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Standard Guide for Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices[1]

This standard is issued under the fixed designation D5876/D5876M; 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) wireline rotary casing advancement drilling and sampling procedures 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 or air is injected through a drill-rod column to rotating bit(s) or coring bit. The fluid or air cools the bit(s) and transports cuttings to the surface in the annulus between the drill rod column and the borehole wall.

NOTE 2—This guide does not include the procedures for fluid rotary systems which are addressed in a separate guide, Guide D5783.

1.2 The term "casing advancement" is sometimes used to describe rotary wireline drilling because the center pilot bit or core barrel assemblies may be removed and the large inside diameter drill rods can act as a temporary casing for testing or installation of monitoring devices. This guide addresses casing-advancement equipment in which the drill rod (casing) is advanced by rotary force applied to the bit with application of static downforce to aid in the cutting process.

1.3 This guide includes several forms of rotary wireline drilling configurations. General borehole advancement may be performed without sampling by using a pilot roller cone or drag bit until the desired depth is reached. Alternately, the material may be continuously or incrementally sampled by replacing the pilot bit with a core-barrel assembly designed for coring either rock or soil. Rock coring should be performed in accordance with Practice D2113.

1.4 *Units*—The values stated in either SI units or Inch-Pound units given in brackets are to be regarded separately as standard. The values stated in each system may not be exactly equivalents; therefore, each system shall be used independently of the other. Combining values from the two system may result in non-conformance with the standard.

1.5 All observed and calculated values are to conform to the guidelines for significant digits and rounding established in D6026. The procedures used to specify how data are collected/recorded or calculated in this standard are regarded as the industry standard. In addition, they are representative of the significant digits that generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any considerations for the user's objective; and it is common practice to increase or reduce the significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analysis method or engineering design.

1.6 Direct rotary wireline drilling methods for geoenvironmental exploration will often involve safety planning, administration, and documentation. This guide does not purport to specifically address exploration and site safety.

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

1.8 *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.*

1.9 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

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

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

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D1452 Practice for Soil Exploration and Sampling by Auger Borings

D1586 Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils

D1587 Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes

D2113 Practice for Rock Core Drilling and Sampling of Rock for Site Exploration

D3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils

D4630 Test Method for Determining Transmissivity and Storage Coefficient of Low-Permeability Rocks by In Situ Measurements Using the Constant Head Injection Test (Withdrawn 2017)[3]

D4631 Test Method for Determining Transmissivity and Storativity of Low Permeability Rocks by In Situ Measurements Using Pressure Pulse Technique (Withdrawn 2017)[3]

D5088 Practice for Decontamination of Field Equipment Used at Waste Sites

D5092 Practice for Design and Installation of Groundwater Monitoring Wells

D5099 Test Methods for Rubber—Measurement of Processing Properties Using Capillary Rheometry

D5608 Practices for Decontamination of Sampling and Non Sample Contacting Equipment Used at Low Level Radioactive Waste Sites

D5782 Guide for Use of Direct Air-Rotary Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices

D6026 Practice for Using Significant Digits in Geotechnical Data

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bentonite, n—in drilling*, 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.

3.2.2 *cleanout depth, n—in drilling*, 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 sloughed material in the bottom of the borehole) is usually recorded to the nearest 0.03 m [0.1 ft].

3.2.3 *drill hole, n—in drilling*, a cylindrical hole advanced into the subsurface by mechanical means. Also known as a borehole or boring.

3.2.4 *drill string, n—in drilling*, the 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.

3.2.5 *filter pack, n—in drilling*, also known as a gravel pack or 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: a nonclogging filter when the aquifer is not suited to natural development or, as a formation stabilizer when the aquifer is suitable for natural development.

3.2.5.1 *Discussion*—Under most circumstances, a clean, quartz sand or gravel should be used. In some cases, a prepacked screen may be used.

3.2.6 *head space, n—in drilling*, on a double- or triple-tube wireline core barrel it is the spacing adjustment made between the pilot-shoe leading edge and the inner kerf of the outer-tube cutting bit. Spacing should be about 1.6 mm [0.0625 in.] or roughly, the thickness of a matchbook. (The head-space adjustment is made by removing the inner-barrel assembly, loosening the lock nut on the hanger-bearing shaft and either tightening or loosening the threaded shaft until the inner barrel is moved the necessary distance, up or down, to obtain the correct setting. Reassemble the inner- and outer-barrel assemblies, attach the barrel to the drill rod or a wireline and suspend vertically allowing the inner-barrel assembly to hang freely inside the outer barrel on the inner hanger-bearing assembly. Check the head space. It is imperative that the adjustment is correct to make sure that the inner barrel is free to rotate without contacting the outer barrel. If incorrectly adjusted, the inner barrel will "hang up" and rotate with the outer barrel as the core is being cut. This will cause the core to break and block entry of core into the inner barrel.)

3.2.7 *in situ testing devices, n—in drilling*, 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 so forth) may require lowering and setting of the device(s) in preexisting boreholes by means of a suspension line or a string of lowering rods or pipes. Centralizers may be needed to correctly position the device(s) in the borehole.

3.2.8 *lead distance, n—in drilling*, the mechanically adjusted length or distance that the inner-barrel cutting shoe is set to extend beyond the outer core-barrel cutting bit in order to reduce potential core-erosion damage that can be caused by the

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

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

circulating drilling-fluid media. Lead distance is checked by vertically suspending the entire core-barrel assembly from a wireline or from a section of drill rod so that the inner-barrel can hang freely from the upper inner-barrel swivel assembly. The cutting shoe extension below the outer core-barrel cutting bit can then be checked. The "stiffer" or more competent the formation to be cored, the less the extension of the inner-barrel cutting shoe is necessary to avoid core erosion.

3.2.9 *overshot, n—in drilling*, a latching mechanism located at the end of the hoisting line. It is specially designed to latch onto or release pilot bit or core-barrel assemblies.

3.2.10 *pilot bit assembly, n—in drilling*, design to lock into the end section of drill rod for drilling without sampling. The pilot bit can be either drag, roller cone, or diamond plug types. The bit can be set to protrude from the rod coring bit depending on formation conditions.

3.2.11 *sub, n—in drilling*, a substitute or adaptor used to connect from one size or type of threaded drill rod or tool connection to another.

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

3.2.13 *wireline drilling, n—in drilling*, a rotary drilling process which uses special enlarged inside diameter drilling rods with special latching pilot bits or core barrels which are raised or lowered inside the rods with a wireline and overshot latching mechanism.

4. Summary of Practice

4.1 Wireline drilling is a rotary drilling process that uses special enlarged inside diameter drilling rods with special latching pilot bits or core barrels which are raised or lowered inside the rods with a wireline and overshot latching mechanism. The bottom section of rod has either a diamond or carbide coring bit at the end and is specially machined to accommodate latching of either pilot bits or core barrels. The overshot mechanism is designed to latch and unlatch bit or barrel assemblies. Bit cutting is accomplished by application of the combination rotary and static down forces to the bit. General drill-hole advancement may be performed without sampling by using either a pilot roller cone or drag bit until the desired depth is reached. Alternately, the material may be continuously or incrementally sampled by replacing the pilot bit with a core-barrel assembly designed for coring either rock or soil.

4.2 The pilot bit or core barrel can be inserted or removed during the drilling process and the large inside diameter rods can act as a temporary casing for testing or installation of monitoring devices.

5. Significance and Use

5.1 Wireline casing advancement may be used in support of geoenvironmental exploration and for installation of subsurface monitoring devices in both unconsolidated and consolidated materials. Use of direct-rotary wireline casing-advancement drilling methods with fluids are applicable to a wide variety of consolidated or unconsolidated materials as long as fluid circulation can be maintained. Wireline casing-advancement drilling offers the advantages of high drilling-penetration rates in a wide variety of materials with the added benefit of the large-diameter drilling rod serving as protective casing. Wireline coring does not require tripping in and out of the hole each time a core is obtained. The drill rods need only be removed when the coring bit is worn or damaged or if the inner core barrel becomes stuck in the outer barrel.

5.1.1 Wireline casing advancers may be adapted for use with circulating air under pressure for sampling water-sensitive materials where fluid exposure may alter the core or in cavernous materials or lost circulation occurs (**1, 2**).[4] Several advantages of using the air-rotary drilling method over other methods may include the ability to drill rather rapidly through consolidated materials and, in many instances, not require the introduction of drilling fluids to the borehole. Air-rotary drilling techniques are usually employed to advance the borehole when water-sensitive materials (that is, friable sandstones or collapsible soils) may preclude use of water-based rotary-drilling methods. Some disadvantages to air-rotary drilling may include poor borehole integrity in unconsolidated materials when casing is not used and the possible volatilization of contaminants and air-borne dust. Air drilling may not be satisfactory in unconsolidated or cohesionless soils, or both, when drilling below the groundwater table. In some instances, water or foam additives, or both, may be injected into the air stream to improve cuttings-lifting capacity and cuttings return. Use of water or other additives, or both, should be documented. The use of air under high pressures may cause fracturing of the formation materials or extreme erosion of the borehole if drilling pressures and techniques are not carefully maintained and monitored. If borehole damage becomes apparent, other drilling method(s) should be considered.

5.1.2 When air is used as the circulating fluid, the user should consult Refs (**1, 2**) and Guide D5782.

5.2 The application of wireline casing advancement to geoenvironmental exploration may involve sampling of groundwater, soil, or rock; or in situ or pore-fluid testing; or installation of other casings for subsequent drilling activities in unconsolidated or consolidated materials.

5.3 The wireline drill rod can act as a temporary casing and may be used to facilitate the installation of a monitoring device. The monitoring device may be installed as the drill rod is removed from the drill hole.

NOTE 3—The user may install a monitoring device within the same drill hole wherein sampling or in situ testing was performed.

5.4 Wireline casing-advancement rotary-drilling methods use fluid or air circulation to lubricate cutting bits and for removal of drill cuttings. In many cases, additives are added to improve circulation, cuttings return, borehole wall stabilization, and sealing of the borehole wall from fluid loss. The use of fluid or air under high pressures may allow for

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

damage to formation materials by fracturing or excessive erosion if drilling conditions are not carefully maintained and monitored. If undesirable formation damage is occurring or evident, other drilling method(s) should be considered.

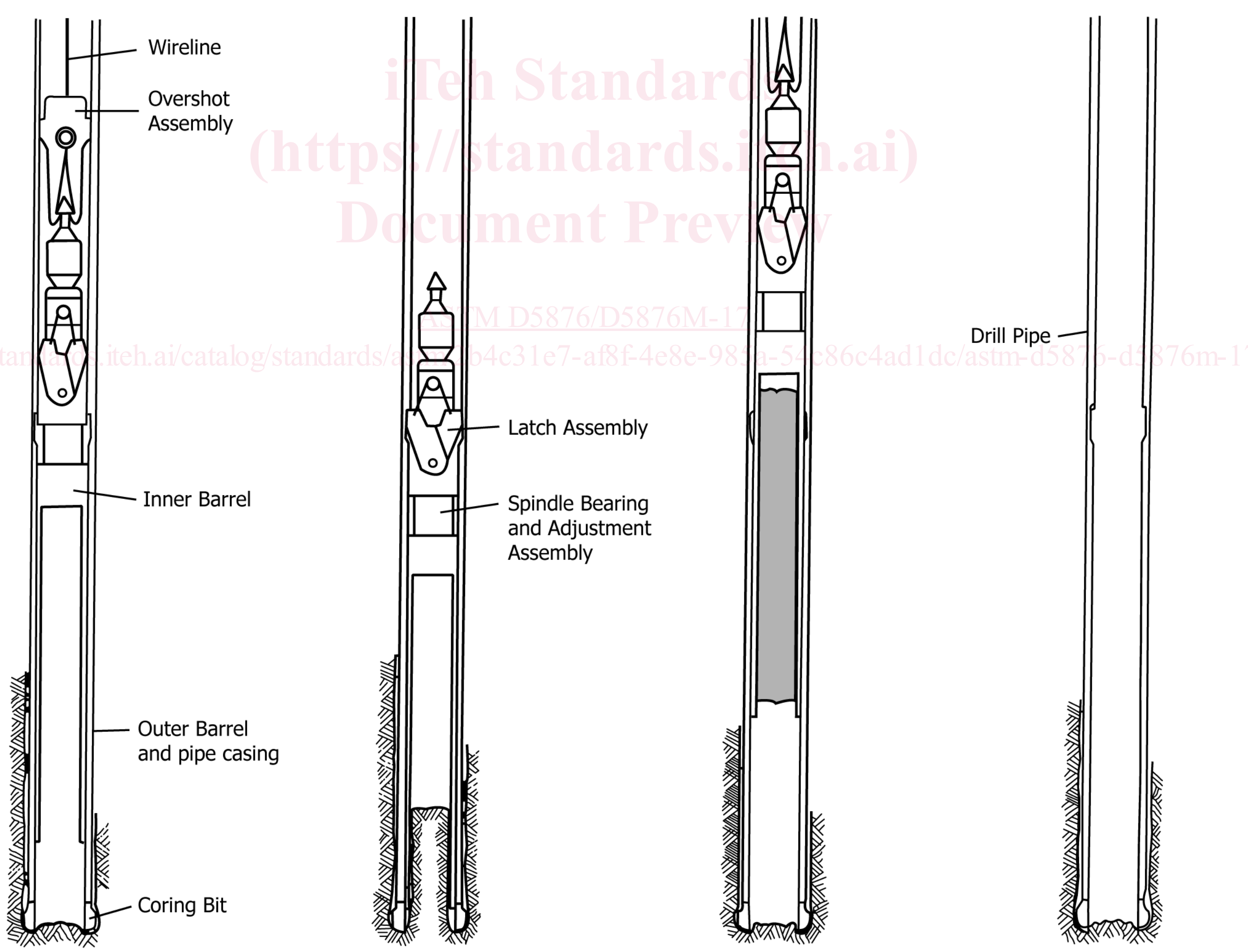
6. Apparatus

6.1 *General*—Direct rotary wireline casing advancement systems and procedures used for geoenvironmental exploration and subsurface water-quality monitoring device installations include direct air or mud-rotary drilling using wireline drill rods. The wireline drill rod has a large inside diameter and is equipped with either a wireline-retrievable center pilot bit for general hole advancement, or a rock- or soil-core barrel for sampling the borehole as it is advanced. Fig. 1 (*a* through *d*) shows basic schematics of the components of a wireline-drilling assembly using a rock core-barrel assembly to sample formations as drilling progresses.

6.2 The basic mechanical components of wireline casing-advancement drilling systems include the drill rig with either hollow spindle or top-head drive, drill rods, coring or casing bits, overshot assembly, pilot bit, or core barrel. Water-based fluid circulation systems require drill fluid, mud pit, suction hose, drill fluid circulation pump, pressure hose, and swivel. Air circulation systems require an air compressor, dust collector, air cleaning device, pressure hose, and swivel.

6.2.1 *Drill Rig*—Most top-head drive or hollow-spindle drills are suitable for performing rotary wireline drilling. Rock-coring drills with smooth hydraulic operation and high RPM capability are desirable for rock-coring operations. Rotary table and kelly drills generally are not acceptable for wireline-drilling use due to difficulty or inability to raise and lower wireline assemblies. The drill 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.

6.2.2 *Drill Rods,* transfer force and rotation from the drill rig to the bit or core barrel. When rotary drilling is stopped, the large inside diameter wireline drill rod acts can as casing, that is, by preventing against hole collapse—to allow for testing or installation of monitoring devices for hole protection. Drill rods conduct drilling fluid to the bit or core barrel. Individual drill rods (that is, drill stem, drill string, drill pipe) should be



(a) INNER BARREL BEING LOWERED INTO POSITION

(b) OBTAINING CORE, OUTER BARREL ROTATING, INNER BARREL STATIONARY

(c) LIFTING INNER BARREL AND CORE OUT OF HOLE

(d) OUTER BARREL AND CORING BIT REMAIN IN HOLE

FIG. 1 Schematics of Wire-Line Drilling Assembly

straight so they do not contribute to excessive vibrations or "whipping" of the drill-rod column. Threaded connections should be in good repair and not leak significantly at the internal fluid pressure typically used for drilling. Drill rods should be made up and kept secure by wrench tightening at the threaded joint(s) to prevent rod damage.

6.2.2.1 Wireline drill rod dimensions are not fully standardized. The available sizes depend on the manufacturing sources (**3**). General hole diameter available from most manufacturers follows the Diamond Core Drill Manufacturers Association (DCDMA) size conventions of A (48-mm), B (59.9-mm), N (75.7-mm), H (96.3-mm), and P (122.6-mm) sizes (**4**). Inside diameter varies depending on the manufacturer.

NOTE 4—Sizes of casings, casing bits, drill rods, and core barrels are standardized by the DCDMA and the American Petroleum Institute (API). Refer to Ref (**4**) for available sizes and capacities of common use drilling equipment used for soil and rock exploration.

6.2.2.2 The wireline lead rod contains shoulders for latching of pilot bits or core barrels. Wireline lead-rod sections are equipped with coring or casing bits. There are many configurations of wireline drilling equipment possible depending on the manufacturer. With rock-coring systems, the wireline lead rod is equipped with a reaming shell to maintain circulation and act as a stabilizer. Some multipurpose systems allow for latching of pilot bit, rock-core barrel, or soil-core barrel to the lead wireline rod section. In most coring operations the lead wireline rod is considered to be the outer barrel in a double- or triple-tube core barrel design (see Practice D2113). The bit is referred to as a core bit.

6.2.2.3 The wireline rod size is usually selected to provide a drill hole of sufficient diameter for specified sampling, testing, or insertion of instrumentation-device components, such as, the screened intake and filter pack and installation devices such as a tremie pipe. The inside diameter of the wireline rod should permit easy insertion and retraction of a sampler or a pipe with a sufficiently large inside diameter to accommodate the placement of completion materials adjacent to the screened intake and riser of an instrumentation device. Coring bits are selected to provide adequate hole or core diameter, or both. Selection of protective casings, bits, and core barrels is made by considering size requirements listed above combined with: annulus circulation capabilities of drill rod used, and the need for tapering from larger to smaller diameters casings ("nesting" of casing) if difficult drilling conditions occur (lost circulation, zones of contamination, and so forth) requiring these problem zones in the borehole to be cased off.

NOTE 5—Drill rods usually require lubricants on the threads to allow easy threading and 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.

6.2.3 The casing bit or core bit provides the material cutting capability. In coring operations, the bit is referred to as a core bit. Rock coring should be performed in accordance with Practice D2113. Soil sampling or coring methods, some of which are listed in 2.2, can also be used to obtain samples. When drilling in a casing-advancement mode using a pilot bit, without sampling, the bit is referred to as a casing bit.

6.2.3.1 Numerous coring or casing bits can be selected depending on the properties of the formation to be drilled or cored. Since it is undesirable to remove the outer bit, design of this bit is highly important. When coring, particularly in unconsolidated materials, it is important that the bit cuts the material and not merely tears it and pushes it aside. Some bit types successfully used include either carbide inserts coring bits or diamond core bits. In rock-coring operations the kerf design inner gage of bit, matrix cutting capacity, and location of drilling-fluid circulation ports are important. The inner gage of the bit can be selected so that the core is slightly undercut, thereby allowing it to move freely up the inner tube and not cause core blockage. If the core is over cut and air is present in the barrel, consideration should be given to possible alteration of the core that may occur during subsequent sealing and storage of the core obtained. It is beyond the scope of this guide to recommend bit styles. Bit selection can be aided by review of literature (**1**, **2**, **3**, **5**, **6**) and consultation with manufacturers.

6.2.3.2 The dimensions of the coring or casing bits often determine the maximum diameter of testing or sampling device that can be inserted through the wireline drill rods. As mentioned previously, the bit size is usually selected to provide a drill hole of sufficient diameter for specified borehole sampling or testing to be accomplished or for insertion of instrumentation device components such as the screened intake, riser pipe, filter pack, and well-completion installation devices such as a tremie pipe in the borehole.

6.2.4 *Wireline Retrievable Pilot-Bit Assembly,* used when no borehole coring/sampling is desired. The assembly is equipped with a receiver for pickup by the overshot latching assembly. Several pilot-bit styles are available including roller cone and drag bit configurations. Bit selection can be aided by review of literature (**1**, **2**, **3**, **5**, **6**) and consultation with manufacturers.

NOTE 6—Bottom-discharge bits are those having drill-fluid circulation discharge ports in direct contact with the base of the hole. If these bits are used to drill loose cohesionless materials, jetting or excessive erosion of the test intervals could occur.

6.2.5 *Overshot,* a latching retrieval assembly that is lowered into the hole with a wireline hoist cable to either retrieve or lower core-barrel inner assemblies or bits equipped with an upper retrieval spear and downhole latching assemblies.

NOTE 7—When lowering a latching bit assembly or retrievable inner-core barrel assembly into a dry hole, a retrievable dry-hole lowering tool should be employed to prevent damaging the outer bit kerf, matrix, or latching assemblies, or combination thereof. Inner tools should not be allowed to free-fall down the drill rod in a dry hole.

6.2.6 *Wireline Core Barrels,* available for obtaining continuous samples of soil or rock. The barrels for use in coring rock vary in design and manufacture from those barrels used for coring unconsolidated materials. The recommended core recovery in rock usually requires a double- or triple-tube, swivel-type design. The inner tube of the rock core barrel consists of a core-lifter case and core lifter that threads onto the lower end of the inner tube. On the upper end of the inner tube is a removable threaded inner-tube head swivel-bearing assembly with an inner-tube latching device and release mechanism. The inner-tube latching device locks into a complementary recess in the wall of the lead outer drill rod such that the drill rod may be rotated while the inner tube remains stationary. The use of split inner tubes or split inner-tube liners inside a solid inner-tube barrel facilitates easier handling, study, and removal of the core from the core barrel.

6.2.6.1 Several types of soil core barrels are also available. Most barrels have a cutting shoe that is either flush with the outer tube cutting bit or, it is made to extend past the outer tube core bit. Sample barrels may be of either the solid- or split-tube configuration. Some barrels may also be equipped with either a split tube or solid tube inner liner to reduce potential exposure of the core to fluids or other materials. Important considerations for sampling results and maximum core recovery are: use of the "correct" lead distance of the inner barrel cutting shoe, using the "optimum" clearance ratio or head space of the cutting shoe, and prevention of inner-barrel rotation. (For maximum core recovery and minimum core damage the user is referred to 3.2.5 and 3.2.8 for making proper lead-distance or head-space adjustments of the inner-barrel cutting shoe.) The lead distance of the cutting shoe ahead of the cutting bit depends on the stiffness of the formations to be sampled. Stiffer materials require less lead distance.

6.2.6.2 The clearance ratio or head space of the cutting shoe with respect to inner barrel should be selected to result in core that fills the barrel without excessive compression of the core due to friction. If the clearance ratio is too great and the core is over cut, core-erosion damage may occur. If core is over cut and air is present in the barrel, alteration of the soil may occur during subsequent packaging, sealing, and storage of the core(s). Use of single-tube split barrels below the water table may expose soil cores to fluids present in the drill rod.

6.2.7 *Pressure Hose,* conducting the drilling fluid from the circulation pump to the swivel.

6.2.8 *Swivel,* directing the drilling fluid to the rotating kelly or drill-rod column.

6.3 *Rotary Wireline Drilling,* with water-based drilling fluids.

6.3.1 *Mud Pit,* a reservoir for the drilling fluid and, if correctly 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, 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 need to be added to the composite mixture before other components; consequently, an auxiliary mixing reservoir may be used to premix these components with water before adding to the mud pit. The quantities and types of drilling-fluid components and additives used in the composite drilling-fluid mixture should be documented.

6.3.2 *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.

6.3.3 *Drilling-Fluid Circulation Pump,* having the capability to lift the drilling fluid from the mud pit and move it through the system against variable pumping heads at a flow rate to provide an annular velocity that is adequate to transport drill cuttings out of the drill hole.

6.3.3.1 Fluid pressures at the bit should be as low as necessary to maintain circulation in order to reduce the potential for hydraulic fracturing or excessive erosion of the surrounding materials. Fluid pressures should be monitored during drilling. Normally, injection fluid pressures are easily monitored. Changes in fluid return and circulation pressures may indicate occurrence of excessive erosion, formation fluid loss, or formation fracturing. Abrupt changes or anomalies in the fluid pressures should be duly noted and documented including the depth(s) of occurrence(s).

6.3.4 *Drilling Fluid,* usually consisting of a water-based circulation media and one or more additives that increase viscosity or provide other desirable physical or chemical properties. Principal functions of drilling fluid include: sealing the drill hole wall to reduce loss of drilling fluid, providing a hydraulic pressure against the drill-hole wall to support the open drill hole, removing cuttings generated at the bit, and lubricating and cooling of the bit. Drilling-fluid management requires considerable experience for successful use. Drilling-fluid program design can be aided by review of literature (**1, 3, 4, 5, 6**) and consultation with manufacturers. If changes to the circulating medium are made, the depth(s) or interval(s) of these changes should be documented. Samples of cuttings can be collected for analysis of materials being penetrated. If samples are taken, the depth(s) and interval(s) should be documented.

NOTE 9—Particular attention should be given to the drilling-fluid makeup-water source and the means used to transport the makeup water to the drilling site as potential sources of contamination in the drilling fluid. If the chemical makeup of the water is determined the test results should be documented.

6.3.4.1 Some commonly used additives for water-based drilling fluids are listed in 6.3.4.2 – 6.3.4.10.

6.3.4.2 Beneficiated bentonite, a primary viscosifier and borehole sealer, consists of montmorillonite with other naturally occurring minerals and various additives such as sodium carbonate or polyacrylates, or both.

6.3.4.3 Unbeneficiated bentonite, a primary viscosifier and drill hole sealer, consists of montmorillonite with other naturally occurring minerals but without additives such as sodium carbonate or polyacrylates.

6.3.4.4 Sodium carbonate powder (soda ash) is used to precipitate calcium carbonate hardness from the drilling fluid water-base before adding other components. An increase in pH will occur with the addition of sodium carbonate. Sodium hydroxide (caustic soda) generally should not be used in this application.

6.3.4.5 Carboxylmethylcellulose powder (CMC) is sometimes used in a water-based fluid as a viscosifier and as an inhibitor to clay hydration.