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Standard Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices[1]

This standard is issued under the fixed designation D 5783; 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 direct (straight) rotary-drilling procedures with water-based drilling fluids may be used for geoenvironmental exploration and installation of subsurface water-quality monitoring devices.

NOTE 1—The term direct with respect to the rotary-drilling method of this guide indicates that a water-based drilling fluid is pumped through a drill-rod column to a rotating bit. The drilling fluid transports cuttings to the surface through the annulus between the drill-rod column and the borehole wall.

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

1.2 Direct-rotary drilling for geoenvironmental exploration and monitoring-device installations will often involve safety planning, administration and documentation. This standard 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.*

1.5 *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 2113 Test Method for Diamond Core Drilling for Site Investigation[2]

D 2487 Test Method for Classification of Soils for Engineering Purposes[2]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)[2]

D 3550 Practice for Ring-Lined Barrel Sampling of Soils[2]

D 5088 Practice for Decontamination of Field Equipment Used at Non-Radioactive Waste Sites[2]

D 5092 Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers[2]

D 5099 Test Method for Rubber—Measurement of Processing Properties Using Capillary Rheometry[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*—the 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.

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

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

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

3.2.4 *cleanout depth*—the depth to which the end of the drill string (bit or core barrel cutting end) has reached after an interval of cutting. The cleanout depth (or drilled depth as it is referred to after cleaning out of any sloughed material in the bottom of the borehole) is usually recorded to the nearest 0.1 ft (0.03 m).

3.2.5 *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.

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

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

3.2.8 *drill string*—the complete direct rotary-drilling assembly under rotation including bit, sampler/core barrel, drill rods and connector assemblies (subs). The total length of this assembly is used to determine drilling depth by referencing the position of the top of the string to a datum near the ground surface.

3.2.9 *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.

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

3.2.10 *grout packer*—an inflatable or expandable annular plug attached to a tremie pipe, usually just above the discharge end of the pipe.

3.2.11 *grout shoe*—a drillable "plug" containing a check valve positioned within the lowermost section of a casing column. Grout is injected through the check valve to fill the annular space between the casing and the borehole wall or another casing.

3.2.11.1 *Discussion*—The composition of the drillable "plug" should be known and documented.

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

3.2.13 *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.

3.2.14 *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.

3.2.15 *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.

3.2.15.1 *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.

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

3.2.17 *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 Direct-rotary drilling may be used in support of geoenvironmental exploration and for installation of subsurface water-quality monitoring devices in unconsolidated and consolidated materials. Direct-rotary drilling may be selected over other methods based on advantages over other methods. In drilling unconsolidated sediments and hard rock, other than cavernous limestones and basalts where circulation cannot be maintained, the direct-rotary method is a faster drilling method than the cable-tool method. The cutting samples from direct-rotary drilled holes are usually as representative as those obtained from cable-tool drilled holes however, direct-rotary drilled holes usually require more well-development effort. If however, drilling of water-sensitive materials (that is, friable sandstones or collapsible soils) is anticipated, it may preclude use of water-based rotary-drilling methods and other drilling methods should be considered.

4.1.1 The application of direct-rotary drilling to geoenvironmental exploration may involve sampling, coring, in-situ or pore-fluid testing, or installation of casing for subsequent drilling activities in unconsolidated or consolidated materials. Several advantages of using the direct-rotary drilling method are stability of the borehole wall in drilling unconsolidated formations due to the buildup of a filter cake on the wall. The method can also be used in drilling consolidated formations. Disadvantages to using the direct-rotary drilling method include the introduction of fluids to the subsurface, and creation of the filter cake on the wall of the borehole that may alter the natural hydraulic characteristics of the borehole.

NOTE 3—The user may install a monitoring device within the same borehole wherein sampling, in-situ or pore-fluid testing, or coring was performed.

4.2 The subsurface water-quality monitoring devices that are addressed in this guide consist generally of a screened or porous intake 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 of the installation, including the quality of materials that will contact sampled water or gas.

NOTE 4—Both water-quality monitoring devices and piezometers should have adequate casing seals, annular isolation seals and backfills to deter movement of contaminants between hydrologic units.

5. Apparatus

5.1 Direct-rotary drilling systems consist of mechanical components and the drilling fluid.

5.1.1 The basic mechanical components of a direct-rotary drilling system include the drill rig with derrick, rotary table and kelly or top-head drive unit, drill rods, bit or core barrel, casing (when required to protect the hole and prevent wall collapse when drilling unconsolidated deposits), mud pit, suction hose, cyclone desander(s), drilling-fluid circulation pump, pressure hose, and swivel.

NOTE 5—In general, in North America, the sizes of casings, casing bits, drill rods, and core barrels are usually standardized by manufacturers according to size designations set forth by the American Petroleum Institute (API) and the Diamond Drill Core Manufacturers Association (DCDMA). Refer to the DCDMA technical manual and to published materials of API for available sizes and capacities of drilling tools equipment.

5.1.1.1 *Drill Rig*, with rotary table and kelly or top-head drive unit should have the ability to rotate a drill-rod column and apply a controllable axial force on the drill bit appropriate to the drilling and sampling requirements and the geologic conditions.

5.1.1.2 *Kelly*, a formed or machined section of hollow drill steel, used with some rotary-drilling systems, that is joined to the swivel at the top and the drill rods below. Flat surfaces or splines of the kelly engage the rotary table so that rotation is transmitted to the drill rods.

5.1.1.3 *Drill Rods*, (that is, drill stems, drill string, drill pipe) transfer force and rotation from the drill rig to the bit or core barrel. Drill rods conduct drilling fluid to the bit or core barrel. Individual drill rods should be straight so they do not contribute to excessive vibrations or "whipping" of the drill-rod column. All threaded connections should be in good repair and not leak significantly at the internal fluid pressure required for drilling. Drill rods should be made up securely by wrench tightening at the threaded joint(s) at all times to prevent rod damage.

NOTE 6—Drill rods usually require lubricants on the threads to allow easy unthreading of the drill-rod tool 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 drill-rod lubricants on chemical analyses of samples should be considered and documented when using direct-rotary 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.

5.1.1.4 *Rotary Bit or Core Bit*, provides the material cutting capability. Therefore, a core barrel can also be used to advance the hole.

NOTE 7—The bit is usually selected to provide a borehole of sufficient diameter for insertion of monitoring-device components such as the screened intake and filter pack and installation devices such as a tremie pipe. It should be noted that if bottom-discharge bits are used in loose cohesionless materials, jetting or erosion of test intervals could occur. The borehole opening should permit easy insertion and retraction of a sampler, or easy insertion of a pipe with an inside diameter large enough for placing completion materials adjacent to the screened intake and riser of a monitoring device. Core barrels may also be used to advance the hole. Coring bits are selected to provide the hole diameter or core diameter required. Coring of rock should be performed in accordance with Practice D 2113. The user is referred to Test Method D 1586, Practice D 1587, and Practice D 3550 for techniques and soil-sampling equipment to be used in sampling unconsolidated materials. Consult the DCDMA technical manual and published materials of API for matching sets of nested casings and rods if nested casings must be used for drilling in incompetent formation materials.

5.1.1.5 *Mud Pit*, is a reservoir for the drilling fluid and, if properly designed and utilized, provides sufficient flow-velocity reduction to allow separation of drill cuttings from the fluid before recirculation. The mud pit is usually a shallow, open metal tank with baffles; however, for some circumstances, an excavated pit with some type of liner, designed to prevent loss of drilling fluid and to contain potential contaminants that may be present in the cuttings and recirculated fluids may be used. The mud pit can be used as a mixing reservoir for the initial quantity of drilling fluid and, in some circumstances, for adding water and additives to the drilling fluid as drilling progresses.

NOTE 8—Some drilling-fluid components must be added to the composite mixture before other components; consequently, an auxiliary mixing reservoir may be required to premix these components with water before adding to the mud pit. All quantities, chemical composition and types of drilling-fluid components and additives used in the composite drilling-fluid mixture should be documented.

5.1.1.6 *Suction Hose*, sometimes equipped with a foot valve or strainer, or both, conducts the drilling fluid from the mud pit to the drilling-fluid circulation pump.

5.1.1.7 *Drilling-Fluid Circulation Pump*, must have the capability to lift the drilling fluid from the mud pit and move it through the system against variable pumping heads and provide an annular velocity adequate to transport drill cuttings out of the borehole.

NOTE 9—Drilling-fluid pressures at the bit should be low to prevent fracturing of the surrounding material. All drilling-fluid pressures should be monitored during drilling. Any abrupt changes or anomalies in the drilling-fluid pressure should be duly noted and documented including the depth(s) of occurrence(s).

5.1.1.8 *Pressure Hose*, conducts the drilling fluid from the circulation pump to the swivel.