

Designation: D6286/D6286M - 20

Standard Guide for Selection of Drilling and Direct Push Methods for Geotechnical and Environmental Subsurface Site Characterization¹

This standard is issued under the fixed designation D6286/D6286M; 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 provides descriptions of various methods for site characterization along with advantages and disadvantages associated with each method discussed. This guide is intended to aid in the selection of drilling method(s) for geotechnical and environmental soil and rock borings for sampling, testing, and installation of wells, or other instrumentation. It does not address drilling for foundation improvement, drinking water wells, or special horizontal drilling techniques for utilities.

1.2 This guide cannot address all possible subsurface conditions that may occur such as, geologic, topographic, climatic, or anthropogenic. Site evaluation for engineering, design, and construction purposes is addressed in Guide D420. Soil and rock sampling in drill holes is addressed in Guide D6169/ D6169M. Pertinent guides and practices addressing specific drilling methods, equipment, and procedures are listed in Section 2. Guide D5730 provides information on most all aspects of environmental site characterization.

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

1.4 This guide does not purport to comprehensively address all methods and the issues associated with drilling for geotechnical and environmental purposes. 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 these methods and qualified professionals should have flexibility to exercise judgment as to possible alternatives not covered in this guide. The guide 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.

1.5 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.

1.5.1 Drilling operators generally are required to be trained for safety requirements such as those of construction and environmental occupational safety programs dictated by country, regional, or local requirements such as the US. OSHA training programs. Drilling safety programs are also available from the National Drilling Association (NDA4U.com) or other country drilling associations.²

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 and 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.

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

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.

Current edition approved May 1, 2020. Published May 2020. Originally approved in 1998. Last previous edition approved in 2019 as D6286 – 19. DOI: 10.1520/D6286_D6286M-20.

² "Drilling Safety Guide," National Drilling Federation, Columbia, SC, 1985, p. 36.

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2. Referenced Documents

- 2.1 ASTM Standards:³
- D420 Guide for Site Characterization for Engineering Design and Construction Purposes
- D653 Terminology Relating to Soil, Rock, and Contained Fluids
- D1452/D1452M Practice for Soil Exploration and Sampling by Auger Borings
- D2113 Practice for Rock Core Drilling and Sampling of Rock for Site Exploration
- D2488 Practice for Description and Identification of Soils (Visual-Manual Procedures)
- D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
- D5088 Practice for Decontamination of Field Equipment Used at Waste Sites
- D5092/D5092M Practice for Design and Installation of Groundwater Monitoring Wells
- D5608 Practices for Decontamination of Sampling and Non Sample Contacting Equipment Used at Low Level Radioactive Waste Sites
- D5730 Guide for Site Characterization for Environmental Purposes With Emphasis on Soil, Rock, the Vadose Zone and Groundwater (Withdrawn 2013)⁴
- D5753 Guide for Planning and Conducting Geotechnical Borehole Geophysical Logging
- D5778 Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils
- D5781/D5781M Guide for Use of Dual-Wall Reverse-Circulation Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water Quality Monitoring Devices
- D5782 Guide for Use of Direct Air-Rotary Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
- D5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
- D5784 Guide for Use of Hollow-Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water Quality Monitoring Devices
- D5872 Guide for Use of Casing Advancement Drilling Methods for Geoenvironmental Exploration and Installation of Subsurface Water Quality Monitoring Devices
- D5875/D5875M Guide for Use of Cable-Tool Drilling and Sampling Methods for Geoenvironmental Exploration and Installation of Subsurface Water Quality Monitoring Devices
- D5876/D5876M Guide for Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geoenviron-

mental Exploration and Installation of Subsurface Water-Quality Monitoring Devices

- D6001 Guide for Direct-Push Groundwater Sampling for Environmental Site Characterization
- D6151/D6151M Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
- D6169/D6169M Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
- D6429 Guide for Selecting Surface Geophysical Methods (Withdrawn 2020)⁴
- D6910/D6910M Test Method for Marsh Funnel Viscosity of Construction Slurries
- D6914/D6914M Practice for Sonic Drilling for Site Characterization and the Installation of Subsurface Monitoring Devices

2.2 Geotechnical Sampling, In situ Testing, and Instrumentation in Drill Holes:

- D1586/D1586M Test Method for Standard Penetration Test (SPT) and Split-Barrel Sampling of Soils
- D1587/D1587M Practice for Thin-Walled Tube Sampling of Fine-Grained Soils for Geotechnical Purposes
- D2573/D2573M Test Method for Field Vane Shear Test in Saturated Fine-Grained Soils
- D3550/D3550M Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
- D4403 Practice for Extensometers Used in Rock
- D4428/D4428M Test Methods for Crosshole Seismic Testing
- D4719 Test Methods for Prebored Pressuremeter Testing in Soils
- D6519 Practice for Sampling of Soil Using the Hydraulically Operated Stationary Piston Sampler
- D6598 Guide for Installing and Operating Settlement Points for Monitoring Vertical Deformations
- D6635 Test Method for Performing the Flat Plate Dilatometer
- D7299 Practice for Verifying Performance of a Vertical Inclinometer Probe
- 2.3 Sampling, Testing, and Installations in Drill Holes:
- D4700 Guide for Soil Sampling from the Vadose Zone

D4044/D4044M Test Method for (Field Procedure) for Instantaneous Change in Head (Slug) Tests for Determining Hydraulic Properties of Aquifers

- D4050 Test Method for (Field Procedure) for Withdrawal and Injection Well Testing for Determining Hydraulic Properties of Aquifer Systems
- D4630 Test Method for Determining Transmissivity and Storage Coefficient of Low-Permeability Rocks by In Situ Measurements Using the Constant Head Injection Test
- D6282/D6282M Guide for Direct Push Soil Sampling for Environmental Site Characterizations
- D6724/D6724M Guide for Installation of Direct Push Groundwater Monitoring Wells
- D6725/D6725M Practice for Direct Push Installation of Prepacked Screen Monitoring Wells in Unconsolidated Aquifers

³ 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.

⁴ The last approved version of this historical standard is referenced on www.astm.org.

- D6907 Practice for Sampling Soils and Contaminated Media with Hand-Operated Bucket Augers
- D7242/D7242M Practice for Field Pneumatic Slug (Instantaneous Change in Head) Tests to Determine Hydraulic Properties of Aquifers with Direct Push Groundwater Samplers
- D7352 Practice for Volatile Contaminant Logging Using a Membrane Interface Probe (MIP) in Unconsolidated Formations with Direct Push Methods
- D7648/D7648M Practice for Active Soil Gas Sampling for Direct Push or Manual-Driven Hand-Sampling Equipment
- D8037/D8037M Practice for Direct Push Hydraulic Logging for Profiling Variations of Permeability in Soils

3. Terminology

3.1 Definitions:

3.1.1 For definitions of common technical terms used within this guide, refer to Terminology D653.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *borehole wall*, n—refers to the naturally-occurring soil(s)/rock(s) surrounding the borehole.

3.2.2 *kelly bar, n—in drilling*, a formed or machined section of hollow drill steel used in rotary drilling, which is joined directly to the swivel at the top and to the drill pipe below.

3.2.2.1 *Discussion*—The flats or splines of the kelly bar engage the rotary table so that the rotation of the rotary table turns the kelly bar, which in turn, rotates the drill pipe and the rotary bit.

3.2.3 *mud rings*, *n*—*in drilling*, soil or rock cuttings that form a ring or rings on the drill rod(s) during a rotary-drilling method, and as such, prevent drill cuttings from being carried up and out of the borehole.

3.2.3.1 *Discussion*—These rings can cause drill rods to become stuck in the borehole if sufficient drilling fluid is not injected or pumped downhole to keep the cuttings fluid so that the ring(s) cannot form on the drill rods and block the cuttings return as drilling progresses.

3.2.4 *orange-peel bucket*, *n*—*in drilling*, a bucket-type device, somewhat elliptical in shape resembling an orange peel, that is lowered down the borehole and used to remove boulders from the bottom of a borehole.

3.2.5 unconsolidated geologic materials, n—in groundwater, geology, or hydrogeology, a loosely aggregated solid (particulate) material of geologic origin (soil, sediments, etc.).

3.2.5.1 *Discussion*—Groundwater hydrologists, and geologists, use the terms unconsolidated formations, deposits, sediments, units, materials, etc., to refer to the general term "soil" including other soils (alluvium, glacial till, etc.) as defined in D653. These terms are often found in groundwater standards applied to aquifers. Unconsolidated materials are non-lithified, typically lacking cementation of individual particles (clay, silt sand, gravel, etc.). The term "unconsolidated" should not be confused with geotechnical terms of the degree of soil consolidation (over, normally, under-consolidated) as defined in D653.

4. Significance and Use

4.1 The 1998 edition of this standard was written solely for selection of drilling methods for environmental applications and specifically for installation of groundwater monitoring wells. The second revision was made to include geotechnical applications since many of the advantages, disadvantages, and limitations discussed extensively throughout this document also apply to geotechnical design use such as data collection (sampling and in-situ testing) for construction design and instrumentation. Besides installation of monitoring wells (D5092/D5092M, D6724/D6724M), Environmental investigations are also made for sampling, in-situ testing, and installation of aquifer testing boreholes (D4044/D4044M, D4050).

4.2 There are other guides for geotechnical investigations addressing drilling methods such as in Eurocode $(1, 2)^5$, U.S. Federal Highway Administration, (3, 4), U.S. Army Corps of Engineers, (5), and U.S. Bureau of Reclamation (6, 7). An authoritative Handbook on Environmental Site Characterization and Ground-Water Monitoring was compiled by Nielsen (8) which addresses drilling methods in detail including the advent of Direct Push methods developed for environmental investigations. Two other major drilling guides have been written by the National Drilling Association (9) and from the Australia Drilling Industry Training Committee (10) and these guides are user for the drillers.

4.3 Table 1 lists sixteen classes of methods addressed in this guide. The selection of particular method(s) for drilling/push boring requires that specific characteristics of each site be considered. This guide is intended to make the user aware of some of the various drilling/push boring methods available and the applications, advantages, and disadvantages of each with respect to determining geotechnical and environmental exploration.

4.3.1 On Table 1, practically all methods allow for coring, but some are much more efficient than others. Some drilling systems such as hollow-stem augers or wireline coring allow for practically continuous coring with minimal time for switching barrels while other drilling methods require the whole drilling equipment be removed from the hole. A prime example is the rate of rock coring using fluid rotary and conventional core barrels versus wireline rock coring. Wireline line rock coring is fast with long continuous runs whereas fluid rotary requires more "trip time" to add and remove shorter length core barrels using drill rods. Table 1 delineates methods where coring is possible, and in general, by either continuous (c) or incremental (i) sampling.

4.3.2 Sampling for environmental contaminants in soil, unconsolidated formations or groundwater often requires special considerations. In many environmental applications the use of drilling fluids (air, water, mud or foam) is often discouraged or even prohibited as these fluids may dilute the analytes of interest or even introduce analytes of concern not previously present (see 5.4).

⁵ The boldface numbers in parentheses refer to the list of references at the end of this standard.