



Standard Practice for Rock Core Drilling and Sampling of Rock for Site Investigation¹

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1. Scope

1.1 This practice covers the guidelines, requirements, and procedures for core drilling, coring, and sampling of rock for the purposes of site investigation. The borehole could be vertical, horizontal, or angled.

1.2 This practice is described in the context of obtaining data for the design, construction, or maintenance of structures, and applies to surface drilling and drilling from adits and exploratory tunnels.

1.3 This practice applies to core drilling in hard and soft rock.

1.4 This practice does not address considerations for core drilling for geo-environmental site characterization and installation of water quality monitoring devices (see Section 2).

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

1.6 This practice does not purport to comprehensively address all of the methods and the issues associated with coring and sampling of rock. Users should seek qualified professionals for decisions as to the proper equipment and methods that would be most successful for their site investigation. Other methods may be available for drilling and sampling of rock, and qualified professionals should have flexibility to exercise judgment as to possible alternatives not covered in this practice. This practice is current at the time of issue, but new alternative methods may become available prior to revisions; therefore, users should consult with manufacturers or producers prior to specifying program requirements.

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 judgment. 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 a project's many unique aspects. The word "Standard" in the*

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title of this document means only that the document has been approved through the ASTM consensus process.

1.8 *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.* Also, the user must comply with prevalent regulatory codes, such as OSHA (Occupational Health and Safety Administration) guidelines, while using this practice. For good safety practice, consult applicable OSHA regulations and other safety guides on drilling (1).

2. Referenced Documents

2.1 ASTM Standards:

D 420 Guide to Site Characterization for Engineering Design, and Construction Purposes²

D 653 Terminology Relating to Soil, Rock, and Contained Fluids²

D 4630 Test Method for Determining Transmissivity and Storage Coefficient of Low Permeability Rocks by In Situ Measurements Using the Constant Head Injection Test²

D 5079 Practices for Preserving and Transporting Rock Core Samples²

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock³

D 5782 Guide for the Use of Direct Air-Rotary Drilling for Geoenvironmental Exploration and Installation of Subsurface Water Quality Monitoring Devices³

D 5783 Guide for Use of Direct Rotary Drilling With Water-Based Drilling Fluid for Geoenvironmental Exploration and Installation of Subsurface Water Quality Monitoring Devices³

D 5876 Guide for Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices³

D 6032 Test Method for Determining Rock Quality Designation (RQD) of Rock Core³

D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling³

2.2 American Petroleum Institute Standard:

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

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

API RP 13B Recommended Practice Standard Procedure for Testing Drilling Fluids⁴

2.3 *NSF Standard:*

NSF 60-1988⁵

3. Terminology

3.1 *Definitions:*

3.1.1 *blind hole, n*—borehole that yields no fluid recovery of the drilling fluids.

3.1.2 *casing, n*—hollow tubes of steel used to support bore hole walls or where fluid losses must be stopped.

3.1.3 *caving hole, n*—borehole whose walls or bottom are unstable and cave or collapse into the drilled borehole.

3.1.4 *core barrels, n*—hollow tubes of steel used to collect cores of drilled rock.

3.1.5 *core bits, n*—coring bits with surface set or impregnated diamonds in tungsten carbide mix of hardened steel, polycrystalline bits, or tungsten carbide (TC) inserts, mounted on a cylindrical coring bit that does the actual core cutting.

3.1.6 *drill rig, n*—includes drilling machine, mast or derrick, circulating pumps, and mounting platform.

3.1.7 *drill rod, n*—hollow steel tubes that are connected to the drill bit or core barrel and to the rotary head of the drilling machine.

3.1.8 *drill platform, n*—a platform for drilling rig.

3.1.8.1 *Discussion*—The platform may need to be constructed at the drilling site to provide a firm base upon which the drill rig is then placed. Platforms are also constructed in the vicinity of the drill hole for workers to hold equipment, serve as a datum, and to allow safe operations.

3.1.9 *drilling machine, n*—includes power unit, hoisting unit, controlled-feed rotary drill head, and water or mud pump.

3.1.10 *overshot, n*—a latching mechanism at the end of the hoisting line, specially designed to latch onto or release pilot bit or core barrel assemblies when using *wireline drilling*.

(D 5786)

3.1.11 *pilot bit assembly, n*—designed to lock into the end section of drill rod for *wireline 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 the formation being drilled.

(D 5786)

3.1.12 *squeezing hole, n*—borehole whose walls move into the drilled opening and squeeze on the drill rods.

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

(D 5786)

3.2 Additional terms are defined in Terminology D 653.

4. Summary of Practice

4.1 *Drilling:*

4.1.1 Drilling is accomplished by circulating a drilling medium through the drill bit while rotating and lowering or

advancing the string of drill rods as downward force is applied to a cutting bit. The bit cuts and breaks up the material as it penetrates the formation, and the drilling medium picks up the cuttings generated by the cutting action of the bit. The drilling medium, with cuttings, then flows outward through the annular space between the drill rods and drill hole, and carries the cuttings to the ground surface, thus cleaning the hole. The string of drill rods and bit is advanced downward, deepening the hole as the operation proceeds.

4.1.1.1 Fluid drilling is accomplished by circulating water or a water-based fluid with additives. Additives such as bentonite or polymers are frequently added to water to lubricate and cool the bit and to circulate (transport) cuttings to the surface. Drill fluid can also act to prevent cave or collapse of the drill hole. After the drilling fluid reaches the surface, it flows to a ditch or effluent pipe and into a settling pit where the cuttings settle to the bottom. Cuttings are sometimes run through a shaker to remove the larger particles. From the settling pit, the drilling fluid overflows into the main pit, from which it is picked up by the suction line of the mud pump and recirculated through the drill string.

NOTE 1—The decrease of mud velocity upon entering the mud pit may cause gelling of the mud and prevent cuttings from settling. Agitation of the mud in the pit can remedy the problem.

4.1.1.2 Air drilling is performed where introduction of fluids is undesirable. Air rotary drilling requires use of an air compressor with volume displacement large enough to develop sufficient air velocity to remove cuttings. Cuttings can be collected at the surface in cyclone separators. Sometimes a small amount of water or foam may be added to the air to enhance return of cuttings. Air drilling may not be satisfactory in unconsolidated and cohesionless soils under the ground water table.

4.2 *Coring:*

4.2.1 Coring is the process of recovering cylindrical cores of rock by means of rotating a hollow steel tube (core barrel) equipped with a coring bit. The drilled core is carefully collected in the core barrel as the drilling progresses.

4.3 *Sampling:*

4.3.1 Once the core has been cut and the core barrel is full, the drill rods or overshot assembly are pulled and the core retrieved. Samples are packaged and shipped for testing (see Practices D 5079).

5. Significance and Use

5.1 Rock cores are samples of record of the existing subsurface conditions at given borehole locations. The samples are expected to yield significant indications about the geological, physical, and engineering nature of the subsurface for use in the design and construction of an engineered structure. The core samples need to be preserved using specific procedures for a stipulated time (Practices D 5079). The period of storage depends upon the nature and significance of the engineered structure.

5.2 Rock cores always need to be handled such that their properties are not altered in any way due to mechanical damage or changes in ambient conditions of moisture and temperature or other environmental factors.

⁴ Available from American Petroleum Institute, 2101 L St. NW, Washington, DC

⁵ Available from NSF International, P.O. Box 130140, Ann Arbor, MI 48113-0140.

6. Apparatus

6.1 *General*—Fig. 1 shows the schematic of a typical rock core drill setup (2). Essential components of the drilling rig with rotary power, hoisting systems, casing, rods, core barrels, including bits and liners, and pumps with circulating system. In addition, equipment should include necessary tools for hoisting and coupling and uncoupling the drill string and other miscellaneous items such as prefabricated mud pits and racks for rod stacking and layout. Normally, a drilling platform of planking is built up around the drilling site.

6.1.1 Rock coring operations can proceed at high rotation rates. It is imperative the drill rig, rods, and core barrels are straight and have a balanced center of gravity to avoid whipping and resulting damage to cores and expensive bits.

6.2 *Drilling Rig*— The drill rig provides the rotary power and downward (or advance) force or hold-back force on the core barrel to core the rock. The preferred diamond drill coring equipments are designs with hydraulic or gear-driven variable speed hollow spindle rotary drill heads, although some core rigs are manufactured with gear or chain pulldown/retract systems. Precise control over bit pressure can best be accomplished by a variable setting hydraulic pulldown/retract system. Hydraulic systems are often equipped with a detent valve, which allows downfeed (or advance) rate to be set at a certain speed regardless of tool weight or down pressure exerted on the

coring bit. Hydraulic feed drill rigs should be supplied with a hydraulic pressure gage that can be related to bit pressures. Deep hole drill rigs should be equipped with hydraulic hold-back control so, if required, the full weight of the drill rods is not exerted on the bit when drilling downward. Diamond drill rigs can apply high rotation rates as high as 1000 rpm as opposed to normal rotary drills operating at 60 to 120 rpm (3). Most diamond core drills are equipped with a mast and powered hoist for hoisting heavy drill strings. A second wireline hoist is helpful for wireline drilling.

6.2.1 The drill machine frame is either skid or truck mounted and should be equipped with a slide base for ease in working around the drill hole. In special cases, the drilling machine may be mounted on a trailer, barge (for overwater drilling), or columns (for underground work). Some drill rigs are designed to be broken down into several pieces for transport into remote areas. The drilling machine may be powered by hydraulics, air, electricity, gas, or diesel. Most surface skid or truck mounted rigs are diesel or gas powered.

6.2.2 Drilling directions are rarely vertical in underground applications, and smaller rigs are frequently equipped with swivel heads to accommodate drilling at angles. Special accommodations must be made for holding and breaking rods when drilling at high angles into crowns of adits. Either top drive drill or column mount machines with hydraulic or pneumatic rod jacks are equipped to handle up holes. For

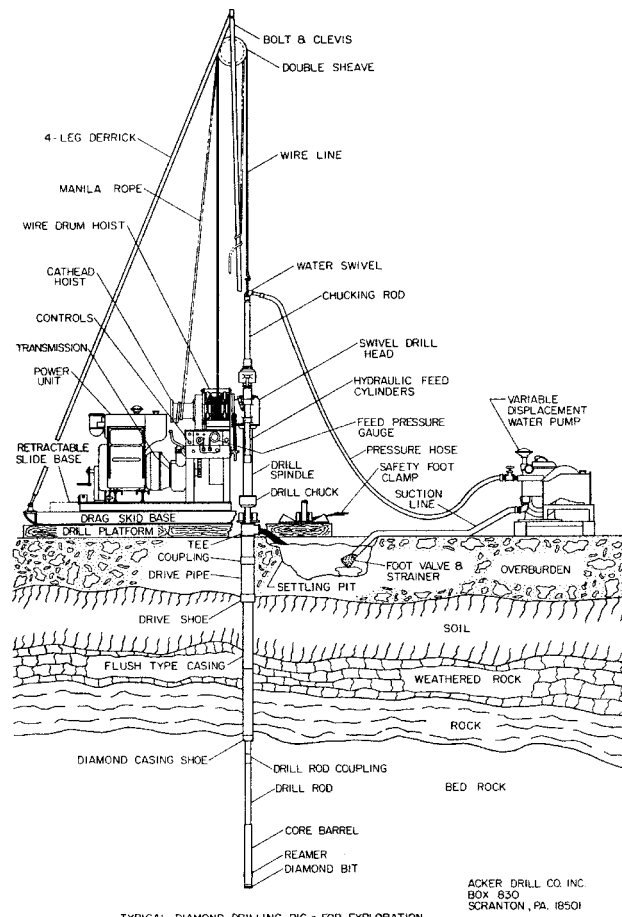


FIG. 1 Schematic of Typical Diamond Core Drill Set-up (2)

confined space drilling operations, drills are column mounted or mounted on small skids. Special power sources may be required for underground work due to air quality considerations. Remote power pack stations usually electric, hydraulic, compressed air, or a combination of the three. Electrically powered hydraulic systems are most common in underground use today

6.3 *Fluid or Air Circulation Systems:*

6.3.1 *Selection of Drill Media*—The two primary methods for circulating drill cuttings are water or water-based fluids or air with or without additives. The predominant method of drilling is water-based fluids. Water-based drilling is effective in a wide range of conditions both above and below the water table. Air drilling is selected when water-sensitive soils such as swelling clays or low density collapsible soils are encountered. Air drilling may also be required above the water table if special testing is required in the unsaturated zone. Air drilling is also convenient in highly fractured igneous rocks and porous formations where water-based fluid losses are unacceptable. The primary functions of the drill fluid are:

- 6.3.1.1 Remove drill cuttings,
- 6.3.1.2 Stabilize the borehole,
- 6.3.1.3 Cool and lubricate the bit,
- 6.3.1.4 Control fluid loss,
- 6.3.1.5 Drop cuttings into a settling pit,
- 6.3.1.6 Facilitate logging of the borehole, and
- 6.3.1.7 Suspend cuttings in the drill hole during coring.

6.3.1.8 No single drill fluid mixture can satisfy all of the above requirements perfectly. In the sections below, considerations for materials that could be used in drilling medium are given.

6.3.2 The pressure hose conducts the drilling fluid or air from the circulation pump or compressor to the swivel.

6.3.3 The swivel directs the drilling fluid or air to a rotating kelly or drill-rod column.

6.3.4 *Rotary Drilling with Water-based Drilling Fluids:*

6.3.4.1 The mud pit is a reservoir for the drilling fluid, and, if properly designed and used, provides sufficient flow velocity reduction to allow separation of drill cuttings from the fluid before recirculation. The mud pit can be a shallow, open metal tank with baffles or an excavated pit with some type of liner, and designed to prevent loss of drilling fluid. 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. It may be necessary to have additional storage tanks for preparing fluids while drilling progresses.

6.3.4.2 The suction line, sometimes equipped with a foot valve or strainer, or both, conducts the drilling fluid from the mud pit to the fluid circulation pump.

6.3.4.3 The fluid circulation pump must be able 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.

6.3.4.4 *Water-based Drilling Fluids*—The four main classes of water-based drilling fluids are: (1) clean, fresh water, (2) water with clay (bentonite) additives, (3) water with polymeric

additives, and (4) water with both clay and polymer additives. For commonly used materials added to water-based fluid, see Section 7 on Materials.

(1) Clean fresh water alone is often not acceptable for core drilling due to poor bit lubrication, erosion due to high velocities required for lifting cuttings, and excessive water loss. In water-sensitive soils, it is desirable to use drill additives to form drill hole wall cakes and prevent moisture penetration. In some cases, water may be required for piezometer installations where other fluid additives are not acceptable, but often newer synthetic polymer materials are acceptable for piezometer and well installations.

(2) Bentonitic drill muds are often used in rotary drilling applications. The bentonite should be added to water with vigorous mixing and recirculation to ensure uniform properties and to reach a dispersed deflocculated state. For diamond core drilling, low viscosity is usually required due to small clearances. The viscosity of a fluid-mud mixture is related to the solids content and particle shapes and alignments of the additives. During the high speed rotary drilling process, solids have a tendency to spin out and collect inside drill rods. For diamond drilling, low solids content is desirable. If mass is required to balance high hydrostatic pressures, additives such as barite or ilmenite (see 7.1.8) can be added to keep solids contents low.

(3) The need for low solids contents and good lubrication properties point to the use of polymer drill fluids. Natural or synthetic polymer fluids are the best additives for diamond core drilling. Polymer chains such as those from guar gum exhibit flow thinning characteristics in high velocity and shear conditions. Polymer fluids can be weighted with salts to balance hydrostatic pressures. Detergents or deflocculating agents can be added to discharge lines to assist in dropping cuttings to maintain fluid properties.

(4) Fluid management requires considerable experience for successful drilling and sampling. Important fluid parameters include viscosity and density, and these parameters can be tested to improve fluid properties. Test Method D 4380 and American Petroleum Institute (API) test procedures are available for testing drill fluids. Fluid design can be improved by consultation with manufacturers, suppliers, and by review of literature (2-8). Because of a large number of suppliers, varying grades of drill fluid products, and varying requirements of each project, providing an exact procedure for design and mixing of drill fluids, is impossible.

6.3.5 *Rotary Drilling Using Air As the Circulation Medium:*

6.3.5.1 The air compressor should provide an adequate volume of air, without significant contamination, for removal of cuttings. Air requirements depend upon the drill rod and bit type, character of the material penetrated, depth of drilling below ground water level, and total depth of drilling. Airflow rate requirements are usually based on an annulus upflow (or outflow) air velocity of about 3000 to 4000 ft/min (1000 to 1300 m/min) although air upflow (or outflow) rates of less than 3000 ft/min (1000 m/min) are often adequate for cuttings transport. Special reaming shells may be required to maintain air circulation between the annulus of the hole wall and large diameter drill rods (9). For some geologic conditions, air-blast

erosion may increase the borehole diameter in easily eroded materials such that the 1000 m/min (3000 ft/min) circulation rate may not be appropriate for cuttings transport.

6.3.5.2 Compressed air alone often can transport cuttings from the borehole and cool the bit. Pure air alone does not work well in very moist soils. In moist, clayey matrices, mud rings and bit balling may occur. For some geologic conditions, water injected into the air stream will help control dust or break down “mud rings” that can form on the drill rods. If water is injected, the depth(s) of water injection should be documented. In these cases, adding water and a foaming agent to make a misting mixture is desirable (3). Under other circumstances, for example if the borehole starts to produce water, injection of a foaming agent may be required. The depth at which a foaming agent is added should also be recorded. If water infiltration into the borehole impedes circulation, the use of stiffer foams or slurries may be needed (3). Air drilling may not be satisfactory in unconsolidated or cohesionless soils under the ground water table, and fluid drilling systems may be required.

6.3.5.3 The dust collector conducts air and cuttings from the borehole annulus past the drill rod column to an air cleaning device (cyclone separator).

6.3.5.4 The air cleaning device (cyclone separator) separates cuttings from the air returning from the borehole via the dust collector. A properly sized cyclone separator can remove practically all of the cuttings from the return air. A small quantity of fine particles is usually discharged to the atmosphere with the “cleaned” air. Some air cleaning devices consist of a cyclone separator alone and others use a cyclone separator combined with a power blower and sample collection filters. When foaming agents are used, a cyclone-type cuttings separator is not used and foam discharge is accumulated near the top of the borehole.

6.4 *Hole Diameters*— Selection of hole diameter and core size is the most important consideration when planning a coring program. Most rock coring operations are performed with casings and core barrels whose sizes have been standardized by the Diamond Core Drill Manufacturers Association (DCDMA) (5,10). Table 1 provides a summary of nomenclature used for drill hole sizing. For each size of hole, there is a family of casings, core barrels, bits, casing bits, and drill rods with the same primary letter symbol (A through Z) whose design is compatible. Furthermore, the size steps are such that the next smaller size letter equipment can be used inside the next larger group. This nesting of casings, barrels, and rods allows for tapering or telescoping of a drill hole through difficult formations. Since the core barrel must pass through the casings selected, anticipating the necessity for telescoping the hole is important so a large enough diameter is selected at the start.

NOTE 2—Inclusion of the following tables and use of letter symbols in the foregoing text is not intended to limit the practice to use of DCDMA tools. The table and the text references are included as a convenience to the user since the majority of tools in use do meet the DCDMA dimensional standards. Similar equipment of approximately equal size on the metric standard system is acceptable unless otherwise stipulated by the engineer or geologist.

6.4.1 Core diameter, barrel design, bit design, and drilling method have a direct influence on sample quality. Usually

when drilling in delicate formations, larger diameter samples provide higher quality samples. Often, obtaining samples of the weaker seams or joints in the rock is critical to design. A larger diameter core barrel can often reduce shearing stresses imparted to a seam or joint in the core and thus reduce mechanical breakage. For core operations related to most surface drilling project investigations, the minimum core size would correspond to “N” sized borings.

6.4.2 In concrete coring operations, the primary consideration for selecting a core diameter is the maximum size aggregate. For interface shear strength determinations on lift lines, the core diameter should be 2½ to 3 times the maximum size aggregate (11).

6.4.3 In underground hard rock drilling, smaller cores may be used for ease of operation.

6.5 *Casing*—For most coring operations, setting casings in overburden materials will be necessary, especially near the surface to control drill fluid circulation. Typically, water-sensitive soils and loose overburden soils are protected by casings that are set in competent bedrock or to firm seating at an elevation below the water-sensitive formation. The casing used should allow for unobstructed passage of the largest core barrel to be used, and should be free of upsets in inside diameter. A listing of DCDMA casing sizes is shown in Table 1. For rock coring operations, the flush inside diameter “W” series casing is used to allow for use of the matching core barrel. In some cases, flush coupled drive pipe can be used to support the hole. Drive pipe is available in thickness schedules 40, 80, and 160.

6.5.1 Casing and drill rod selection should be based on uphole (or outflow) velocity of the circulation system selected. Uphole (or outflow) velocity should be sufficient to bring up all drill cuttings.

6.5.2 Casing or temporary drill hole support can be accomplished through several methods. One casing advancement technique is to drill incrementally ahead of the casing and then drive the casing to the previous depth. Driven casings should be equipped with a hardened shoe to protect end threads. The inside diameter of the shoe should be flush with the casing inside diameter to avoid hang-ups of the core barrel. In some cases, water-sensitive zones may require cementing for stabilization. Casing can be equipped with diamond casing shoes that allow the casing to be advanced with rotary drilling. The casing shoe should have the same inside diameter as the casing. Casing “shoes” should not be confused with casing “bits” (10). Casing bits are only acceptable for temporary, rotary installation of casing where coring operations are not required, such as temporary installation of a large diameter telescoped casing. Casing “bits” have an inside diameter that is not large enough to pass a core barrel of the same nominal hole size. Hollow-stem augers may be used as casing through overburden soils. Liners may be used inside large diameter casings or augers to increase fluid circulation velocity and optimize cuttings return. If liners are used, they should not be driven and care should be taken to maintain true hole alignment.

6.6 *Drill Rods*—Drill rod selection should be based on consideration of the uphole (or outflow) velocity of the circulating fluids for the circulation system selected. Uphole

TABLE 1 Diamond Core Drill Manufacturers Association Casing Specifications (10)

NOTE 1—W series casing is known as “flush-coupled casing”. W series casing has flush inside diameter throughout, while X series casing has upset diameter with coupling inside diameter equal to flush wall inside diameter.

DCDMA Casing Design										
Size	Outside Diameter		Inside Diameter W Series		Inside Diameter X Series		Gallons Per 100 ft	Mass Per ft	Threads Per Inch	
	in.	mm	in.	mm	in.	mm			W series	X series
RW, RX	1.44	36.5	1.20	30.5	1.20	302.0	5.7	1.8	5	8
EW, EX	1.81	46.0	1.50	38.1	1.63	41.3	9.2	2.8	4	8
AW, AX	2.25	57.2	1.91	48.1	2.00	50.8	14.8	3.8	4	8
BW, BX	2.88	73.0	2.38	60.3	2.56	65.1	23.9	7.0	4	8
NW, NX	3.50	88.9	3.00	76.2	3.19	81.0	36.7	8.6	4	8
HW, HX	4.50	114.3	4.00	100.0	4.13	104.8	65.3	11.3	4	5
PW, PX	5.50	139.7	5.00	127.0	5.13	130.2		14.0	3	5
SW, SX	6.63	168.3	6.00	152.4	6.25	158.8		16.0	3	5
UW, UX	7.63	193.7	7.00	177.8	7.19	182.6			2	4
ZW, ZX	8.63	219.1	8.00	203.2	8.19	208.0			2	4

velocity should be sufficient to bring up all drill cuttings. Most drilling operations are done with DCDMA drilling rods conforming to the dimensions given in Table 2. Drill rods are normally constructed of tubular steel and have a flush outside wall diameter. Drill rod sections usually have threaded female connections machined in each end. The rods are connected by either removable or welded pins (in one end) strengthened by addition of material at the inside walls. Some drill rod pins are constructed of high strength steel because the joints are a weak link and are subject to failure. Some larger rods are composed of composite materials to reduce weight. Nonmagnetic rods are available for drill holes requiring use of magnetic surveying equipment.

6.6.1 Tables 3 and 4 lists dimensions of wireline and API drill rods that also can be used. Wireline drill rod dimensions are not standardized and are specific to individual manufacturers. The API internal flush joint rods have upset walls on the outside joint and should not be used in air drilling, as air erosion of the formation could occur at the joints.

6.7 *Conventional Core Barrels*—Many types of core barrels are available. A conventional core barrel is attached to the

drilling rods (see 6.6) and the complete set of connected rods and barrel must be removed from the hole at the end of each core run. Torque is applied to the drill rods while the circulating fluid is pumped through the center of the drill rods to the bit. Fluid returns along the annulus between the borehole wall and barrel and drill rods. Conventional barrels are used in smaller drilling operations, such as short underground holes, or when intermittent sampling is to be performed. Most continuous high production coring today is performed with wireline equipment.

6.7.1 Several series of conventional core barrels have standardized dimensions set by the DCDMA (10) in North America. Other organizations such as the British Standards Institute have adopted DCDMA size conventions, while others have different standard dimensions such as metric or Swedish (Craelius) (4). The DCDMA WG, WM, WT series of barrels have standard dimensions as shown in Table 5. Most manufacturers make core barrels fitting the dimensional requirements of one of these series, but there may be variation of other design features such as inner liners, bearings, fluid routing, or

TABLE 2 Diamond Core Drill Manufacturers Association Drill Rod Specifications (10)

Drill Rods, W Series Drill Rod										
Rod Type	Outside Diameter		Inside Diameter		Coupling Identification		Mass Per Foot, lbm	Threads Per Inch	Thread Type	
	in.	mm	in.	mm	in.	mm				
RW	1.094	27.8	0.719	18.3	0.406	10.3	1.4	4	Regular	
EW	1.375	34.9	0.938	22.2	0.437	12.7	2.7	3	Regular	
AW	1.750	44.4	1.250	31.0	0.625	15.9	4.2	3	Regular	
BW	2.125	54.0	1.500	44.5	0.750	19.0	6.1	3	Regular	
NW	2.625	66.7	2.000	57.4	1.38	34.9	7.8	3	Regular	
HW	3.500	88.9	3.062	77.8	2.375	60.3	9.5	3	Regular	
WJ Series Drill Rod										
AWJ	1.75	44.5	1.43	36.4	0.63	16.1	3.6	5	Taper	
BWJ	2.13	54.0	1.81	46.0	0.75	19.3	5.0	5	Taper	
NWJ	2.63	66.7	2.25	57.0	1.13	28.8	6.0	4	Taper	
KWJ	2.88	73.0	2.44	61.9	1.38	34.9	...	4	Taper	
HWJ	3.50	88.9	2.88	73.1	1.75	44.5	...	4	Taper	
Old Standard										
E	1.313	33.3	0.844	21.4	0.438	11.1	...	3	Regular	
A	1.625	41.3	1.266	28.6	0.563	14.3	...	3	Regular	
B	1.906	48.4	1.406	35.7	0.625	15.9	...	5	Regular	
N	2.375	60.3	2.000	50.8	1.000	25.4	...	4	Regular	

TABLE 3 Wireline Drill Rod Dimensions

Rod Type	Wireline Drill Rods							
	Outside Diameter		Inside Diameter		Gallons Per 100 ft	Weight Per lbm	Threads Per Inch	Thread Type
	in.	mm	in.	mm				
AQWL ^A	1.750	44.5	1.375	34.9	7.7	3.3	4	Taper
AXWL ^B	1.813	46.0	1.500	38.1	9.18	2.8	4	Regular
BQWL ^A	2.188	55.6	1.812	46.0	13.4	4.0	3	Taper
BXWL ^B	2.250	57.2	1.906	48.4	14.82	3.8	4	Regular
NQWL ^A	2.750	69.9	2.375	60.3	23.0	5.2	3	Taper
NXWL ^B	2.875	73.0	2.391	60.7	23.30	6.8	3	Regular
HQWL ^A	3.500	88.9	3.062	77.8	38.2	7.7	3	Taper
HXWL ^B	3.500	88.9	3.000	76.2	36.72	8.7	3	Regular
PQWL ^A	4.625	117.5	4.062	103.2
CPWL ^B	4.625	117.5	4.000	101.6

^AQ Series rods are specific manufacturer's design.

^BX Series rods are specific manufacturer's design.

TABLE 4 American Petroleum Institute Drill Rod Dimensions (12)

API Tool Joints—Regular External Flush (in.-lb System)				
Type/size	Rod o.d. (in.)	Rod o.d. (mm)	Rod i.d. (in.)	Rod i.d. (mm)
API 2-3/8	3.125	79.4	1	25.4
API 2-7/8	3.75	95.3	1.25	31.8
API 3-1/2	4.25	108.0	1.5	38.1
API 4	5.25	133.4	1.75	44.5
API 4-1/2	5.75	146.1	2.25	57.2
API 5 1/2	6.75	171.5	2.75	69.9
API 6 5/8	7.75	196.9	3.5	88.9
API 7 5/8	8.88	225.6	4.0	101.6
API 8 5/8	10.0	254	4.75	120.7
API Tool Joints—Regular Internal Flush				
Type/size	Rod o.d. (in.)	Rod o.d. (mm)	Rod i.d. (in.)	Rod i.d. (mm)
API 2-3/8	3.375	85.7	1.75	44.5
API 2-7/8	4.125	104.8	2.125	54.0
API 3-1/2	4.75	120.7	2.687	68.3
API 4	5.75	146.1	3.25	82.6
API 4-1/2	6.125	155.6	3.75	95.3

core extrusion methods. Some manufacturers make core barrels that do not fit dimensional DCDMA standards for core diameters. An example is the “D₃ and D₄” series core barrels shown in Table 5. Use of other nonstandardized core barrels is acceptable if the type of barrel is appropriate for the drilling conditions and the type of barrel used is reported.

6.7.2 For most investigations and when rock types are unknown, it is desirable to specify a swivel type, double tube core barrel with a split inner barrel, or solid inner barrel with split liners (also know as “triple tube”). The barrel should be equivalent to, or better than, “M” series design to reduce fluid exposure. If the formation is poorly lithified, and contains soil-like layers such as shales with interbedded clay seams, a large diameter core barrel may be specified to aid in recovery. These desired components are discussed below.

6.7.3 Core barrels generally come in 5- or 10-ft core run lengths. Ten-foot core runs can be performed with good rock conditions. If soft, friable, or highly fractured formations are encountered, it may be necessary to select barrels with 5-ft core runs to reduce the possibility of blockages and improve core recovery.

6.7.4 Important design components of a conventional core barrel are tube type (triple, double, or single), inner tube rotation (rigid or swivel), core bit type, including fluid discharge locations (internal discharge - contacting core, or face

TABLE 5 Approximated Core and Hole Diameters for Core Barrels

^A Core barrel type/group	Set bit dimension inside diameter = core diameter		Set reaming shell = hole diameter	
	in.	mm	in.	mm
Conventional Core Barrels ^B				
RWT (d)	0.735	18.7	1.175	29.8
EWD ₃	0.835	21.2	1.485	37.7
EWG (s.d.), EWM (d)	0.845	21.5	1.485	37.7
EWT (d)	0.905	23.0	1.485	37.7
AWD ₃ , AWD ₄	1.136	28.9	1.890	48.0
AWG (s.d.), AWM (d)	1.185	30.1	1.890	48.0
AWT (d)	1.281	32.5	1.890	48.0
BWD ₃ , BWD ₄	1.615	41.0	2.360	59.9
BWG (s.d.), BWM (d)	1.655	42.0	2.360	59.9
BWT (s.d.)	1.750	44.4	2.360	59.9
NWD ₃ , NWD ₄	2.060	52.3	2.980	75.7
NWG (s.d.), NWM (d)	2.155	54.7	2.980	75.7
NWT (s.d.)	2.313	58.8	2.980	75.7
HWD ₃ , HWD ₄	2.400	61.1	3.650	92.7
HWG (s.d.)	3.000	76.2	3.907	99.2
HWT (s.d.)	3.187	80.9	3.907	99.2
DCDMA Large Diameter—Double-Tube Swivel—Core Barrels				
2 3/4 × 3 7/8	2.690	68.3	3.875	98.4
4 × 5 1/2	3.970	100.8	5.495	139.3
6 × 7 3/4	5.970	151.6	7.750	196.8
Wireline Core Barrel Systems ^C				
AXWL (joy)	1.016	25.8	1.859	47.2
AQWL	1.065	27.1	1.890	48.0
BXWL	1.437	36.5	2.375	60.3
BQWL	1.432	36.4	2.360	60.0
BQ ₃ WL	1.313	33.4	2.360	60.0
NXWL	2.000	50.8	2.984	75.8
NQWL	1.875	47.6	2.980	75.7
NQ ₃ WL	1.75	44.4	2.980	75.7
HXWL	2.400	61.0	3.650	92.7
HQWL	2.500	63.5	3.790	96.3
HQ ₃ WL	2.375	60.3	3.790	96.3
CPWL	3.345	85.0	4.827	122.6
PQWL	3.345	85.0	4.827	122.6
PQ ₃ WL	3.25	82.6	4.827	122.6

^As = single tube; d = double tube.

^BConventional double-tube core barrels are available in either rigid or swivel designs. The swivel design inner barrel is preferred for sampling because it aids in preventing core rotation. In general, smallest core for given hole size results in best recovery in difficult conditions, that is, triple-tube core barrels. Use of double-tube-swivel type barrels with split liners is recommended in geotechnical investigations for best recovery and least sample damage.

^CWireline dimensions and designations may vary according to manufacturer.

discharge and waterway design), core lifter, and reaming shell.

6.7.5 Single Tube Core Barrel—The single tube core barrel

is the simplest in design (see Fig. 2). The core is subjected to drill fluid circulation over its entire length. Once the core in the barrel is broken from parent material, it will rotate with the assembly. These effects break up all but the most competent core (4, 12). Because of fluid exposure and rotational effects, this barrel should not be used to sample weak, friable, and water-sensitive materials. Additional disadvantages of this core barrel include: poor diamond performance of the cutting bit in fractured or friable formations, frequent core blocking, and severe diamond erosion due to re-drilling of broken fragments. This system is only suitable for sampling massive, hard,

competent, homogeneous rock or concrete. Due to these disadvantages, this core barrel type is not recommended for routine investigations.

6.7.5.1 In shallow applications, generally less than 5 ft (2 m) competent concrete or soil cement is cored with single tube masonry core barrels with portable drill rigs (11). If there is evidence of excessive core erosion, breakage, or blocking, use of double tube swivel type barrels should be considered.

6.7.6 *Double Tube Core Barrel*—Double tube core barrels contain an inner barrel that protects the core from contact with drill fluid and from erosion or washing from the circulating

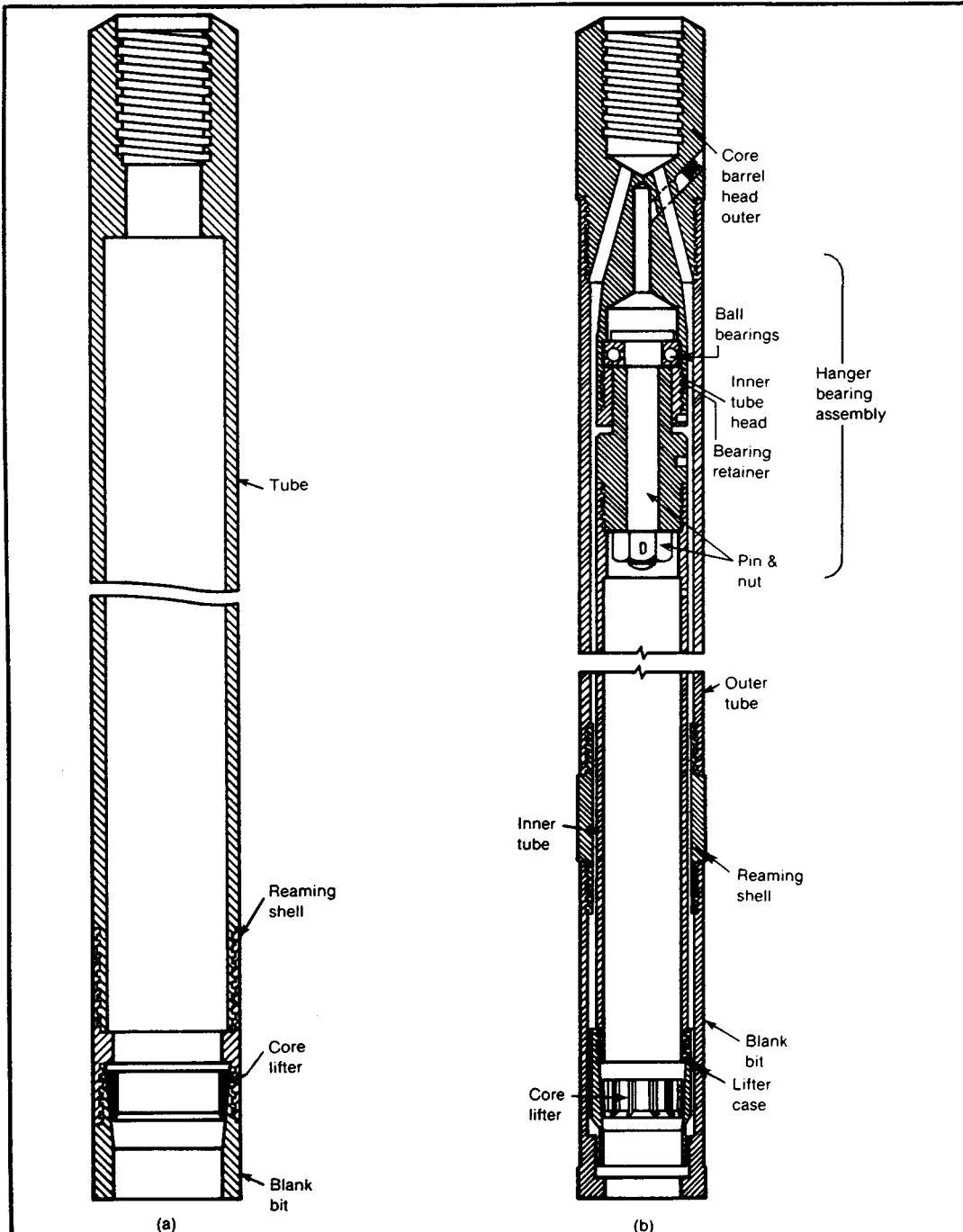


FIG. 2 Diagram of Two Types of Core Barrels: (a) Single Tube and (b) Double Tube

fluid. The bottom of the core may be subjected to fluid exposure depending on the locations of fluid discharge. Some barrel designs have fluid discharge near the lifter, near the bit, or on the bit face (see 6.7.7). The advantage of double tube design is greater protection of the core. Washing erosion is reduced and weaker zones can be recovered.

6.7.6.1 The inner barrel of double tube core barrels may be either solid or split. The barrel may be designed to accept split liners. Barrels accepting liners require a special inside diameter bit gage. Use of a split barrel or inner liners is preferred for easier handling of cores. Sections of the cores containing weak seams are more likely to remain intact. The cores may be rolled onto PVC half rounds. The use of split liners or PVC half rounds aids in placement of core in core boxes and handling of cores that require sealing for moisture preservation. In certain materials, such as expansive shales or blocked high fractured materials, the split liner may spring apart even though it is taped before sampling. In these cases, removing the inner barrel may be difficult. Remedies include use of a shorter core barrel, triple tube design with extruder (see 6.7.7.1), or the solid liner.

6.7.6.2 Double tube core barrels come in two designs, either rigid or swivel type.

(1) *Rigid Double Tube Barrel*—This barrel is rarely used in practice today due to limitations listed below. In the rigid barrel design, the inner barrel is fixed and it spins at the same rate as the outer barrel. Rigid tube barrels have fewer working parts, but suffer from similar disadvantages as single tube barrels. Core recovery is poor and diamond wear in friable and fractured formations is excessive. In softer deposits, there will be rotation of broken core, core blockage, and resulting crushing and grinding, which causes excessive bit wear. This type of design is not preferred for routine investigations where rock conditions are not known, as the equipment is only acceptable in hard competent formations.

(2) *Swivel Type Double Tube Barrels*—In the swivel type barrel (Fig. 3 and Fig. 4 show typical barrels) the inner barrel is connected to the drill string through a bearing that allows the inner barrel to remain stationary during coring. The core is completely protected once it enters the liner. This design reduces rock crushing and grinding and resulting blockages. Depending on the fluid discharge point, the core may be exposed to fluids near the bottom of the barrel and there could be erosion of soft or fractured formations.

(3) Double tube swivel type core barrels are the best selection for drilling rock of varying hardness and fracture. This type of barrel is typically the minimum requirement when drilling investigations are for engineering structures where varying conditions would be encountered.

6.7.7 *Triple Tube Core Barrels*—The triple tube barrel is essentially a double tube barrel with a liner inside the inner tube. The inner liner is made from either split metal half rounds or tubular acrylic. The use of split liners increases efficiency in handling and logging. If the purpose of the investigation is solely for logging of cores, the use of solid acrylic liners may be acceptable.

6.7.7.1 Many manufacturers offer the triple tube option and barrels are available that also have hydraulic core extrusion

systems. These systems help with removing the inner liners by use of a piston in the top of the inner barrel. This feature is especially helpful if split liners are bowed apart by lateral expansion of the core. The extrusion systems allow for simple loading and unloading of liners.

6.7.8 *Conventional Barrel Standardized Designs*—DCDMA standardized barrels come in three designs, WG, WM, and WT series.

6.7.8.1 The “G” series barrels are the most simple in design and have a simple pin threaded bit into which the core lifter is inserted. Due to the simplicity of design, these barrels are the most rugged, with fewer parts and less maintenance. The only disadvantage is that the fluid exits above the lifter and the bottom of the core is exposed to fluids during drilling.

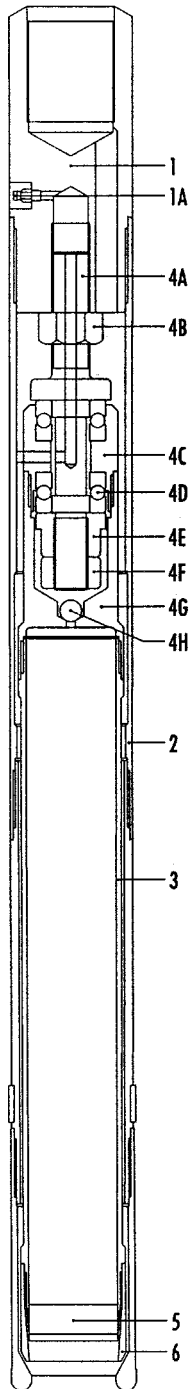
6.7.8.2 The “M” design core barrel is the best available tool for recovering of rock cores even in the most friable and caving stratum. The inner barrel is equipped with a lifter case that extends into the bit shank and therefore reduces exposure of the core to fluid during drilling. The fluid only contacts the core near the crown of the bit, and washing or eroding of the core is minimized. Face discharge bits are also available for almost no core exposure to fluids. The DCDMA “M” designs have been modified by individual manufacturers. Barrels such as the D₄ type barrels are equivalent to “M” design barrels.

6.7.8.3 The “T” series design stands for thin walled or thin kerf. This design provides larger core-to-hole size ratio. This barrel style has a thin kerf and requires fewer diamonds and less torque for drilling. It gives good performance in hard, dense, and friable shattered rock formations (4). This type of core barrel is thin and lightweight and must be handled with care.

6.7.9 *Large Diameter, Double Tube, Swivel Design*—The large diameter conventional core barrel is similar in design to the double tube, swivel type, “WM” design, but with the addition of a ball valve in all the three sizes to control fluid flow. A sludge barrel to catch heavy cuttings is also incorporated on the two larger sizes (Fig. 5). The three sizes standardized by DCDMA are 2¾-in. (69.8 mm) by 3⅞-in. (98.4 mm), 4-in. (101.6 mm) by 5½-in. (139.7 mm), and 6-in. (152.4 mm) by 7¾-in. (196.8 mm). Other sizes such as 4⅝-in. (117.5 mm) by 3-in. (76.2 mm), 5¼-in. (146 mm) by 4-in. (101.6 mm), and 8-in. (203.2 mm) by 5⅞-in. (149.2 mm) have been designed by individual manufacturers. The larger barrels with increased annulus are suitable for larger rotary rig mud pumps and air compressors. Options include either conventional or face discharge bits with either conventional core lifter or spring finger basket retainers. Some core barrel systems can be converted to soil coring operations, but require carbide bit and a projecting cutting shoe. Some large diameter barrels are convertible from conventional to wireline coring operation.

6.8 *Wireline Core Barrels*—Wireline drilling for investigation in rock is a principal drilling system used for deep rock coring applications using surface mounted drill rigs (Fig. 6 and Fig. 7). In the wireline system, the drill rods are only removed from the hole to replace the coring bit, to free a stuck inner barrel, or to adjust the headspace of the inner barrel. The inner core barrel can be removed and replaced without removing the drill rods, allowing for continuous coring. The drill rods

NWD4-SERIES D4 CORE BARREL



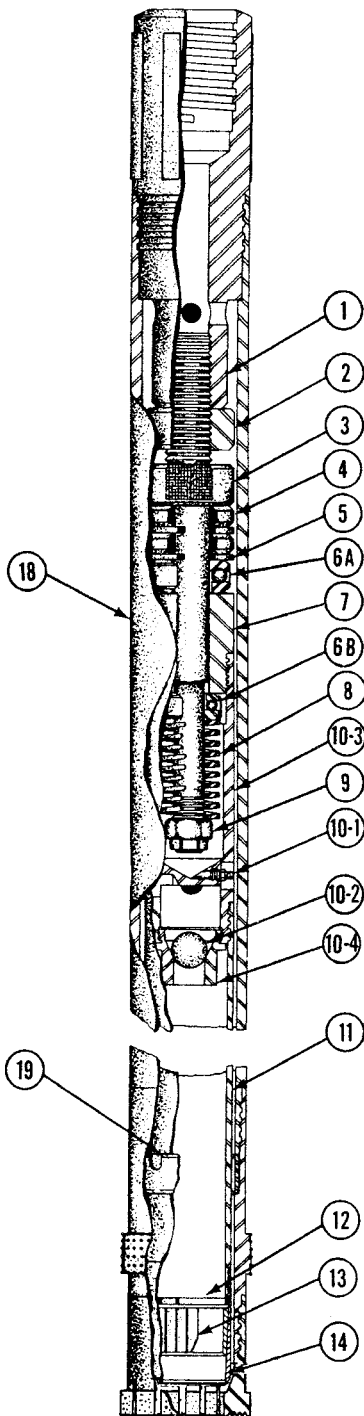
NWD4 SERIES D4 CORE BARREL					
HOLE SIZE	CORE SIZE	OUTER TUBE O.D.	OUTER TUBE I.D.	INNER TUBE O.D.	INNER TUBE I.D.
2.980 in	2.060 in	2.906 in	2.562 in	2.375 in	2.135 in
75.7 mm	51.3 mm	73.8 mm	65.1 mm	60.3 mm	54.2 mm
NWD4 SERIES D4 CORE BARREL ASSEMBLIES					
PART DESCRIPTION					
Core Barrel Assembly - 5 ft (1.5 m)					
Core Barrel Assembly - 10 ft (3.0 m)					
Core Barrel Assembly - 5 ft (1.5 m) Split					
Core Barrel Assembly - 10 ft (3.0 m) Split					
SPARE PARTS FOR NWD4 SERIES D4 CORE BARREL					
1. Core Barrel Head, NW Rod					
A. Grease Fitting					
2. Outer Tube, 5 ft (1.5 m), C.P. Ends					
Outer Tube, 10 ft (3.0 m), C.P. Ends					
3. Inner Tube, 5 ft (1.5 m), C.P. ID					
Inner Tube, 10 ft (3.0 m), C.P. ID					
Inner Tube, Split, 5 ft (1.5 m) C.P. ID					
Inner Tube, Split, 10 ft (3.0 m) C.P. ID					
4. Bearing Assembly					
A. Bearing Shaft					
B. Lock Nut					
C. Bearing Retainer					
D. Bearing, Thrust Ball (2 Required)					
E. Hex Nut, Flanged					
F. Hex Nut, Regular					
G. Inner Tube Connector					
H. Ball					
5. Core Lifter, Skirtless					
6. Inner Tube Shoe/Case, C.P. ID					
7. Thread Protector Sub					

FIG. 3 Typical Double Tube Swivel Type-Conventional Core Barrel

also act as a casing, and fluid is circulated from the bit through the annulus between the drill hole wall and drill rod. Wireline drill rod dimensions are not standardized. Table 3 lists the typical wireline rod sizes and Table 5 lists core barrel sizes of predominant types of wireline equipment available. Other systems such as heavy duty systems with differing dimensions may be available and are acceptable for use if dimensions are reported.

6.8.1 The inner barrel assembly is locked into the lead section of wireline drill rod by means of a retrievable overshot latching mechanism. A latching device locks into a complementary recess in the wall of the leading outer tube such that the outer tube could be rotated without causing the rotation of the inner tube. After the core run, the overshot mechanism is lowered through the rods and latches onto a spearhead on the top of the core barrel assembly and is hoisted to the surface

NV2" Core Barrel



Item No.	Description	No. Req'd	Unit Weight	
			lbs	kg
1-20	Core Barrel Assy 5 ft	—	76.0	34,5
1-20	Core Barrel Assy 10 ft	—	126.0	57,2
-	Core Barrel Assy 15 ft **	—	178.0	80,8
1-10	Head Assy	—	19.0	8,6
1	Outer Tube Head	1	8.7	3,9
2	Lock Nut	1	*	*
3	Spindle	1	3.1	1,4
4	Shut Off Valve	2	*	*
5	Valve Adjusting Washer	2	*	*
6A	Ball Thrust Bearing	1	*	*
6B	Hanger Bearing	1	*	*
7	Spindle Bearing	1	1.6	0,7
8	Compression Spring	1	*	*
9	Self Locking Nut	1	*	*
10	Inner Tube Cap Assy	—	3.6	1,6
10-1	Hydraulic Grease Fitting	1	*	*
10-2	Stainless Steel Ball	1	*	*
10-3	Inner Tube Cap	1	3.2	1,5
10-4	Check Valve Body	1	*	*
11	Inner Tube, 5 ft	1	12.3	5,6
11	Inner Tube, 10 ft	1	24.5	11,1
11	Inner Tube, 15 ft	1	38.0	17,2
12	Stop Ring	1	*	*
13	Fluted Core Lifter	1	*	*
14	Core Lifter Case	1	*	*
18	Outer Tube, 5 ft	1	44.0	20,0
18	Outer Tube, 10 ft	1	77.6	35,2
19	Inner Tube Stabilizer	1	*	*
20	Thread Protector (not shown)	1	2.5	1,1

Weights less than one pound (0.45 kg)

The Core Barrel Assembly 15 foot, consists of one Head Assembly, one each inner Tube 15 foot, Stop Ring, Core Lifter, Core Lifter Case, Outer Tube 5 foot, Outer Tube 10 foot, Thread Protector and two Inner Tube Stabilizers.

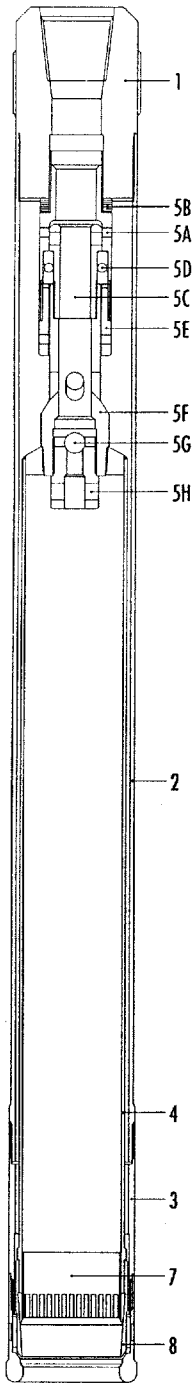
FIG. 4 Typical Double Tube Swivel Type-Core Barrel

with cable and wireline winch. The inner tube assembly consists of an inner tube with removable core lifter case and core lifter at one end, and a removable inner tube head swivel bearing, suspension adjustment, and a latching device with a release mechanism at the opposite end. If continuous coring is

not required, the retrievable inner core barrel assembly can be replaced with a pilot bit for hole advancement.

6.8.2 Wireline coring systems are designed for long life bits with wide kerf and impregnated or surface set diamonds. Both internal discharge and face discharge bits are available. The

7-3/4 in X 5-7/8 in CORE BARREL



7-3/4 in X 5-7/8 in CORE BARREL					
HOLE SIZE	CORE SIZE	OUTER TUBE O.D.	OUTER TUBE I.D.	INNER TUBE O.D.	INNER TUBE I.D.
8.000 in	5.875 in	7.500 in	7.000 in	6.500 in	6.125 in
203.2 mm	149.2 mm	190.5 mm	177.8 mm	165.1 mm	155.6 mm
7-3/4 in X 5-7/8 in CORE BARREL ASSEMBLIES					
PART DESCRIPTION					
Core Barrel Assembly - 5 ft (1.5 m)					
Core Barrel Assembly - 10 ft (3.0 m)					
Core Barrel Assembly - 5 ft (1.5 m) Split					
Core Barrel Assembly - 10 ft (3.0 m) Split					
SPARE PARTS FOR 7-3/4 in X 5-7/8 in CORE BARREL					
1. Core Barrel Head (4-1/2" A.P.I. Reg.)					
2. Outer Tube, 5 ft (1.5 m)					
Outer Tube 10 ft (3.0 m)					
3. Outer Tube Sub					
4. Inner Tube 5 ft (1.5 m), CP, ID					
Inner Tube 10 ft (3.0 m), CP, ID					
Inner Tube 5 ft (1.5 m) Split					
Inner Tube 10 ft (3.0 m) Split					
5. Bearing Assembly					
A. Cartridge Cap					
B. Shim, Set					
C. Bearing Retainer					
D. Bearing, Thrust, Ball					
E. Cartridge Plug					
F. Inner Tube Plug					
G. Ball					
H. Pressure Relief Plug					
6. Inner Tube Connector, Split					
7. Core Lifter, HF					
8. Inner Tube Shoe, BW					
9. Thread Protector Sub					
10. Tube Clamp, 7-1/2 in (190.5 mm) (outer)					
OPTIONAL EQUIPMENT					
11. Core Lifter, Skirtless, HF					

Note: If you do not see the item or size you are looking for, please contact you for additional product information.

FIG. 5 Typical Large Diameter Series —Conventional Core Barrel

inner core barrel has a dual shut-off valve that stops fluid circulation to alert the driller of a core blockage.

6.8.3 The advantages of wireline drilling are:

6.8.3.1 Significant reduction in rod handling time compared with conventional core barrels.

6.8.3.2 Increased coring bit life with decreased diamond loss.

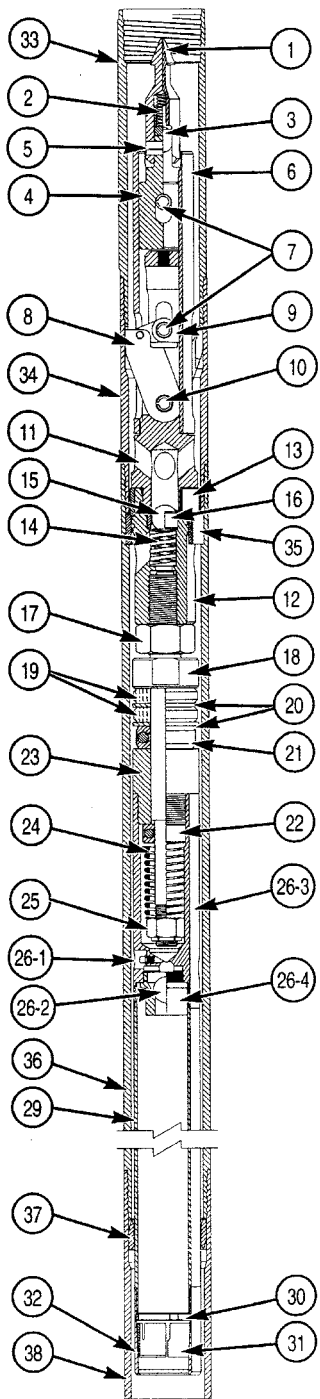
6.8.3.3 High core recovery.

6.8.3.4 Caving is reduced and rods aid to stabilize the drill hole walls.

6.8.3.5 Rods are flush or near flush both inside and outside and can be used as a temporary casing.

6.8.3.6 Various in-hole instrumentation packages can be sent through the end of the drill string to test the bottom of the hole. Wireline packer systems can be used for pressure water test (Test Method D 4630).

NQ Core Barrel



Item No.	Description	No. Req'd	Unit Weight	
			lbs	kg
1-38	Core Barrel Assy 5 ft	—	-	-
1-38	Core Barrel Assy 10 ft	—	-	-
1-32	Inner Tube Assy 5 ft	—	-	-
1-32	Inner Tube Assy 10 ft	—	-	-
1-28	Head Assy	—	-	-
1	Spearhead Point	1	*	*
2	Compression Spring	1	*	*
3	Detent Plunger	1	*	*
4	Spearhead Base	1	1.3	0,6
5	Spirol Pin, 7/16" x 1"	1	*	*
6	Retracting Case	1	-	-
7	Spring Pin, 1/2" x 2"	2	*	*
8	Latch	2	*	*
9	Link	2	*	*
10	Spring Pin, 1/2" x 1-1/2"	1	*	*
11	Upper Latch Body	1	2.9	1,3
12	Lower Latch Body	1	3.1	1,4
13	Landing Shoulder	1	-	-
14	Dry Hole Spring, Light (not installed)			
15	Stainless Steel Ball, 22 mm (not installed)			
16	Bushing (not installed)			
17	Hex Nut	1	*	*
18	Spindle	1	3.1	1,4
19	Shut Off Valve, Hard	2	*	*
20	Valve Adjusting Washer	2	*	*
21	Thrust Bearing	1	*	*
22	Hanger Bearing	1	*	*
23	Spindle Bearing	1	1.6	0,7
24	Compression Spring	1	*	*
25	Self Locking Nut	1	*	*
26	Inner Tube Cap Assy	—	3.3	1,5
26-1	(consists of 26-1, -2, -3, -4)			
26-1	Hydraulic Grease Fitting	1	*	*
26-2	Stainless Steel Ball, 22 mm	1	*	*
26-3	Inner Tube Cap	1	2.9	1,3
26-4	Check Valve Body	1	*	*
27	Landing Indicator Bushing (not installed)			
28	Dry Hole Spring, Medium (not installed)			
29	Inner Tube, 5 ft	1	12.3	5,6
29	Inner Tube, 10 ft	1	24.5	11,1
30	Stop Ring	1	*	*
31	Core Lifter	1	*	*
32	Core Lifter Case	1	1.6	0,7
33	Full-Hole H/T Tanged Locking Coupling**	1	5.9	2,7
34	Adapter Coupling	1	3.2	1,5
35	Landing Ring	1	*	*
36	Outer Tube, 5 ft	1	44.0	20,0
36	Outer Tube, 10 ft	1	77.6	35,2
37	Inner Tube Stabilizer	1	*	*
38	Thread Protector	1	2.5	1,1

Weights less than 1.0 lb (0,45 kg)
 *H/T" means "Heat-Treated"

FIG. 6 Typical Wireline Rock Coring System

6.8.3.7 Two inner barrel assemblies can be used for maximum productivity in continuous coring operations.

6.8.4 The disadvantages of wireline drilling are:

6.8.4.1 Equipment is more expensive than conventional equipment, and

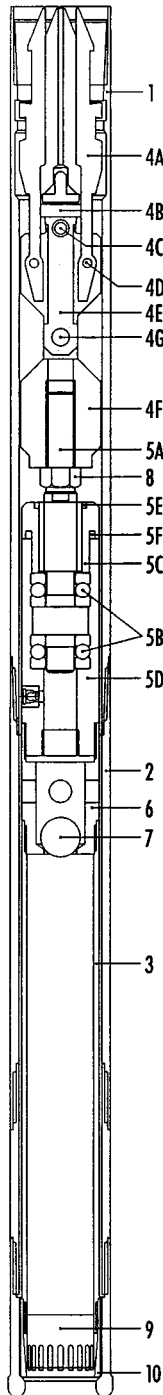
6.8.4.2 Wireline systems are complicated and operations require additional training.

6.8.5 Table 5 lists common wireline core barrel sizes. They are available in "A" through "P" size. When rock samples are

to be obtained for testing of engineering properties, "H" size is recommended, "N" is minimum, and "P" size will result in better recovery of difficult formations.

6.8.6 The wireline core barrel is essentially a double tube swivel type core barrel. Since the core lifter is part of the inner barrel assembly, exposure of the core to drill fluid is minimized similar to "M" style conventional core barrels. Most systems can be adjusted for front discharge (inside above bit gage) or face discharge.

NXB WIRELINE CORE BARREL



NXB WIRELINE CORE BARREL					
HOLE SIZE	CORE SIZE	OUTER TUBE O.D.	OUTER TUBE I.D.	INNER TUBE O.D.	INNER TUBE I.D.
2.980 in	1.875 in	2.875 in	2.391 in	2.200 in	1.969 in
75.7 mm	47.6 mm	73.0 mm	60.7 mm	55.9 mm	50.0 mm
NXB WIRELINE CORE BARREL ASSEMBLIES					
PART DESCRIPTION					
Core Barrel Assembly - 5 ft Complete (1.5 m)					
Core Barrel Assembly - 10 ft Complete (3.0 m)					
Core Barrel Assembly 5 ft (1.5 m) Split					
Core Barrel Assembly 10 ft (3.0 m) Split					
SPARE PARTS FOR NXB WIRELINE CORE BARREL					
1. Locking Coupling					
Locking Coupling, NQ Box Thread					
2. Outer Tube 5 ft (1.5 m)					
Outer Tube 10 ft (3.0 m)					
3. Inner Tube 5 ft (1.5 m)					
Inner Tube 10 ft (3.0 m)					
Inner Tube, Split, 5 ft (1.5 m)					
Inner Tube, Split, 10 ft (3.0 m)					
4. Quad-Latch Pivot Head Assembly					
A. Quad latch (4 required)					
B. Spring - Blue (Top)					
C. Spring - Red (Bottom)					
D. Pin (4 required)					
E. Head Base (Top)					
F. Head Base (Bottom)					
G. Pin					
5. Bearing Assembly					
A. Bearing Shaft					
B. Bearing (2 required)					
C. Bearing Retainer					
D. Housing w/Zerk & cap					
E. O-Ring					
F. O-Ring					
6. Inner Tube Connector					
InnerTube Connection, Split					
7. Ball					
8. Nut					
9. Core Lifter, Skirtless, Buttress					
10. Inner Tube Shoe/Case, CP					

FIG. 7 Typical Wireline Rock Coring System

6.8.7 Most manufacturers offer a triple tube barrel, which is preferred for most operations. The third tube is a split inner liner that facilitates sample handling.

6.8.8 Some wireline barrels systems are convertible from soil sampling to rock sampling operation. These barrels are equipped with soil barrels that can lead in front of the core bit. Some systems are equipped with spring loaded soil core barrels. These systems are advantageous when soils or soft rock are encountered.

6.9 *Core Barrel Bits*— One of the most important equipment decisions in rock core drilling is the bit selection. Both the bit and reaming shell act together to cut the hole. There are many bit design factors involved when selecting the proper bit for good core recovery. Factors included in selection are:

- 6.9.1 Diamond type—source,
- 6.9.2 Diamond matrix (surface set or impregnated),
- 6.9.3 Rock hardness, grain size, and formation,
- 6.9.4 Drill power, and

6.9.5 Barrel type.

6.9.6 Bit selection is a trial and error process that may require several iterations. After a bit is selected, it is tried with the drill to be used. Penetration rate and bit life should be evaluated and a different design selected if necessary.

6.9.7 Important features of diamond drilling bits include crown shape, diamonds, and waterways. The crown is the end of the bit that contains a kerf equipped with cutting media. A round or semi-round kerf is frequently used with conventional core barrels. Flat, stepped, or v-ring designs are often used with wireline drilling with impregnated bits.

6.9.8 Important features of the diamonds themselves are the size, quality, quantity, setting, and matrix quality (4). Surface set bits are used in most conventional coring operations. The size of diamonds is expressed in equivalent stones per carat (SPC). The typical SPC range is from 20 to 100 for surface set bits, with the finer stones being used for harder rock matrixes. Larger diamonds are used for softer, more friable formations. Impregnated bits are fragments mixed with metal and pressed and sintered into the bit. The diamond fragments are throughout the crown and the bit is, in a sense, self-sharpening. Impregnated bits are used in more severe drilling conditions and in wireline drilling where long life is essential.

6.9.9 Waterway design is also an important aspect of bit selection. Surface channel routing of the fluids from inside gage to outside is typical in conventional and wireline drilling for most crystalline rocks that are not sensitive to fluid erosion. Face discharge bits should be used for soft friable formations where fluid erosion is detrimental. Step-face discharge configurations further inhibit core erosion. Special flush discharge air ports are used with air and air-foam drilling operations. The softer the matrix, the larger the waterways must be to avoid blocking and plugging.

6.9.10 For very soft materials, it is not necessary to use diamonds as the cutting media. Diamonds can often be replaced with tungsten carbide or polycrystalline inserts for coring soft materials. Carbide and polycrystalline bits often have cutting teeth arranged in a sawtooth fashion. Polycrystalline bits (diamond grown to tungsten carbide substrates that are soldered or furnace onto the crown) have replaced natural diamonds for coring in some softer sedimentary formations. Some core barrels, such as the large diameter series, can readily be changed from diamond rock coring to carbide soil sampling modes.

6.9.11 Manufacturers are an excellent resource to assist in selecting the matrix and style of bit, depending on rock conditions, drill power, and barrel type. Most manufacturers have a method for rating diamond matrices and bits into different series and groups (3). DCDMA has selection codes for impregnated bits (10). Manufacturers should be consulted for initial recommendations for your specific drilling conditions, and as the project progresses, they can work with the driller to refine designs and drilling technique. Based on wear patterns, it may be possible to switch series or design to optimize results. In hard competent formations, bit selection may be drill rig-dependent (rotation rate and advance forces). It is beyond the scope of this practice to address drill bit selection. In addition to manufacturers' advice, there are

several useful references to provide information in evaluating causes for wear (3, 4, 10).

6.9.12 Most diamond bits have salvage value and should be returned to manufacturers for credit toward future purchases.

6.10 *Reaming Shells*—The reaming shell is a subassembly of a row or strip of material placed on the outside of the core barrel for some distance behind the core bit. It is designed to ream and enlarge the hole to a final diameter and must allow for adequate fluid circulation to the surface. The shell also acts as a collar or centralizer for the barrel. Manufacturers should be consulted for appropriate reaming shell designs for the formations to be drilled. They may be surface set with diamond bits, impregnated with diamond particles, inserted with tungsten carbide strips or slugs, hard faced with various types of hard surfacing materials, or furnished blank, as appropriate to the formation being cored.

6.11 *Core Lifters*—Core lifters are used to break the core from parent material at the end of a core run. As coring progresses, the lifter floats up in its beveled recessed slot in the shoe. After an increment of core has been drilled that corresponds to core barrel length, the rotation is stopped. Fluid is circulated until cuttings are cleared, and then the drill pipe is steadily retracted. The lifter will slide down the beveled shoe and impart an increasing grip on the core. The core frequently breaks near the base of the hole, and often a snap can be felt in the drill pipe as the core breaks from parent material.

6.11.1 Core lifters of the split ring type, either plain or hard surfaced, are recommended and must be maintained in good condition, along with core lifter cases or inner tubes extensions or inner tube shoes. Basket or finger type lifters with any necessary adapters may be used with core barrels if directed by the engineer or the geologist.

6.12 *Core Boxes*—These are durable waxed cardboard or wooden boxes with partitioned compartments for storing the core samples (see Practice D 5079).

6.13 *Auxiliary Equipment*—The following auxiliary equipment is typically used for the rock core drilling project:

6.13.1 *Drilling bits*—roller rock bits, drag bits, chopping bits, boulder busters, and fishtail bits;

6.13.2 *Tools*—pipe wrenches, core barrel wrenches, chain tong, strap wrench, watch, RPM counter, lubrication equipment, core splitters, rod wicking, extruders, hand sieves or strainers, and marking and packaging tools;

6.13.3 *Rod holding equipment*—closed pulling ring, open iron ring, knife edge holding dog, holding iron, chucking rods, safety foot clamp, manila rope, bolt, and clevis pins;

6.13.4 *Fluid circulation equipment*—hoses, positive displacement pump along with packing and seals, water swivel, pressure gages, flow meters, water-level meters, and mud pit; and

6.13.5 *Drill area, platform, and leveling*—cribbing, planking, lumber, saw horses, metal saw horses with chain vise.

7. Reagents and Materials

7.1 *Water-Based Drill Fluid Additives*—Listed below are commonly used additives for water-based drilling fluids. Drilling additives in contact with drinking water aquifers should meet the requirements of NSF 60-1988.

NOTE 3—In some areas, certain types of drill fluid products are not allowed by state and local environmental authorities. Before using any drill fluid product, check with the authorities to determine its acceptability.

7.1.1 Beneficiated bentonite, a primary viscosifier and drill hole sealer, consists of montmorillonite with other naturally occurring minerals and various additives such as guar gum, sodium carbonate, or polyacrylates, or a combination thereof.

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

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

7.1.4 Carboxymethylcellulose powder (CMC) is sometimes used in a water-based fluid as a viscosifier and as an inhibitor to clay hydration. Some additives to water-based drilling-fluid systems retard clay hydration, thus inhibiting swelling of clays on the drill hole wall and “balling” or “smearing” of the bit.

7.1.5 Potassium chloride (muriated potash) or diammonium phosphate can be used as an inhibitor to clay hydration.

7.1.6 Polyacrylamide, a primary viscosifier and clay hydration inhibitor, is a polymer mixed with water to create a drilling fluid.

7.1.7 Guar gum, a primary viscosifier, drill-hole sealer, and hydration inhibitor, is a starch mixed with a water base. The water must be neutral to slightly acidic and hydrochloric acid is sometimes used to pre-treat the water base. Guar gum will degrade with time, but various chemicals can be used to accelerate decomposition.

7.1.8 Barium sulfate increases the density of water-based drilling fluids to help support the borehole wall. It is a naturally occurring high-specific gravity mineral processed to a powder for rotary drilling fluid applications.

7.1.9 Lost-circulation materials are added to the drilling fluid to seal the drill-hole wall when fluids are being lost through large pores, cracks, or joints. These additives usually consist of various coarse textured materials such as shredded paper or plastic, bentonite chips, wood fibers, or mica.

7.1.10 Attapulgite, a primary viscosifier for rotary drilling in high-salinity environments, is a clay mineral drilling-fluid additive.

8. Precautions

8.1 The drilling and sampling equipment shall be complete and in good order. A sufficient amount of drill rods, casings, drill bits, core barrels, core barrel liners, water meters, pumps, and pressure gages shall be in hand before the start of drilling. Measurement devices such as pressure gages and RPM counters shall be functioning in conformance with the manufacturer’s specifications.

8.2 The use of fluid or air under high pressure may cause damage to formation materials by fracturing or excessive erosion if drilling conditions are not carefully maintained and monitored. If formation damage is evident and undesirable,

other drilling method(s) should be considered.

8.2.1 Fluid pressure should be monitored during drilling. Fluid pressure at the bit should be as low as possible to maintain circulation and to reduce possibility of hydraulic fracturing or excessive erosion of surrounding materials. Normally, injection fluid pressures are fully monitored. Changes in fluid return and circulation pressure may indicate occurrence of excessive erosion, formation fluid loss, core blockage, or formation fracturing. Any abrupt changes or anomalies in the fluid pressure should be noted and documented, including the depth(s) of occurrence(s).

9. Procedure

9.1 Perform site inspections to determine locations of boreholes, and to select disposal sites for waste products during drilling.

9.1.1 Evaluate applicable methods for environmental protection and traffic regulation during core drilling.

9.1.2 Determine site accessibility and availability of water for core drilling operation. Check around the drill site for overhead obstructions or hazards, such as power lines, before raising the mast. A survey of underground and all other utilities is required before drilling to evaluate hazards.

9.2 Fabricate and assemble the drill mounting platform. The platform can take a variety of forms. The type of platform will depend on the terrain encountered, the stipulated depth of the borehole, and the accessibility of the drill site. Specialized mountings such as a barge or stilts or specially constructed towers are necessary to mount platforms for drilling over water.

9.3 For water-based fluid drilling operation, a mud pit is positioned to collect and filter fluid return flow. An initial quantity of drilling fluid is mixed, usually using the mud pit as the primary mixing reservoir.

9.3.1 For air-based circulation systems, the dust collector or cyclone separator is positioned and “sealed” to the ground surface.

9.4 Case any interval of the borehole that penetrates the overburden. This will prevent collapsing of loose materials into the borehole or loss of drill fluid. The casing should extend through the overburden and extend at least 5 ft (1.5 m) into the rock. Casing may be omitted if the borehole will stand open without caving. Deeper casing(s) or nested casing(s) may be required to facilitate adequate drill hole fluid circulation and hole control. Records of casing(s) lengths and depth intervals installed should be maintained and documented.

9.4.1 Surface casings can be installed using a variety of drilling methods. Hollow-stem audeer drilling (D 6151) has been used successfully for surface casing and has an added benefit of obtaining samples of the overburden soils. The surface casing is normally backfilled, pressed, or sealed in place wit bentonite or cement, or both.

9.4.2 A datum for measuring drill hole depth should be established and documented. This datum normally consists of a stake driven into stable ground surface, the top of the surface casing, or the drilling deck. If there is possibility for movement of the surface casing, it should not be used as a datum. If the hole is to be later surveyed for elevation, record and report the height of the datum to the ground surface.

9.5 The core barrel is assembled following manufacturers' instructions. Keep core barrels cleaned and lubricated and free from damage, dents, or other defects that might affect core quality. Inspect barrels for wear, clearances, dents, or galls. Check condition of core lifters, fluid passages, relief holes, ball checks, valve rubbers, and inner barrel stabilizers, if present. Assemble and disassemble core barrels with the correct tools for the job.

9.5.1 The inner tube of double tube core barrels must be positioned correctly for proper operation. For both conventional and wireline systems where fluid circulates between the bit and lifter case, check that the proper clearance is maintained for circulation. For wireline systems, this will require engaging the inner barrel while the outer barrel is held vertically. If clearances are not correct, they should be adjusted using the adjustment screw on top of the barrel assembly.

9.5.2 For swivel type inner barrels, inspect the bearing assemblies and confirm the inner barrel is free to rotate smoothly when assembled.

9.6 An initial assembly of lead drill rod and core barrel is attached to the drill mechanism through a spindle or below the drill head, and placed within the top of the surface casing. Hole depth is determined by keeping track of the length of the rod-bit assemblies and comparing its position relative to the established surface datum. Hole depth for increments of drilling, coring, and sampling is recorded on the drill log.

9.7 The drilling-fluid circulation pump or air compressor is activated, causing drilling fluid or air to circulate through the system.

9.8 Drilling fluid or air circulation is initiated and rotation and axial force are applied to the drill rod and bit until drilling progresses to a depth where: (1) when the core sample has fully entered the core barrel or blockage is apparent, (2) sampling or in-situ testing will be performed, or (3) the length of the drill-rod column limits further penetration.

9.8.1 Maintain fluid circulation at a rate suitable for the formation to be drilled. Fluid should be circulated at a rate sufficient to circulate cuttings and cool the bit. Fluid pressures should be monitored during drilling. Avoid drilling at excessive advance rate, which could cause plugging of the bit and core blockage and damage. Changes in fluid return and circulation pressures may indicate occurrence of excessive erosion, formation fluid loss, or formation fracturing. Any abrupt changes or anomalies in fluid pressure should be noted and documented, including depth(s) of occurrence(s).

9.8.2 Maintain air circulation at a rate suitable for the formation, and avoid circulation losses. Add water or foam as necessary to maintain circulation. Zones of low air return or no air return should be documented. Should air-blast erosion occur, depth(s) of the occurrence(s) should be noted and documented. Air is particularly susceptible to blocking off circulation and causing uplift to occur very quickly.

9.8.3 Samples of drill cuttings can be collected for analysis of materials penetrated. If cuttings samples are obtained, the depth(s) and interval(s) should be documented.

9.8.4 The selection of proper rotation rate and down feed (advance) or hold-back pressure depends on many factors. The drilling process is iterative in nature. Diamond drilling in a

harder matrix usually requires higher rotation rates and down force pressures. With the correct material and equipment configurations, diamond bit performance is generally optimum at rotation rates of at least 400 rpm or greater. Rates of up to 1000 rpm can be used, depending on the material. However, too high a rate can cause tearing of the formation and core recovery problems. Softer materials with other bits such as polycrystalline, require slower rotation rates. Vibration is extremely important to the drill hole and core quality and must be minimized. Sufficient thrust needs to be transmitted to the bit so that bit elements can cut the rock. The goal is to find the rotation rate and thrust that will result in high quality core and acceptable bit life.

9.8.4.1 Monitor advance or down force pressure, or hold-back pressures, and rotation rates of drill rods during drilling. Observe the penetration rate and drill cuttings as they relate to the geologic strata being penetrated. Document occurrences of any significant abrupt changes and anomalies during drilling.

9.9 Rotation is stopped, the advance or down force pressure is released, and circulation is continued for a short time until the drill cuttings are removed from the borehole annulus. Circulation is stopped and the barrel is rested on the hole bottom to determine hole depth.

9.10 Remove the core barrel and the core from the borehole. Disassemble the core barrel and remove the core.

9.10.1 With double tube barrels, when the barrel is retracted, the core lifter grips the core and the core is normally broken from the base material at the base of the hole. The core lifter is located inside the barrel above the bit typically about 0.1ft. When the core is broken there will be a small pedestal of core left in the hole. As long as the lifter is not slipping, and core is of good quality, successive recoveries will be close to 100%. If for some reason, the lifter case slips, there will be low recovery recorded and there will be a longer pedestal on the subsequent sampling event. If there appears to be excessive core on the subsequent run, or there is visible evidence of the lifter slipping, these occurrences should be noted. If it is obvious the pedestal was present, the length can be accounted for in determination of recovery (see 10.1) of the previous run. These occurrences and corrections should be appropriately noted in the drill report.

9.10.2 With single tube core barrels in shallow drilling operations, the core can be broken with a wedge and lifted by wire hoop to the surface.

9.11 Reassemble the core barrel and return it to the borehole. Check for proper barrel conditions as noted in 9.7. The use of two barrels can greatly speed coring operations; as one barrel is cleaned and reassembled the other is in use in coring.

9.12 Drilling depth is increased by attaching an additional drill-rod section(s) to the top of the previously advanced drill-rod column and resuming drilling operations in accordance with 9.8-9.12.

9.13 *Rock Core Handling*—Use of split inner barrel liners greatly increases the efficiency of handling of cores, especially in broken formations. Cores can be transferred into plastic half rounds for logging and sealing. Log, preserve, and place core samples in core boxes in accordance with Practice D 5079.

9.14 *Rock Core Recovery*—Rock core shall be recovered

continuously in the borehole. If recovery drops below 100 % (see Section 10), modify the drilling procedure, that is, adjust the drilling RPM, down feed pressure, the drilling fluid type and flow, or change the type and the size of core barrel or bit used, until core recovery is improved to a level acceptable to the project geologist or project engineer. Minimize mechanical breaks in the core during core drilling as much as possible.

9.14.1 *Poor Recovery*— Stop core drilling when recovery equals or falls below 50 %. If recovering samples is important, select a better core barrel or bit design. In some cases, it may be necessary to attempt soil sampling techniques (11).

9.15 If conditions prevent advance of the drill hole to the stipulated depth, the borehole shall be cemented and redrilled, or reamed and cased, cased and advanced with a smaller size drill bit and core barrel, or abandoned, as directed by the engineer or geologist.

9.16 Prepare boring logs and place the rock sample in core boxes, and mark and pack them in accordance with Practice D 5079.

10. Calculation

10.1 *Calculate Percent Core Recovery*—Determine the rock core recovery as the ratio of length of core recovered to the length drilled, and express as a percent.

$$\text{Percent core recovery} = \frac{\text{Length of the recovered core}}{\text{Total length of the core run}} \times 100 \quad (1)$$

10.2 Calculate Rock Quality Designation (RQD) in accordance with D 6032.

11. Report

11.1 Report the following information:

11.1.1 *Site Conditions*— Site description: description of the site and any unusual circumstances.

11.1.2 *Personnel*—document all personnel at the site during the drilling process, including the driller, helpers, geologist or logger, engineer, and other monitors or visitors.

11.1.3 *Weather conditions during drilling.*

11.1.4 Working hours, operating times, break-down times, and sampling times. Report any long-term delays in the drilling and installation process.

11.1.5 Report any unusual occurrences that may have happened during the investigation.

11.1.6 *Drilling Methods:*

11.1.6.1 Description of the coring system including type, sizes, core barrels, fluid pump, fluid circulation, and discharge systems. Note intervals of equipment change or drilling method changes and reasons for change.

11.1.6.2 Type, quantities, and drill hole locations of use of additives added to the circulation media. If changes to the circulating medium are made, such as addition of water or conversion to foam, the depth(s) or interval(s) of these changes should be documented.

11.1.6.3 Descriptions of circulation rates, cuttings returns, including quantities, over intervals used. Note the quantity and locations of loss of circulation and probable cause.

11.1.6.4 Descriptions of drilling conditions related to drilling pressures, rotation rates, and general ease of drilling related to subsurface materials encountered. These descriptions can be

very general, and should report how the sampling of different materials progressed.

11.1.6.5 *Records of casing installed*—Report type, amount and times of installation. Record water levels (dates and elevation) observed during drilling.

11.1.7 *Sampling*—When core sampling or undisturbed sampling at the base of the boring separate from coring operations, report condition of the base of the boring before sampling and any slough or cuttings present in the recovered sample. Samples of fluid circulation cuttings can be collected for analysis of materials being penetrated. If cuttings samples are taken, the depth(s) and interval(s) should be documented.

11.1.8 *In-situ Testing:*

11.1.8.1 For devices inserted below the base of the drill hole, report the depths below the base of the hole and any unusual conditions during testing.

11.1.8.2 For devices testing or seating at the drill hole wall, report any unusual conditions of the drill hole wall such as inability to seat pressure packers.

11.1.9 *Installations*—A description of completion materials and methods of placement, approximate volumes placed, intervals of placement, methods of confirming placement, and areas of difficulty or unusual occurrences.

11.2 *Boring Logs*— Boring logs should be completed in accordance with Guide D 5434. Some information that the boring log should include is:

11.2.1 Project identification, boring number, location, orientation, date boring began, date boring completed, and drillers' name(s).

11.2.2 Elevation coordinates of the top of the borehole.

11.2.3 Elevation of, or depth to, ground water surface, and any changes in water level, including the dates and times measured.

11.2.4 Elevations or depths at which the drilling fluid returns were lost and amount of return with depth. Report advance or down feed and hold-back pressures, rotation rates of drill rods, fluid/gas pressure, and circulations return during drilling. Report the penetration rate and drill cuttings as they relate to the geologic strata being penetrated. Document any significant abrupt changes and anomalies that occur during drilling.

11.2.5 Size, type, and design of core barrels used. Size, type, and set of core bits and reaming shells used. Size, type, and design and lengths of all casing used, and locations or elevations of casings used. Records of casing(s) lengths and depth intervals installed should be maintained and documented.

11.2.6 Length of each core run and the percentage of core recovery.

11.2.7 Driller's description of the core in each run, if no engineer or geologist was present.

11.2.8 Geologist's or engineer's description of the core recovered in each run. Subsurface description, including dip of strata, jointing, cavities, fissures, core loss, and any other observations made by the geologist, engineer, or the driller that could yield information about the formation encountered during drilling. Depth, thickness, and apparent nature of the filling of each soft seam or cavity encountered. Report the

calculated RQD and D 6032.

11.2.9 Any change in the character of the drilling fluid or drilling fluid return.

11.2.10 Reservoir, tidal, or current information, if the drilling is near or over a body of water.

11.2.11 Drilling time in minutes per foot and down feed gage pressure, when applicable, and the RPM of the drill rods.

11.2.12 Notations of character of drilling, that is, soft, slow, easy, smooth, and others.

12. Precision and Bias

12.1 This practice does not produce numerical data; therefore, a precision and bias statement is not applicable.

12.2 The boring log reflects the subjective opinions of the engineer, the geologist, or the driller. Therefore, the designer must exercise proper prudence when interpreting the boring logs.

12.3 This procedure produces data on rock type and rock quality and recovery factors such as RQD (D 6032) that may reflect the biases of the persons collecting the data. Precision for determination of RQD will be addressed in D 6032.

13. Keywords

13.1 diamond drilling; exploration; rock; rock coring; rock investigations; site characterization

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SUMMARY OF CHANGES

This section identifies the principal changes to this practice that have been incorporated since the last issue. There have been significant changes to the standard. The previous standard was developed in the 1970's. Since that time wireline systems have gained preference in industry.

- (1) Expanded Section 1 to add reference to other drilling standards and safety standards.
- (2) Added logging and transport and storage standards to Section 2.
- (3) Added a Terminology section and defined drilling-related terms.
- (4) Added Section 4, Summary of Practice, to describe drilling, coring, and sampling processes.
- (5) Expanded Apparatus section to discuss the advantages and disadvantages of selecting specific designs. Added sections on fluid and air drilling. Changed and expanded section on wireline drilling methods.
- (6) Added section on materials and presented major drill fluid materials and additives.
- (7) Removed section on transportation and storage of rock core and referred to Practice D 5079.
- (8) Added new Section 8, Precautions, to warn against fracturing and drill hole disturbance.
- (9) Added section on Calculations and added recovery and RQD. Referred to RQD as a separate D 6032.
- (10) Changed section Boring Log to Report and referred to Guide D 5434.

 **D 2113**

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