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Standard Practice for Sampling of Soil Using the Hydraulically Operated Stationary Piston Sampler[1]

This standard is issued under the fixed designation D 6519; 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 practice covers a procedure for sampling of cohesive, organic, or fine-grained soils, or combination thereof, using a thin-walled metal tube that is inserted into the soil formation by means of a hydraulically operated piston. It is used to collect relatively undisturbed soil samples suitable for laboratory tests to determine structural and chemical properties for geotechnical and environmental site characterizations.

1.1.1 Guidance on preservation and transport of samples in accordance with Practice D 4220 may apply. Samples for classification may be preserved using procedures similar to Class A. In most cases, a thin-walled tube sample can be considered as Class B, C, or D. Refer to Guide D 6286 for use of the hydraulically operated stationary piston soil sampler for environmental site characterization. This sampling method is often used in conjunction with rotary drilling methods such as fluid rotary; Guide D 5783; and hollow stem augers, Practice D 6151. Sampling data should be reported in the substance log in accordance with Guide D 5434.

1.2 The hydraulically operated stationery piston sampler is limited to soils and unconsolidated materials that can be penetrated with the available hydraulic pressure that can be applied without exceeding the structural strength of the thin-walled tube.

1.3 *This practice does not purport to address all the safety concerns, if any, associated with its use and may involve use of hazardous materials, equipment, and operations. It is the responsibility of the user to establish and adopt appropriate safety and health practices. 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.*[2]

1.4 The values stated in 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 nonconformance with the standard.

1.5 *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 judgement. 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 title means only that the document has been approved through the ASTM consensus process. This practice does not purport to comprehensively address all of the methods and the issues associated with sampling of soil. 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 soil, and qualified professionals should have flexibility to exercise judgment as to possible alternatives not covered in this practice. The 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.*

2. Referenced Documents

2.1 *ASTM Standards-Soil Classification:*

D 653 Terminology Relating to Soil, Rock, and Contained Fluids[3]

D 2488 Practice for Description and Identification of Soils (Visual-Manual Method)[3]

D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock[3]

2.2 *ASTM Standards-Drilling Methods:*

D 1452 Practice for Soil Investigation and Sampling by Auger Borings[3]

D 5782 Guide for Use of Direct Air-Rotary Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices[4]

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[1] This practice is under the jurisdiction of ASTM Committee D-18 on Soil and Rock and is the direct responsibility of Subcommittee D18.02 on Sampling and Related Field Testing for Soil Evaluation

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[2] *Drilling Safety Guide,* National Drilling Assn., 3008 Millwood Ave., Columbia, SC 29205.

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

[4] *Annual Book of ASTM Standards*, Vol 04.09.

D 5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices[4]
D 5784 Guide for Use of Hollow-Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices[4]
D 6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling[4]
D 6286 Selection of Drilling Methods for Environmental Site Characterization

2.3 *ASTM Standards—Soil Sampling:*

D 420 Guide to Site Characterization for Engineering, Design, and Construction Purposes[3]
D 1587 Practice for Thin-Walled Tube Geotechnical Sampling of Soils[3]
D 3694 Practices for Preparation of Sample Containers and for Preservation of Organic Constituents[5]
D 4700 Guide for Soil Sampling from the Vadoze Zone[3]
D 5299 Guide for Decommissioning of Ground Water Wells, Vadose Zone, Monitoring Devices, Boreholes, and Other Devices for Environmental Activities[3]
D 4220 Practices for Preserving and Transporting Soil Samples[3]
D 6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations[4]

3. Terminology

3.1 Terminology used within this guide is in accordance with Terminology D 653 with the addition of the following:

3.1.1 *incremental drilling and sampling*—insertion method where rotary drilling and sampling events are alternated for incremental sampling. Incremental drilling is often needed to penetrate harder or deeper formations.

3.1.2 *sample recovery*—the length of material recovered divided by the length of sampler advancement and stated as a percentage.

3.1.3 *sample interval*—Defined zone within a subsurface strata from which a sample is gathered.

3.1.4 *soil core*—cylindrically shaped soil specimen recovered from a sampler.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *friction clutch*—a device to lock the thin-walled tube head to the outer barrel of the stationary piston sampler to prevent uncontrolled thin-walled tube rotation.

3.2.2 *hydraulically activated stationary piston sampler*—a stationary piston sampler in which the thin-walled tube is forced over a fixed piston into the soil strata by hydraulic fluid pressure or pneumatic pressure. Also known as an "Osterberg" piston sampler, which was developed by Professor Jori Osterberg of Northwestern University.

4. Summary of Practice

4.1 Hydraulic stationary piston sampling of soils consists of advancing a sampling device into subsurface soils generally through a predrilled bore hole to the desired sampling depth. See Fig. 1 for a schematic drawing of the sampling process. The sampler is sealed by the stationary piston to prevent any intrusion of formation material. At the desired depth, fluid or air is forced into the sampling barrel, above the inner sampler head, forcing the thin-walled tube sampler over the piston into the soil formation. The hydraulically operated stationary piston sampler has a prescribed length of travel. At the termination of the sampler travel length the fluid flow is terminated. The sample is allowed to stabilize in the thin-walled tube. The sample is then sheared by rotating the sampler. The sampler is retrieved from the borehole, and the thin-walled tube with the sample is removed from the sampler. The sample tube is then sealed properly or field-extruded as desired. The stationary piston sampler is cleaned and a clean thin-walled tube installed. The procedure is repeated for the next desired sampling interval. Sampling can be continuous for full-depth borehole logging or incremental for specific interval sampling.

5. Significance and Use

5.1 Hydraulically activated stationary piston samplers are used to gather soil samples for laboratory or field testing and analysis for geologic investigations, soil chemical composition studies, and water quality investigations. The sampler is sometimes used when attempts to recover unstable soils with thin-walled tubes, Practice D 1587, are unsuccessful. Examples of a few types of investigations in which hydraulic stationary piston samplers may be used include building site foundation studies containing soft sediments, highway and dam foundation investigations where softer soil formation need evaluation, wetland crossings utilizing floating structures, and hazardous waste site investigations. Hydraulically activated stationary piston samplers provide specimens necessary to determine the physical and chemical composition of soils and, in certain circumstances, contained pore fluids (see Guide D 6169).

5.2 Hydraulically activated stationary piston samplers can provide relatively undisturbed soil samples of soft or loose formation materials for testing to determine accurate information on the physical characteristics of that soil. Samples of soft formation materials can be tested to determine numerous soil characteristics such as; soil stratigraphy, particle size, moisture content, permeability, sheer strength, compressibility, and so forth. The chemical composition of soft formation soils can also be determined from the sample if provisions are made to ensure that clean, decontaminated tools are used in the sample gathering procedure. Field-extruded samples can be field-screened or laboratory-analyzed to determine the chemical composition of soil and contained pore fluids. Using sealed or protected sampling tools, cased boreholes, and proper advancement techniques can help in the acquisition of good representative samples. A general knowledge of subsurface conditions at the site is beneficial.

5.3 The use of this practice may not be the correct method for investigations of softer formations in all cases. As with all sampling methods, subsurface conditions affect the performance of the sample gathering equipment and methods used. For example, research indicates that clean sands may undergo

[5] *Annual Book of ASTM Standards*, Vol 11.02.

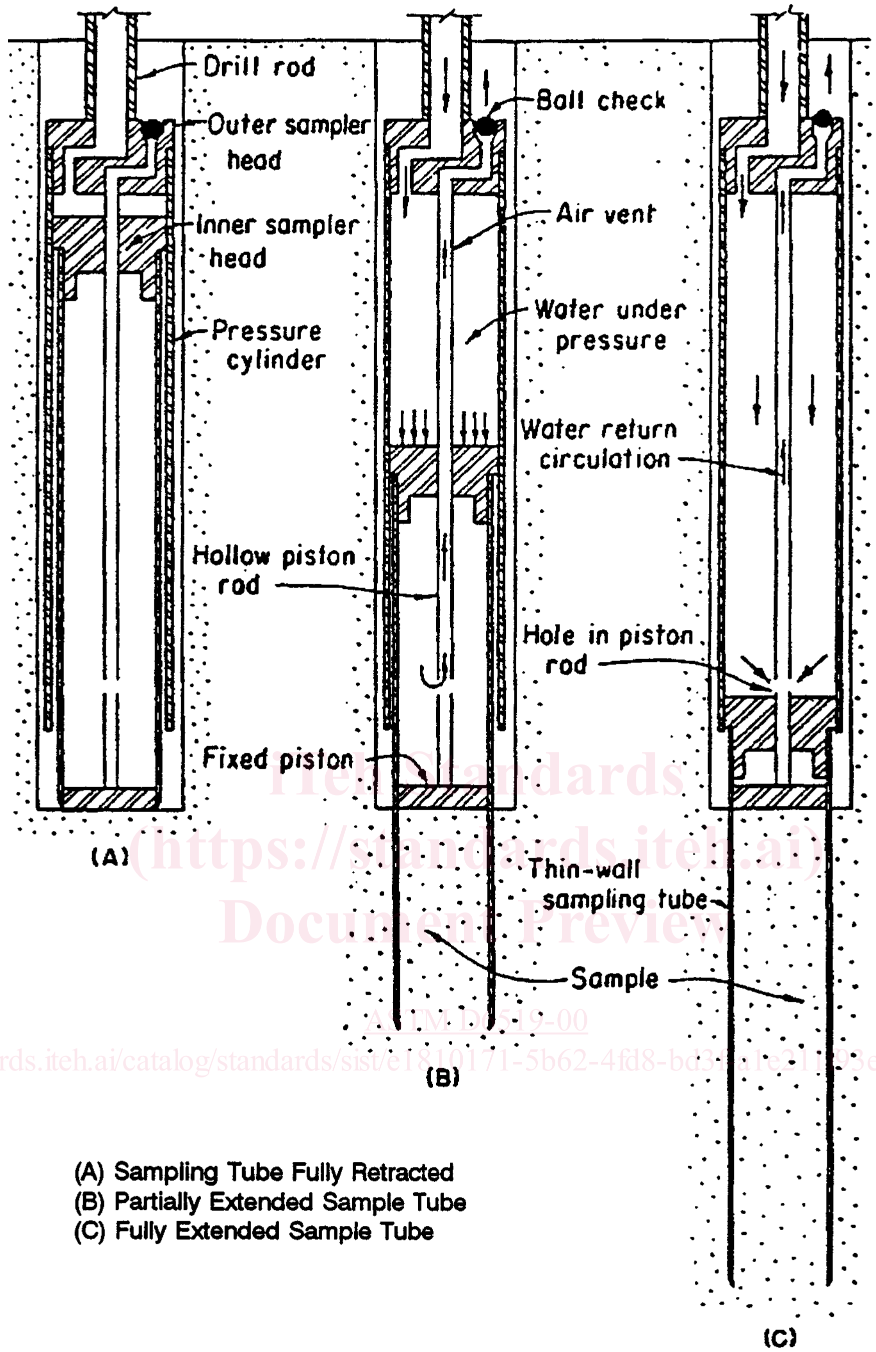

FIG. 1 Sampler in Operation

volume changes in the sampling process, due to drainage[6]. The hydraulically activated stationary piston sampler is generally not effective for cohesive formations with unconfined, undrained shear strength in excess of 2.0 tons per square foot, coarse sands, compact gravelly tills containing boulders and cobbles, compacted gravel, cemented soil, or solid rock. These formations may damage the sample or cause refusal to penetration. A small percentage of gravel or gravel cuttings in the base of the borehole can cause the tube to bend and deform, resulting in sample disturbance. Certain cohesive soils, depending on their water content, can create friction on the thin-walled tube which can exceed the hydraulic delivery force. Some rock formations can weather into soft or loose deposits where the hydraulically activated stationary piston sampler may be functional. The absence of ground water can affect the performance of this sampling tool. As with all sampling and borehole advancement methods, precautions must be taken to prevent cross-contamination of aquifers through migration of contaminates up or down the borehole. Refer to Guide D 6286 on selecting drilling methods for

[6] Marcosion and Bieganovsky, "Liquefaction Potential of Dams & Foundations, Report 4, Determination of In situ Density of Sands," *Research Report S-76-2,* U.S. Army Engineer Water Way Experimental Station, Vicksburg, MS, 1977.

environmental site characterization for additional information about work at hazardous waste sites.

6. Criteria for Selection

6.1 Important criteria to consider when selecting the hydraulically activated stationary piston sampler include the following:

6.1.1 Size of sample.

6.1.2 Sample quality (Class A, B, C, or D) for physical testing. Refer to Practices D 4220.

6.1.3 Sample handling requirements such as containers and preservation requirements.

6.1.4 Soil conditions anticipated (cohesiveness).

6.1.5 Ground-water depth anticipated.

6.1.6 Boring depth required.

6.1.7 Chemical composition of soil and contained pore fluids.

6.1.8 Available funds.

6.1.9 Estimated cost.

6.1.10 Time constraints.

6.1.11 History of tool performance under anticipated conditions (consult experienced users and manufacturers).

6.1.12 Site accessibility.

6.1.13 Decontamination requirements.

7. Apparatus

7.1 The hydraulically activated stationary piston sampler (Fig. 2) consists of an outer barrel, an outer barrel head with threaded connection for drill rod with a fluid-injection port leading into the inner barrel, a fluid-exit port fitted with a check valve, a friction clutch assembly to control rotation, a piston rod that attaches to the sampler head and serves as a conduit from the base of the piston for the discharge of fluid, an inner sampler head which slides over the piston rod to which the thin-walled tube is attached, a piston that attaches to the lower end of the piston rod, a thin-walled tube, and in some cases a removable outer barrel shoe. Necessary expendable supplies are thin-walled tubes, tube sealing material, sample containers for use in field extrusion, and O-ring seals.

7.1.1 *Thin-walled Tube*—The hydraulically activated stationary piston sampler is designed to accommodate standard sized 3.0-in. (76.2-mm) diameter thin-walled tubes. Samplers are also available to utilize 5.0-in. (127.0-mm) diameter thin-walled tubes as well (Fig. 3). The thin-walled tubes are generally manufactured in accordance with Practice D 1587. Thin-walled tube retaining fastener patterns may vary (Fig. 3). The most desirable pattern is the one recommended in Practice D 1587. Regardless of the pattern used, a minimum of four fasteners should be utilized to provide sufficient strength to resist any rotation or extraction forces. Sealing of thin-walled tube ends should be completed in accordance with Practice D 1587 and with Practices D 4220.

7.1.2 *Sample Tube*—Thin-walled tubes are available in various types of materials, including stainless steel, galvanized steel, and brass. There are also different types of materials that can be used to coat the tube surfaces. When using thin-walled tubes in areas with chemically contaminated soil, consideration should be given to the effect these chemicals may have on the tube composition. The reaction of the chemical with the thin-walled tube may affect the sample properties as well as storage procedures. Samples for geotechnical testing require certain minimum volumes and specific handling techniques. Practices D 4220 offers guidance for handling samples submitted for physical testing.

7.2 *Power Sources*—Hydraulic activation of the stationary piston sampler requires a power source to supply fluid or air to the sampler. Rotary drilling equipment fitted with fluid pumps or air compressions may be used. The drill rig should have a tower for placing and removing the sampler from the borehole. The drill rig should also have sufficient retraction power to extract the full sample tube, overcoming the suction and the friction of the formation soils. The fluid pump should be capable of supplying 200 psi (1380 kN/m^2). Piston, progressive cavity, and peristaltic pumps work well. The pump should be equipped with a pressure-relief valve set at a minimum of 200 psi. Air compressors capable of delivering 175 psi (1207.5 kN/m^2) are acceptable. Pressure requirements are governed by the soil resistance values of the formation being sampled. Drilling tools needed to operate the sampler include drill rods to position the sampler and to transfer the activation fluid, rod-handling tools, pipe wrenches, fluid swivels, and so forth; casing or hollow stem augers to provide a stable borehole; a pipe vise to secure the sampler for thin-walled tube removal and loading; wood blocks for reloading the thin-walled tube into the sampler barrel without damage to the cutting edge; hand tools to remove and install the tube fasteners; and a brush with buckets for cleaning the sampler.

7.2.1 *Rotary Drilling Equipment*—Drills are required that are capable of performing drilling functions in accordance with Practice D 6151 and Guide D 5783. Drill units generally offer a ready hydraulic system for the retraction of samplers from the sampled formation and downward thrust for pushing the sampler through minimal amounts of borehole cave-in to reach desired sampling depth as well as reactive weight to counteract the thin-walled tube discharge pressure. Because most drills are equipped with leveling jacks, better weight application is achieved. Vertical pushing is improved because of the ability to level the machine. Tool handling is facilitated by high-speed winches common to drilling rigs, extended masts for long tool pulls, and sampler holding devices. Drill units are commonly fitted with fluid pumps that will provide the activation fluid. The unit must have a working pressure measurement gage in the fluid discharge line positioned where it can be easily read. This gage will be the indicator of how the sampler is functioning as well as when the thin-walled tube has been fully extruded.

7.3 *Activation Fluid*—The generally accepted activation fluid for using the hydraulically activated stationary piston sampler is clean water. The sealing areas inside the sampler have tight tolerances and as such cannot tolerate many physical impurities. The use of regular drilling water that is contaminated with drill cuttings can impair the operation of the sampler and cause damage to the seal system. Water containing drill fluid additives can be used to activate the sampler. However, this fluid must also be free of foreign particles. In certain cases it may be advantageous to use drilling fluid additives such as when the injection of clean water may negatively affect