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Standard Guide for Use of Cable-Tool Drilling and Sampling Methods for Geoenvironmental Exploration and Installation of Subsurface Water Quality Monitoring Devices[1]

This standard is issued under the fixed designation D5875/D5875M; 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 cable-tool drilling and sampling procedures used for geoenvironmental exploration and installation of subsurface water quality monitoring devices.

1.2 Several sampling methods exist for obtaining samples from drill holes for geoenvironmental purposes and subsequent laboratory testing. Selection of a particular drilling procedure should be made on the basis of sample types needed and geohydrologic conditions observed at the study site.

1.3 Drilling procedures for geoenvironmental exploration often will involve safety planning, administration and documentation. This guide does not purport to specifically address exploration and site safety.

NOTE 1—This guide does not include considerations for geotechnical site characterizations.

1.4 The values stated in either SI units or inch-pound units are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.5 *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.*

1.6 *This guide offers an organized collection of information or a series of options and does not recommend a specific course of action. This document cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this guide may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.*

1.7 *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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D4428/D4428M Test Methods for Crosshole Seismic Testing

D5088 Practice for Decontamination of Field Equipment Used at Waste Sites

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of general technical terms used within this standard, refer to Terminology D653.

3.1.2 *jars*—a tool composed of two connected links or reins with vertical play between them (see Fig. 1 and Ref (**1**)).[3] Drilling jars have a stroke of 230 to 460 mm [9 to 18 in.] whereas, fishing jars have a stroke of 460 to 900 mm [18 to 36 in.]. Jars permit a sudden upward load or shock to loosen a string of tools stuck in the borehole.

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

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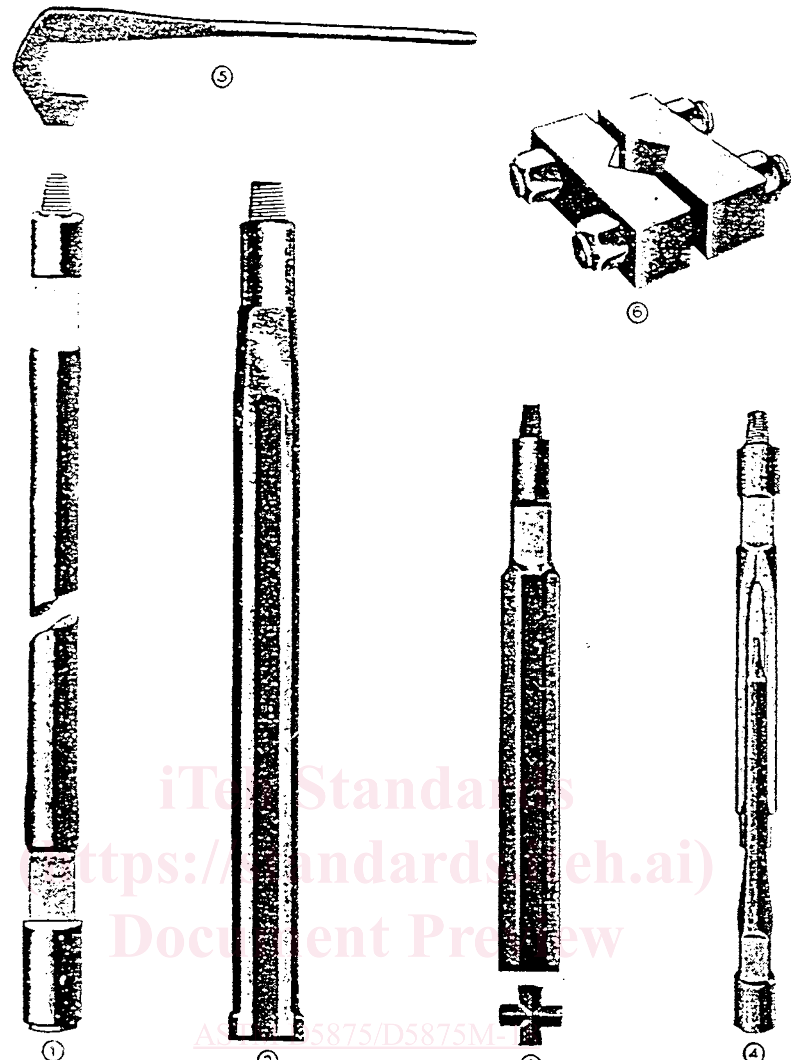
[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

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

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



1. Drill Stem.
2. Regular pattern bit.
3. Star or four-wing bit.
4. Jars.
5. Wrench for tightening drive clamps.
6. Drive clamps.

FIG. 1 Drilling Tools

4. Significance and Use

4.1 Cable-tool rigs (also referred to as churn rigs, water-well drilling rigs, spudders, or percussion rigs) are used in the oil fields and in the water-well industry. The Chinese developed the percussion method some 4,000 years ago.

4.2 Cable-tool drilling and sampling methods may be used in support of geoenvironmental exploration and for installation of subsurface water quality monitoring devices in both unconsolidated and consolidated materials. Cable-tool drilling and sampling may be selected over other methods based on its advantages, some of which are its high mobility, low water use, low operating cost, and low maintenance. Cable-tool drilling is the most widely available casing-advancement method that is restricted to the drilling of unconsolidated sediment and softer rocks.

4.2.1 The application of cable-tool drilling and sampling to geoenvironmental exploration may involve sampling unconsolidated materials. Depth of drill holes may exceed 900 m [3000 ft] and may be limited by the length of cable attached to the bull reel. However, most drill holes for geoenvironmental exploration rarely are needed to go that deep. Rates for cable-tool drilling and sampling can vary from a general average of as much as 7.5 to 9 m/h [25 to 30 ft/h] including setting 200 mm [8 in.] diameter casing to considerably less than that depending on the type(s) of material drilled, and the type and condition of the equipment and rig used.

NOTE 2—As a general rule, cable-tool rigs are used to sample the surficial sediments (that is, overburden), and to set surface casing in order that rotary-core rigs subsequently may be set up on the drill hole to core drill hard rock if coring is needed.

NOTE 3—The quality of the result produced by this standard is dependent on the competence of the personnel performing it, and the suitability of the equipment and facilities used. Agencies that meet the criteria of Practice D3740 are generally considered capable of competent and objective testing/sampling/evaluation/and the like. Users of this standard are cautioned that compliance with Practice D3740 does not in itself assure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors.

4.2.2 The cable-tool rig may be used to facilitate the installation of a subsurface water quality monitoring device(s) including in situ testing devices. The monitoring device(s) may be installed through the casing as the casing is removed from the borehole. The sand line can be used to raise, lower, or set in situ testing device(s). If necessary, the casing may also be left in the borehole as part of the device.

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

5. Apparatus

5.1 Cable-tool rigs (see Fig. 2) have a string of drill tools with a drive clamp (see Fig. 1 and Ref (**2**)) on the drill string connected by wire rope that periodically can be hoisted and allowed to "fall" for percussion drilling in unconsolidated and consolidated sediment and for driving/retrieving casing. The full string of drilling equipment consists of drill bit (see Fig. 1 and Ref (**3**)—Regular bit used for all-around general drilling and, Ref (**4**)—Star bit used for chopping and breaking hard materials and rock), drilling jars (optional), and a drill stem (see Fig. 1 and Ref (**5**)), with a swivel socket (see Fig. 2) connected by a wire rope fastened to a drum called a bull reel that raises and lowers the drilling tools and permits percussion drilling either by crushing the material or by drive sampling. The spudding beam, commonly referred to as the walking beam, that is driven by the pitman and crank, imparts a reciprocating motion to the drilling line.

NOTE 5—Cable-tool rigs have the capacity to lift and drop heavy drive clamps for installing large-diameter casing in unconsolidated sediment.

5.2 Drilling rigs for water wells have been converted (for the purpose of geoenvironmental-engineering explorations) by replacing the jars and stem, and replacing the chopping bit (see Fig. 1 and Ref (**4**)) with a drive barrel that is used for sampling purposes. If the bit becomes stuck in the borehole it can normally be freed by upward blows of the drilling jars (jars can also be used in the same mode to extract casing). The primary function of the drilling jars is to transmit the energy from the bull wheel to the drill stem and the sample barrel. The stroke of the drilling jars is 230 mm to 460 mm [9 to 18 in.] and distinguishes them from fishing jars that have a stroke 460 to 920 mm [18 to 36 in.]. Jars are often not used when hard-rock drilling (**2**, **6**).

5.3 The swivel socket connects the drill string to the cable and, in addition, the weight of the socket supplies part of the weight of the drill tools. The socket also imparts part of the upward energy to the jars when their use becomes necessary. The socket transmits the rotation of the cable to the tool string and bit (drive barrel) so that the drive is completed on the downstroke, thereby assuring that a round, straight hole will result. The elements of the tool string are typically coupled together in the United States with right-hand threaded tool joints of standard API (American Petroleum Institute) design and dimension (**6**).

5.4 The wire rope cable that carries and rotates the drilling tool is called the drill line. It is typically a 16-mm [0.625-in.] to 25-mm [1-in.] left-hand lay cable that twists the tool joint on each upward stroke to prevent it from unscrewing. The drill line is reeved over a crown sheave at the top of the mast, down to the spudding sheave on the walking beam, to the heel sheave, and then to the working-line side of the bull-reel (see Fig. 2). The stroke of the cable-tool rig should be controlled and sufficient tension maintained on the wire cable to keep the jars open or extended when in operation (often referred to as tight-line drilling). Bull reels generally are set-up with a separator on the drum to provide a working-line and a storage-line side (**6**).

NOTE 6—The mast must be constructed safely to carry the needed loads for drilling, sampling, and completion of boreholes of the diameter and depth for which the rig manufacturer specifies the equipment. To allow for contingencies it is recommended that the rated capacity of the mast should be twice the anticipated weight load or normal pulling load.

5.5 The characteristic up and down or spudding action of a cable-tool rig is imparted to the drill line and drilling tools by the walking beam. The walking beam pivots at one end while its out end, which carries the sheave for the drill line, is moved up and down by a single or double pitman connected to a crankshaft. The vertical stroke of the walking beam, and thus the drill tools, can be varied by adjusting the position of the pitman on the bull gear and the connection to the walking beam. The number of strokes per minute can be varied by changing the speed of the driveshaft. The bull gears are driven by a pinion mounted on a clutch. This clutch, the friction drive for sand line (on smaller cable tool rigs only), and the drive pinion for the drill-line reel are mounted on the same shaft assembly.

5.6 Another drum, called a casing reel, frequently is added to the basic machine assembly. The casing reel is capable of exerting a powerful pull on a third cable, the casing- or main-line. This cable is used for handling heavy casing, tools, and pumps, or other heavy hoisting. It may be used to pull a string of casing when the cable is reeved with blocks to make two-, three-, or four-part lines (**6**).

5.7 Another commonly used hoisting device on a cable-tool rig is called a cathead. Use of this drum requires that a heavy line of manila rope be carried on a separate sheave at the top of the derrick. This line may be used for handling light loads at shallow depths (usually 3 m [10 ft] or less) and alternately lifting and dropping tools such as a drive block or bumper, spears, heads for driving casing, and individual lengths of casing so they may be stood on end and joined to the last piece in the ground (**2**). The cathead and line is often used to shake the sample from large-diameter drive barrels. Should standard-penetration tests be needed for specific geoenvironmental studies, standard rotary drill rods and drop hammer can be manipulated using the cathead and line.

5.8 Depending on the length of the drive barrels, the drive of the sampling is usually 0.6 m [2 ft]. Prior to drilling, tools must

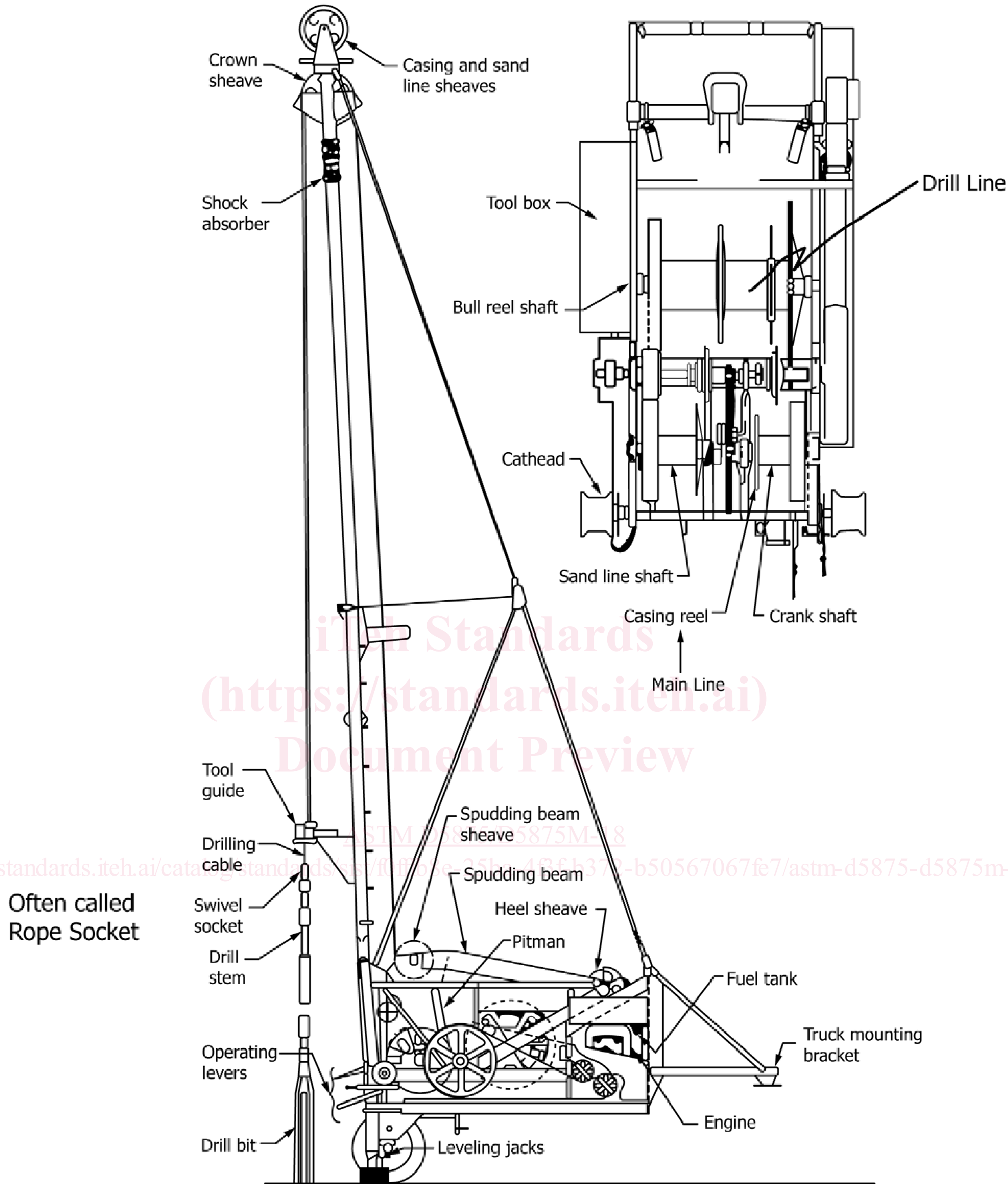


FIG. 2 Diagram of a Cable Tool Drilling System

be measured and the measurements recorded. Drive samples are usually disturbed. Therefore, laboratory testing is normally limited to obtaining only Atterberg Limits, mechanical analysis or chemical analysis of the disturbed samples. Poly(methyl methacrylate) or plastic liners can be inserted within the drive barrel, and the complete sample can be reexamined in the laboratory. In addition, sampling with the drive barrel provides the user with a complete geological sequence and field classification of the sampled materials at the time of drilling. When cohesionless sediment is encountered, and if sampling is needed, the recovery is best while sampling is conducted from inside the casing. Attempts to sample below the bottom of the casing, especially when these materials are below the water table or the materials totally saturated, are usually futile. (When such conditions are observed the drive barrel acts analogous to a piston and creates a suction when the bottom of