctly position the device(s) in the borehole.

3.2.10 *intermittent-sampling devices*—usually barrel-type samplers that are driven or pushed below the bottom of a borehole following completion of an increment of drilling. The user is referred to the following ASTM Standards relating to suggested sampling methods and procedures: Practice D 1452, Test Method D 1586, Practice D 3550, and Practice D 1587.

3.2.11 *mast*—or derrick, on a drilling rig is used for supporting the crown block, top drive, pulldown chains, hoisting lines, etc. It must be constructed to safely carry the expected loads encountered in drilling and completion of wells of the diameter and depth for which the rig manufacturer specifies the equipment.

3.2.11.1 *Discussion*—To allow for contingencies, it is recommended that the rated capacity of the mast should be at least twice the anticipated weight load or normal pulling load.

3.2.12 *piezometer*—an instrument for measuring pressure head.

3.2.13 *subsurface water-quality monitoring device*— an instrument placed below ground surface to obtain a sample for analysis of the chemical, biological or radiological characteristics of subsurface-pore water or to make in-situ measurements.

4. Significance and Use

4.1 Dual-wall reverse-circulation drilling can be used in support of geoenvironmental exploration and for installation of subsurface water-quality monitoring devices in unconsolidated and consolidated materials. Dual-wall reverse-circulation drilling methods permit the collection of water-quality samples at any depth(s), allows the setting of temporary casing during drilling, cuttings samples can be taken continuously as circulation is maintained at all times during drilling. Other advantages of the dual-wall reverse-circulation drilling method include: (*1*) the capability of drilling without the introduction of any drilling fluid(s) to the subsurface; (*2*) maintenance of hole stability for sampling purposes and monitor-well installation/construction in poorly-indurated to unconsolidated materials.

NOTE 3—The user of dual-wall reverse-circulation drilling for geoenvironmental exploration and monitoring-device installations should be cognizant of both the physical (temperature and airborne particles) and chemical (compressor lubricants and possible fluid additives) qualities of compressed air that may be used as the circulating medium.

4.2 The application of dual-wall reverse-circulation drilling to geoenvironmental exploration may involve soil or rock sampling, or in-situ soil, rock, or pore-fluid testing.

NOTE 4—The user may install a monitoring device within the same borehole wherein sampling, in-situ or pore-fluid testing, or coring was performed.

4.3 The subsurface water-quality monitoring devices that are addressed in this guide consist generally of a screened- or porous-intake device and riser pipe(s) that are usually installed with a filter pack to enhance the longevity of the intake unit, and with isolation seals and low-permeability backfill to deter the movement of fluids or infiltration of surface water between hydrologic units penetrated by the borehole (see Practice D 5092). Inasmuch as a piezometer is primarily a device used for measuring subsurface hydraulic heads, the conversion of a piezometer to a water-quality monitoring device should be made only after consideration of the overall quality and integrity of the installation to include the quality of materials that will contact sampled water or gas.

NOTE 5—Both water-quality monitoring devices and piezometers should have adequate casing seals, annular isolation seals and backfills to deter communication of contaminants between hydrologic units.

5. Apparatus

5.1 The basic mechanical components of dual-wall reverse-circulation drilling systems include dual-wall pipe, drill compressor and filter(s), water pump, discharge hose, cleaning device (cyclone separator). The dual-wall drill advanced by the percussive action of an above-ground pile hammer or by rotation from a rotary-drive unit.

NOTE 6—Other methods, such as vibratory equipment sonic resonators, may be used to apply the energy required to advance the dual-wall drill pipe.

5.1.1 *dual-wall drill pipe*, consists of an inner pipe secured concentrically within an outer pipe. Inner-pipe connections utilize pin and box components with seals. Outer-pipe connections are flush threaded.

NOTE 7—Drill pipes usually require lubricants on the threads to allow easy unthreading (breaking) of the connecting joints. Some lubricants have organic or metallic constituents, or both, that could be interpreted as contaminants if detected in a sample. Various lubricants are available that have components of known chemistry. The effect of pipe-thread lubricants on chemical analyses of samples should be considered and documented when using dual-wall reverse-circulation drilling. The same consideration and documentation should be given to lubricants used with water swivels, hoisting swivels, or other devices used near the drilling axis.

5.1.2 The drill bit is attached to the bottom of the dual-wall drill pipe and provides the soil- or rock-cutting capability. Drill bit types include tricone roller, down-the-hole (DTH) hammer or, open faced. Drill bit selection should be based upon the character of the soils or rocks penetrated. DTH lubricants should be documented.

NOTE 8—In North America, the sizes of casings bits, drill rods and core barrels are standardized by American Petroleum Institute (API) and the Diamond Core Drill Manufacturers Association (DCDMA). Refer to the DCDMA technical manual and to published materials of API for available sizes and capacities of drilling tools equipment.

5.1.3 The air compressor and filter(s) should provide an adequate volume of air for removal of cuttings without significant contamination generated at the bit. Air requirements will vary depending upon the size and configuration of the drill pipe used, and the character of the soil and rock penetrated. The air-flow rates are usually based on maintaining an upflow air velocity of about 1,400 m/min (4200 ft/min).

NOTE 9—The quality of compressed air entering the borehole and the quality of air discharged from the borehole and air-cleaning devices must be considered. If not adequately filtered, the air produced by most oil-lubricated air compressors inherently introduces a significant quantity of oil into the circulation system. High-efficiency, in-line, air filters are usually required to prevent significant contamination of the borehole. Air-quality monitoring may be required and, if performed, results should be documented.

5.1.4 A water pump may be used to inject water into the circulating air stream or may be used to inject water without air as the circulating fluid. If water is injected, the approximate volumes and locations should be reported.

5.1.5 A discharge hose conducts discharged drill cuttings and circulation-return air away from the borehole.

5.1.6 *Air-Cleaning Device System*, generally called a cyclone separator, separates cuttings from the air returning from the borehole.

NOTE 10—A properly-sized cyclone separator can remove practically all of the cuttings from the return air. A small quantity of fine particles, however, are usually discharged to the atmosphere with the “cleaned” air. Some air-cleaning devices consist of a cyclone separator alone. In special cases, the cyclone separator can be combined with a HEPA (high-efficiency particulate air) filter for removing dust particles that might be radioactive. In other special situations, the cyclone separator may be used in conjunction with a charcoal-filtering arrangement for removal of organic volatiles. Samples of drill cuttings can be collected for analyses of materials penetrated. If samples are obtained, the depth(s) and interval(s) of sample collection should be documented.

5.1.7 *Pile Hammer*, is commonly used to advance dual-wall drill pipe. The percussive force of the pile hammer is applied only to the outer pipe.

5.1.8 *Rotary-Drive Unit*, may be used to advance dual-wall drill pipe by rotation. Torque generated from a rotary-drive unit is applied only to the outer pipe.

6. Drilling Procedures

6.1 *Dual-Wall Percussion-Hammer Method (see Fig. 1)*:

6.1.1 As a prelude to and throughout the drilling process stabilize the drill rig, and raise the drill-rig mast and position the cyclone separator. If air-monitoring operations are performed the prevalent wind direction relative to the exhaust from the drill rig should be considered. Also, the location of the cyclone relative to the rig exhaust should be considered since air-quality monitoring will be performed at the cyclone separator discharge point.

6.1.2 Thread an open-faced bit to the drill pipe.

6.1.3 Force compressed air down the annular space formed between the inner pipes and outer pipes as the percussive action of the pile hammer advances the dual-wall drill pipe. Conduct drill cuttings to the surface through the inner pipe.

6.1.4 Continue air circulation and the percussive action until

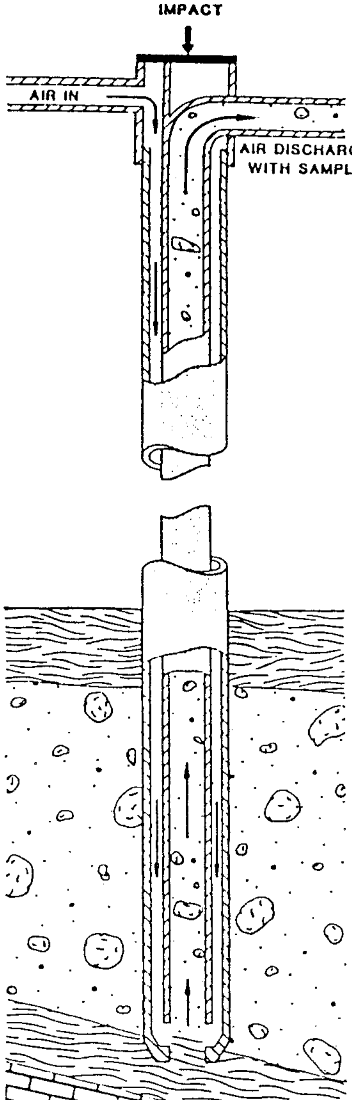

FIG. 1 Drilling with the Dual Wall Percussion Hammer Method

drilling progresses to a depth where sampling or in-situ testing is to be performed or until the length of the drill-pipe section limits further penetration.

NOTE 11—At a minimum, the following information should be documented: number of impacts or driving conditions (i.e. hard, soft, rapid/slow penetration rate), air pressures, water added, volume of cuttings or cuttings return, air quality data, samples taken, water losses, heaving, and any observed unusual occurrences. Drilling rates depend on many factors such as the density or stiffness of unconsolidated material and the existence of cobbles or boulders, the hardness and/or durability of the rock, the swelling activity of clays or shales encountered in the borehole and the erosiveness of the borehole wall. Drilling rates can vary from a few mm (less than an in./min) to about 1 m (3 ft)/min, depending on subsurface conditions. Other factors influencing drilling rates include the weight of the drill string. These data as well as any other drilling-rate information should be recorded.

6.1.5 The percussive action is then stopped. Maintain air circulation, however, for a short time until the drill cuttings are removed from the inner pipe.

6.1.6 Increase drilling depth by attaching an additional section of dual-wall drill pipe to the top of the previously-advanced section of dual-wall drill pipe.

6.1.7 Sampling or in-situ testing can be performed at any depth. Insert the sampling or in-situ testing device through the open inner pipe and open-faced bit and lower to the material at the bottom of the borehole.

NOTE 12—Sampling and testing devices should be decontaminated according to Practice D 5088 prior to testing.

6.2 *"Triple-Wall" Percussion Method (see Fig. 2)*:

6.2.1 As a prelude to and throughout the drilling process, stabilize the drill rig, and raise the drill rig mast with the cyclone separator positioned. If air-monitoring operations are performed, the prevalent wind direction relative to the exhaust from the drill rig should be considered. Also, the location of the cyclone relative to the rig exhaust should be considered since air-quality monitoring will be performed at the cyclone separator discharge point.

6.2.2 Place a single-wall, flush-threaded pipe over the outside of the dual-wall drill pipe, thus making a triple-wall drilling assembly.

6.2.3 Advance the triple-wall drilling assembly as a single unit by the percussive action of the pile hammer as described in 6.1. Drill cuttings are removed only through the dual-wall part of this drill-pipe assembly.

6.2.4 Perform sampling or in-situ testing at any depth. Insert the sampling or in-situ testing device through the open inner pipe and open-faced bit and thence into the material at the bottom of the borehole.

NOTE 13—Sampling and testing devices should be decontaminated according to Practice D 5088 prior to testing.

6.3 *Dual-Wall Rotary Method (see Fig. 3)*:

6.3.1 As a prelude to and throughout the drilling process first stabilize the drill rig, raise rig mast, and position the cyclone separator. If air-monitoring operations are performed, consider the prevalent wind direction relative to the exhaust from the drill rig. Also, consider the location of the cyclone separator relative to the rig exhaust since air-quality monitoring may be performed at the cyclone separator discharge point.

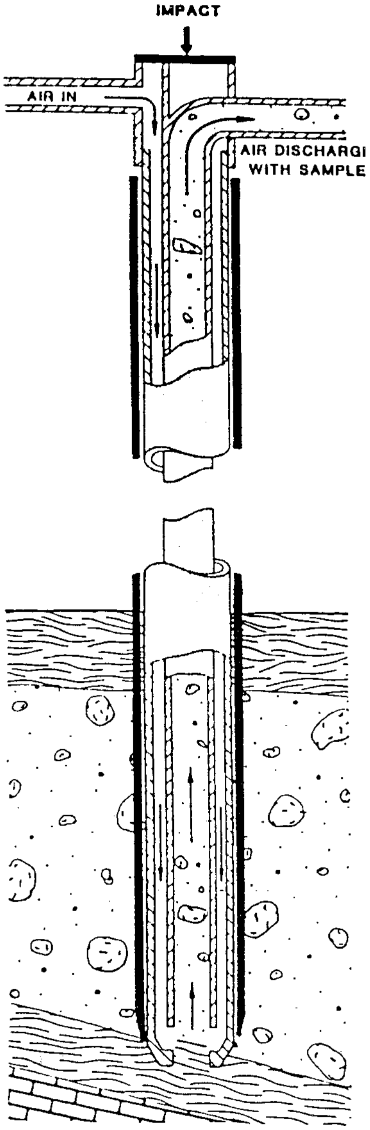

FIG. 2 Drilling with the "Triple Wall" Percussion Hammer Method

6.3.2 Thread an open-faced multicone roller bit or DTH-hammer bit (using appropriate crossover sub) to the drill pipe.

6.3.3 Force compressed air down the annular space formed between the inner pipes and outer pipes as the rotation from the top-head drive unit advances the dual-wall drill pipe. Conduct drill cuttings to the surface through the inner pipe. Drill the borehole and temporarily case in one pass.

6.3.4 Continue air circulation and rotation until drilling progresses to a depth where sampling or in-situ testing is to be performed or until the length of the drill-pipe section limits further penetration.

6.3.5 Then stop the rotation. Maintain air circulation, however, for a short time until the drill cuttings are removed from the inner pipe.

6.3.6 Drilling depth can be increased by attaching an additional section of dual-wall drill pipe to the top of the previously-advanced section of dual-wall drill pipe.

6.4 *"Triple-Wall" for Dual-Wall Rotary Method*:

6.4.1 As a prelude to and throughout the drilling process, stabilize the drill rig and raise the drill rig mast. Position the

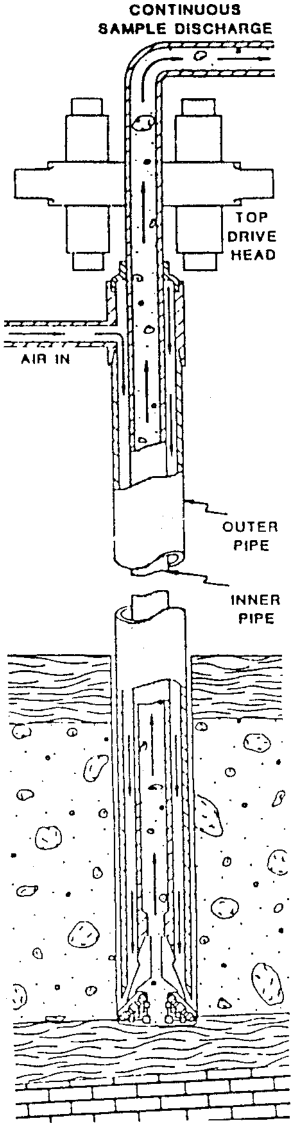

FIG. 3 Drilling with the Dual Wall Rotary Method

cyclone separator and "seal" to the ground surface. If air-monitoring operations are performed, consider the prevalent wind direction relative to the exhaust from the drill rig. Also, consider the location of the cyclone relative to the rig exhaust since air-quality monitoring will be performed at the cyclone-separator discharge point.

6.4.2 Thread an open-faced, tricone roller bit or down-the-hole (DTH) hammer bit to the dual-wall drill pipe.

6.4.3 Force compressed air down the annular space between the inner pipe and the outer pipe as the rotation from the top-head-drive unit advances the dual-wall drill pipe assembly. Conduct drill cuttings to the surface through the inner pipe.

6.4.4 Continue air circulation and rotation until drilling progresses to a depth where sampling or in-situ testing is to be conducted or until the length of drill-pipe section limits further penetration.

6.4.5 Stop the rotation. Maintain air circulation, however, for a short time until the drill cuttings are removed from the inner pipe.

6.4.6 Place a single-wall, flush-threaded drill pipe over the outside of the dual-wall drill pipe, thus making a triple-wall drilling assembly.

6.4.7 Then advance this triple-wall drill pipe to the same depth as the bit on the dual-wall pipe by rotating and washing it over the dual-wall string.

6.4.8 To facilitate downhole testing, remove the dual-wall drill-pipe assembly, leaving the triple-wall pipe temporarily in place to support the borehole wall. Then insert the sampling or in-situ testing device into the formation at the bottom of the borehole.

6.4.9 Increase drilling depth by placing the dual-wall drill string into the triple-wall pipe and attaching an additional section of dual-wall pipe to the top of the previously-advanced section of dual-wall drill pipe.

6.4.10 Repeat the sampling procedure as outlined in the above section describing use of the triple-wall procedure.

NOTE 14—In all of the drilling methods discussed above, compressed air alone can often transport drilled cuttings to the surface. For some geologic conditions, injection of water into the air stream will help control dust or aid in the recovery of some types of materials. Water may also be circulated without air to remove drilled cuttings or control flowing sand conditions. The chemical makeup and quantity of water added to the air stream during the drilling process should be documented because it may affect the mechanical and chemical characteristics of the soil and water samples collected. Containment and disposal of contaminated and potentially-contaminated drilling fluids and associated cuttings should be in accordance with applicable regulations.

7. Installation of Monitoring Devices

7.1 Subsurface water-quality monitoring devices are generally installed in boreholes drilled by dual-wall percussion-hammer method using the four-step procedure. The four steps consist of: (*1*) drilling, with or without sampling, (*2*) the dual-wall drill pipe is temporarily left in place to support the borehole wall after total depth of the borehole is reached, (*3*) insertion of the monitoring device through the inside of the inner pipe, and (*4*) addition of well-completion materials such as filter packs, annular seals and grouts as the dual-wall drill pipe is extracted from the borehole.

NOTE 15—Practical tooling dimensions commonly employed when utilizing the dual-wall percussion-hammer drilling method to install nominal 10.16 cm (4 in.) diameter instrumentation devices typically include: dual-wall hammer pipe at 22.86 cm OD by 15.24 cm ID, or 16.83 cm OD by 10.79 cm ID (9 in. OD by 6 in. ID, or 6⅝ in. OD by 4¼ in. ID).

7.2 *Triple-Wall Percussion-Hammer Drilling Method*—Subsurface water-quality monitoring devices are generally installed in boreholes drilled by the "triple-wall" percussion-hammer drilling method using a four-step procedure. The four steps consist of: (*1*) drilling, with or without sampling, (*2*) removal of the inner, dual-wall drill pipe after total depth of the borehole is reached, and temporarily, leaving the outer pipe in place to support the borehole wall, (*3*) insertion of the monitoring device inside the cased borehole, and (*4*) addition of well-completion materials such as filter packs, annular seals and grouts as the outer pipe is hydraulically extracted from the borehole.

NOTE 16—Practical tooling dimensions commonly employed when utilizing the dual-wall percussion-hammer drilling method with the triple-wall casing to install nominal 15.24 cm (6 in.) diameter and larger instrumentation devices typically include: dual-wall hammer pipe at 22.86 cm OD by 15.24 cm ID (9 in. OD by 6 in. ID); and triple-wall casings at 27.30 cm OD by 24.76 cm ID (10¾ in. OD by 9¾ in. ID). In certain applications, triple-wall casings to 45.72 cm (18 in.) in diameter can be practically employed. In most cases, centralizers are only used to center monitoring devices in boreholes drilled by the triple-wall percussion hammer drilling method when larger triple-wall casings are used.

7.3 *Dual-Wall Rotary-Drilling Method*— Subsurface water-quality monitoring devices are generally installed in boreholes drilled by dual-wall rotary-drilling method using the four-step procedure. The four steps consist of: (*1*) drilling, (*2*) removal of the dual-wall drill pipe, (*3*) insertion of the monitoring device, and (*4*) addition of well-completion materials such as filter packs, annular seals and grouts.

7.4 *Triple-Wall Reverse-Rotary Drilling Method*— Instrumentation devices are generally installed in boreholes drilled by the dual-wall reverse-rotary drilling method and utilizing a triple-wall casing. The installation procedure involved uses the following steps: (*1*) drilling with or without sampling, (*2*) removal of the dual-wall drill pipe, (*3*) insertion of the monitoring device, and (*4*) addition of well-completion materials such as filter packs, annular seals, and grouts as the outer triple-wall casing is removed.

NOTE 17—Practical tooling dimensions commonly employed when utilizing the dual-wall reverse-rotary drilling method with the triple-wall casing, to install nominal 5.08 cm (2 in.) diameter instrumentation devices, typically include: dual-wall drill pipe at 11.43 cm OD by 5.40 cm ID (4½ in. OD by 2⅛ in. ID); drill bits at 12.38 cm (4⅞ in.) to 12.70 cm (5 in.); and triple-wall casing at 12.70 cm ID by 13.97 cm OD (5 in. ID by 5½ in. OD). The drilling shoe, or bit, on the triple-wall casing is then a nominal 15.24 cm (6 in.) OD.

NOTE 18—In most cases, a centralizer should be used to center a monitoring device in the borehole drilled by the triple-wall percussion-hammer drilling method or the dual-wall reverse-rotary drilling method. If caving overburden conditions occur, temporary surface casing may be needed to prevent hole collapse. The user is referred to Practice D 5092 for monitoring-well installation methods and Practice D 5088 for suggested methods of field-equipment decontamination.

7.5 Assemble water-quality monitoring devices with attached fluid conductors (risers) and insert into the borehole with the least possible addition of contaminants.

7.5.1 Some materials, such as screens and risers, may require cleaning or decontamination, or both, at the job site (see Practice D 5088).

7.5.2 Prior to installation, store all monitoring-device materials undercover and place upwind and well away from the drill rig and any other sources of contamination such as electrical generators, air compressors, or industrial machinery.

7.5.3 Clean hoisting tools, particularly wire rope and hoisting swivels and decontaminate according to Practice D 5088 before using.

7.6 Select filter materials, bentonite pellets, granules and chips, and grouts and install according to subsurface monitoring or instrumentation requirements.

NOTE 19—Filter packs, for monitoring devices are usually installed in borings drilled with dual-wall reverse-circulation methods by placing the materials through the casing-riser annulus. This annular area then serves the same function as a separate tremie pipe for placing the annular materials. In some cases, it may be appropriate to use a tremie pipe inserted in the annulus between the inner pipe and the monitoring-device riser provided it is sufficiently large. Monitoring devices installed in a saturated zone ordinarily have sand size filter packs that are selected primarily on the basis of the grain size characteristics of the hydrologic unit adjacent to the screened intake. The coefficient of uniformity of the filter-pack sand is usually less than 2.5. Filter packs for monitoring devices installed in a vadose zone may be predominantly silt sized. These filter materials are often mixed with water of known quality, inserted through a tremie pipe, and tamped into place around the device. Care should be taken when adding backfill or filter material(s), or both, so that the materials do not bridge. However, if bridging does occur during the installation procedure, tamping rods or other tamping devices may be used to dislodge the“ bridge”.

7.7 Sealing materials, consisting of either bentonite pellets, chips, or granules, are usually placed directly above the filter pack of a monitoring device.

NOTE 20—It may be effective, when granular filter packs are used, to install a thin, fine sand, secondary filter either below the annular seal or both above and below the seal. These secondary filters protect both the monitoring-device filter and the seal from intrusion of grout installed above the seal.

7.8 The backfill that is placed above the annular seal is usually a bentonite or cement-base grout.

NOTE 21—Grouts should be designed and installed in consideration of the ambient hydrogeologic conditions. The constituents should be selected according to specific performance requirements and these data documented. Typical grout mixtures are given in Practice D 5092 and Practice D 4428.

NOTE 22—Grouting equipment should be cleaned and decontaminated prior to use according to Practice D 5088. Also, the equipment used for grouting should be constructed from materials that do not “leach” significant amounts of contaminants to the grout.

7.8.1 The initial position of the tremie pipe and grouting pressures should be controlled to prevent materials from being jetted into underlying seal(s) and filter(s) (use of a tremie pipe having a plugged bottom and side-discharge ports should be considered to minimize bottom-jetting problems).

7.8.2 When it is appropriate to use a grout line the grout should be discharged at a depth of approximately 1.5 to 3 m (5 to 10 ft) below the grout surface within the annulus (after the initial 1.5 to 3 m (5 to 10 ft) of grout has been deposited above the uppermost filter or seal).

NOTE 23—The need for chemical analysis of samples of each grout component and the final mixture should be documented. Also, it should be noted that if cements are used for grouting, they generate hydroxides and heat thereby, causing a localized increase in the alkalinity and temperature of the surrounding ground water.

7.8.3 The grout should be installed from the bottom of the borehole to the top of the borehole so as to displace fluids in the borehole.

8. Development

8.1 Most monitoring-device installations should be developed to remove any air that may have been introduced into the formation by the drilling method, suspended solids from drilling fluids, and disturbance of geologic materials during installation and to improve the hydraulic characteristics of the filter pack and the geohydrologic unit adjacent to the intake. For suggested well-development methods and techniques the user is referred to Test Method D 5099. The method(s) selected and time expended to develop the installation and the changes in water quality discharged at the surface should be carefully observed and documented.

NOTE 24—Under most circumstances, development should be initiated as soon as possible following completion however, time should be allowed for initial setting of grout.

9. Field Report and Project Control

9.1 The field report should include information recommended under Guide D 5434, and identified as necessary and pertinent to the needs of the exploration program.

9.2 Other information in addition to Guide D 5434 should be considered if deemed appropriate and necessary to the needs of the exploration program. Additional information should be considered as follows:

9.2.1 *Drilling Methods*:

9.2.1.1 Description of the dual-wall drilling method system.

9.2.1.2 Type, quantities, and locations in the borehole of use of additives added to the circulation media.

9.2.1.3 Description of circulation rates, cuttings return, including quantities, over intervals used.

9.2.1.4 Descriptions of drilling conditions related to drilling pressures, rotation rates, and general ease of drilling as related to subsurface materials encountered.

9.2.2 *Sampling*—Document conditions of the bottom of the borehole prior to sampling and report any slough or cuttings present in the recovered sample.

9.2.3 *In-situ Testing*:

9.2.3.1 For devices inserted below the bottom of the borehole document the depths below the bottom of the hole and any unusual conditions during testing.

9.2.3.2 For devices testing or seating at the borehole wall, report any unusual conditions of the borehole wall such as inability to seat borehole packers.

9.2.4 *Installations*—A description of well-completion materials and placement methods, approximate volumes placed, depth intervals of placement, methods of confirming placement, and areas of difficulty of material placement or unusual occurrences.

10. Keywords

10.1 down-the-hole hammer (DTH) drilling; drilling; dual-wall reverse-circulation drilling method(s); geoenvironmental exploration; ground water; percussion-hammer drilling method; triple-wall percussion-hammer drilling method; vadose zone

APPENDIX

(Nonmandatory Information)

X1. REFERENCES

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