Designation: D4700 – 15

Standard Guide for Soil Sampling from the Vadose Zone[1]

This standard is issued under the fixed designation D4700; 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.

INTRODUCTION

This standard was developed in 1991 and has not undergone a technical revision. Since that time, many other guides and practices were developed in the response to the need for improved environmental exploration methods. There are new guides for Soil and Rock sampling and Mechanical Drilling. New Direct Push and Sonic methods were developed. The revision of this standard will add all the new related standards but there will not be significant additions or deletions to the original content. The user will be directed to the related standards.

1. Scope

1.1 This guide covers procedures that may be used for obtaining soil samples from the vadose zone (unsaturated zone). Samples can be collected for a variety of reasons including the following:

1.1.1 Stratigraphic description,
1.1.2 Hydraulic conductivity testing,
1.1.3 Moisture content measurement,
1.1.4 Moisture release curve construction,
1.1.5 Geotechnical testing,
1.1.6 Soil gas analyses,
1.1.7 Microorganism extraction,
1.1.8 Pore liquid evaluation, or
1.1.9 Laboratory chemical analysis identifying contaminant types and concentrations within soils.

1.2 Guides D6169 on Selection of Soil and Rock Sampling Devices and D6282 on Drilling methods for Environmental Site Characterization provide subsequent supplemental information to the contents of this standard.

1.2.1 Direct Push Soil Sampling (Guide D6282) and Sonic Drilling for Site Characterization (Practice D6914) are used extensively for environmental soil sampling in the Vadose zone.

1.3 Subsurface explorations are documented in accordance with D5434 on Logging of Subsurface Explorations.

1.4 Soil core may require processing using Practice D6640 on Collection and Handling of Soil Cores for Environmental Explorations.

1.5 This guide focuses on methods that provide soil samples for chemical analyses of the soil or contained liquids or contaminants. However, comments on how methods may be modified for other objectives are included.

1.6 This guide does not describe sampling methods for lithified deposits and rocks (for example, sandstone, shale, tuff, granite).

1.7 In general, it is prudent to perform all field work with at least two people present. This increases safety and facilitates efficient data collection.

1.8 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered standard.

1.9 *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.*

1.10 *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*

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[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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unique aspects. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids
D1452 Practice for Soil Exploration and Sampling by Auger Borings
D1586 Test Method for Penetration Test (SPT) and Split-Barrel Sampling of Soils
D1587 Practice for Thin-Walled Tube Sampling of Soils for Geotechnical Purposes
D2488 Practice for Description and Identification of Soils (Visual-Manual Procedure)
D3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils
D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction
D4220 Practices for Preserving and Transporting Soil Samples
D5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock
D6151 Practice for Using Hollow-Stem Augers for Geotechnical Exploration and Soil Sampling
D6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations
D6282 Guide for Direct Push Soil Sampling for Environmental Site Characterizations
D6286 Guide for Selection of Drilling Methods for Environmental Site Characterization
D6519 Practice for Sampling of Soil Using the Hydraulically Operated Stationary Piston Sampler
D6640 Practice for Collection and Handling of Soils Obtained in Core Barrel Samplers for Environmental Investigations
D6907 Practice for Sampling Soils and Contaminated Media with Hand-Operated Bucket Augers
D6914 Practice for Sonic Drilling for Site Characterization and the Installation of Subsurface Monitoring Devices

3. Terminology

3.1 *Definitions:*

3.1.1 For definitions of common technical terms in this standard, refer to Terminology D653.

3.1.2 For definitions and classifications of soil related terms used, refer to Practice D2488.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *cascading water*—perched ground water that enters a well casing via cracks or uncovered perforations, trickling, or pouring down the inside of the casing.

[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.

3.2.2 *sludge*—a water charged sedimentary deposit.

3.2.2.1 *Discussion*—The water-formed sedimentary deposit may include all suspended solids carried by the water and trace elements that were in solution in the water. Sludge usually does not cohere sufficiently to retain its physical shape when mechanical means are used to remove it from the surface on which it deposits, but it may be baked in place and be adherent.

4. Summary of Guide

4.1 Sampling vadose zone soil involves inserting into the ground a device that captures, retains, and recovers a sample. Devices and systems for vadose zone sampling are divided into two general groups, namely the following: samplers used in conjunction with hand operated devices; and samplers used in conjunction with multipurpose auger, direct push, sonic, or other type of drill rigs. This guide discusses these groups and their associated practices.

4.2 The discussion of each device is organized into three sections, describing the device, describing sampling methods, and limitations and advantages of its use.

4.3 This guide identifies and describes a number of sampling methods and samplers. It is advisable to consult available site-specific geological and hydrological data to assist in determining the sampling method and sampler best suited for a specific project. It is also advisable to contact a local firm providing the services required as not all sampling and drilling methods described in this guide are available nationwide.

5. Significance and Use

5.1 Chemical analyses of liquids, solids, and gases from the vadose zone can provide information on the presence, possible source, migration route, and physical-chemical behavior of contaminants. Remedial or mitigating measures can be formulated based on this information. This guide describes devices and procedures that can be used to obtain vadose zone soil samples.

5.2 Soil sampling is useful for the reasons presented in Section 1. However, it should be recognized that the general method is destructive, and that resampling at an exact location is not possible. Therefore, if a long term monitoring program is being designed; other methods for obtaining samples should be considered.

NOTE 1—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/inspection/etc. Users of this standard are cautioned that compliance with Practice D3740 does not in itself ensure reliable results. Reliable results depend on many factors; Practice D3740 provides a means of evaluating some of those factors

6. Criteria for Selecting Soil Samplers

6.1 Important criteria to consider when selecting devices for vadose zone soil sampling include the following:

6.1.1 Type of sample: An encased core sample, an uncased core sample, a depth-specific representative sample, or a sample according to requirements of the analyses,

6.1.2 Sample size requirements,

6.1.3 Suitability for sampling various soil types,

6.1.4 Maximum sampling depth,

6.1.5 Suitability for sampling soils under various moisture conditions,

6.1.6 Ability to minimize cross contamination,

6.1.7 Accessibility to the sampling site, and

6.1.8 Personnel requirements.

6.2 The sampling devices described in this guide have been evaluated for these criteria. The results are summarized in Fig. 1.

7. Sampling with Hand Operated Devices

7.1 These devices, which have mostly been developed for agricultural purposes, include:

7.1.1 Screw-type augers,

7.1.2 Barrel augers,

7.1.3 Tube-type samplers,

7.1.4 Hand held power augers, and

7.1.5 Trench sampling with shovels in conjunction with machine excavations.

7.2 The advantages of using hand operated devices over drill rigs are the ease of equipment transport to locations with poor vehicle access, and the lower costs of setup and decontamination. However, a major disadvantage is that these devices are limited to shallower depths than drill rigs.

7.3 Practice D1452 on Soil Exploration and Sampling by Auger Borings provides additional information on the augers systems listed below.

7.4 *Screw-Type Augers:*

7.4.1 *Description*—The screw or ship auger is essentially a small diameter (for example, 1.5 in. (3.81 cm)) wood auger from which the cutting side flanges and tip have been removed (**1**)[3] see Fig. 2(*a*). According to the Soil Survey Staff (**1**), the spiral part of the auger should be about 7 in. (18 cm) long, with the distances between flights about the same as the diameter (for example, 1.5 in. (3.81 cm)) of the auger. This facilitates measuring the depth of penetration of the tool. Variations on this design include the closed spiral auger and the Jamaica open spiral auger (**2**) (see Fig. 2(*b*) and (*c*)). The auger is welded onto a length of solid or tubular rod. The upper end of this rod is threaded, to accept a handle or extension rods. As many extensions are used as are required to reach the target sampling depth. The rod and the extensions are marked in even increments (for example, in 6-in. (15.24-cm) increments) above the base of the auger to aid in determining drilling depth. A wooden or metal handle fits into a tee-type coupling, screwed into the uppermost extension rod.

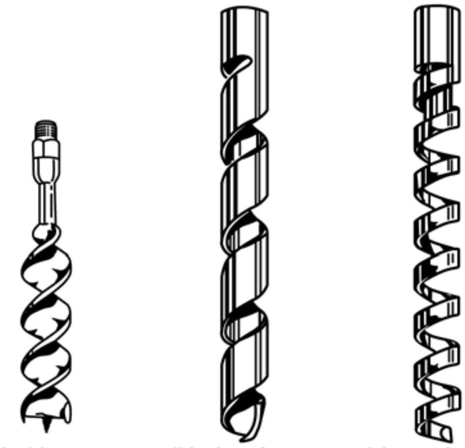

FIG. 2 Screw Type Augers

7.4.2 *Sampling Method*—For drilling, the auger is rotated manually. The operator may have to apply downward pressure to start and embed the auger; afterwards, the auger screws itself into the soil. The auger is advanced to its full length, and then pulled up and removed. Soil from the deepest interval penetrated by the auger is retained on the auger flights. A sample can be collected from the flights using a spatula. A foot pump operated hydraulic system has been developed to advance augers up to 4.5 in. (11.43 cm) in diameter. This larger diameter allows insertion of other sampling devices into the drill hole, once the auger is removed, if desired (**3**).[4]

7.4.3 *Comments*—Samples obtained with screw-type samplers are disturbed and are not truly core samples. Therefore, the samples are not suitable for tests requiring undisturbed samples, such as hydraulic conductivity tests. In addition, soil structures are disrupted and small scale lithologic features cannot be examined. Nevertheless, screw-type samplers are still suitable for use in collecting samples for the purpose of detecting contaminants. However, it is difficult to avoid transporting shallow soils downward when reentering a drill hole. When representative samples are desired from a discrete interval, the borehole must be made large enough to insert a sampler and extend it to the bottom of the borehole without touching the sides of the borehole. It is suggested that a larger diameter auger be used to advance and clear the borehole, then a smaller diameter auger sampler be used to obtain the sample.

Type of Sampler	Obtains Core Sample		Most Suitable Core Types		Operation in Stoney Soils		Most Suitable Soil Moisture Conditions			Access to Sample Sites During Poor Soil Conditions		Relative Sample Size		Labor Req'mts	
	Yes	No	Coh.	Coh'less	Fav.	Unfav.	Wet	Dry	Inter.	Yes	No	Sm.	Lg.	Sngl.	2/More
A. Drill Rig Samplers															
1. Multipurpose Drill Rig	◆		◆	◆	◆		◆	◆	◆	◆		◆	◆		
2. Split-barrel Drive Sampler	◆		◆		◆			◆			◆		◆		◆
3. Thin-Walled Tube Sampler	◆		◆			◆			◆	◆			◆		◆
4. Piston Sampler	◆		◆			◆	◆			◆			◆		◆
5. Continuous Sample Tube system	◆		◆		◆		◆	◆	◆	◆		◆	◆		◆
6. Hand-Held Power Auger		◆			◆					◆			◆		◆
B. Hand Operated Samplers															
1. Screw-Type Auger		◆				◆	◆			◆		◆		◆	
2. Barrel Auger															
a. Post-Hole Auger		◆	◆		◆		◆			◆			◆	◆	
b. Dutch Auger		◆	◆		◆		◆								
c. Regular Barrel Auger		◆	◆		◆				◆	◆		◆		◆	
d. Sand Auger		◆		◆	◆				◆	◆			◆	◆	
e. Mud Auger		◆	◆		◆		◆			◆			◆	◆	
3. Tube-Type Sampler															
a. Soil Sampling Tube															
(1) Wet Tip	◆					◆	◆			◆				◆	
(2) Dry Tip	◆					◆	◆			◆		◆		◆	
b. Veihmeyer Tube	◆								◆			◆		◆	

NOTE 1—This table does not contain new drilling methods added in the 2015 revision.

FIG. 1 Criteria for Selecting Soil Sampling Equipment

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

[4] This reference is manufacturer's literature, and it has not been subjected to technical review.

Screw-type augers work better in wet, cohesive soils than in dry, loose soils. Sampling in very dry (for example, powdery) soils may not be possible with these augers as soils will not be retained on the auger flights. Also, if the soil contains gravel or rock fragments larger than about one tenth of the hole diameter, drilling may not be possible (**4**).[4]

7.5 *Barrel Augers:*

7.5.1 *Description*—The barrel auger consists of a bit with cutting edges welded to a short tube or barrel within which the soil sample is retained, welded in turn to shanks. The shanks are welded to a threaded rod at the other end. Extension rods are attached as required to reach the target sampling depth. Extensions are marked in increments above the base of the tool. The uppermost extension rod contains a tee-type coupling for a handle. The auger is available in carbon steel and stainless steel with hardened steel cutting edges (**5**, **6**).[4]

7.5.2 *Sampling Method*—The auger is rotated to advance the barrel into the ground. The operator may have to apply downward pressure to keep the auger advancing. When the barrel is filled, the unit is withdrawn from the soil cavity and a sample may be collected from the barrel.

7.5.3 *Comments*—Barrel augers generally provide larger samples than screw-type augers. The augers can penetrate shallow clays, silts, and fine grained sands (**7**).[4] The augers do not work well in gravelly soils, caliche, or semi-lithified deposits. Samples obtained with barrel augers are disturbed and are not core samples. Therefore, the samples are not suitable for tests requiring undisturbed samples, such as hydraulic conductivity tests. Nevertheless, the samplers are still suitable for use in collecting samples for the purpose of detecting contaminants. Because the sample is retained inside the barrel, there is less of a chance of mixing it with soil from a shallower interval during insertion or withdrawal of the sampler. The following are five common barrel augers:

7.5.3.1 Post-hole augers (also called Iwan-type augers),

7.5.3.2 Dutch-type augers,

7.5.3.3 Regular or general purpose barrel augers,

7.5.3.4 Sand augers, and

7.5.3.5 Mud augers.

7.5.4 *Post-Hole Augers*—The most readily available barrel auger is the post-hole auger (also called the Iwan-type auger) (**8**). As shown in Fig. 3, the barrel consists of two-part cylindrical leaves rather than a complete cylinder and is slightly tapered toward the cutting bit. The taper and the cupped bit help to retain soils within the barrel. The barrel is available with a 3 to 12-in. (7.62 to 30.48-cm) diameter. There are two types of drilling systems, one has a single rod and handle, and the other has two handles. In stable, cohesive soils, the auger can be advanced up to 25 ft (7.62 m) (**8**).

7.5.5 *Dutch-Type Augers*—The Dutch-type auger (commercially developed by Eijkelkamp) is a smaller variation of the post-hole auger design. As shown in Fig. 4, the pointed bit is continuous with two, narrow part-cylindrical barrel segments, welded onto the shanks. The barrel generally has a 3 in. (7.62 cm) outside diameter. This tool is best suited for sampling wet, clayey soils.

7.5.6 *Regular or General Purpose Barrel Augers*—A version of the barrel auger commonly used by soil scientists and county agricultural agents is depicted in Fig. 5(*a*) and (*b*). As shown, the barrel is a complete cylinder. As with the post-hole auger, the cutting blades are cupped so that soil is loosened and forced into the barrel as the unit is rotated and pushed into the ground. Each filling of the barrel corresponds to a depth of penetration of 3 to 5 in. (7.62 to 12.70 cm) (**1**). The most popular barrel diameter is 3.5 in. (8.89 cm), but sizes ranging from 1.5 to 7 in. (3.81 to 17.78 cm) are available (**6**).[4] Plastic, stainless steel, PTFE (polytetrafluoroethylene), or aluminum liners can also be used (**6**).[4] Extension rods are available in 4 ft (1.22 m) lengths. The rods can be made from standard black pipe, from lightweight conduit or from seamless steel tubing. The extensions have evenly spaced marks to facilitate determining sample depth. The regular barrel auger is suitable for use in loam type soils.

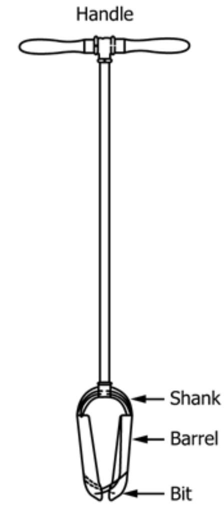

FIG. 3 Post-Hole Type (Iwan-type) Barrel Auger

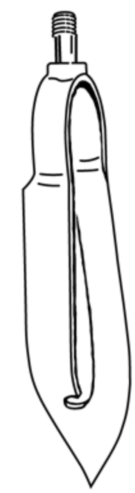

FIG. 4 Dutch-type Auger

NOTE 2—Committee D34 has used the term "Bucket" in Practice D6907 to refer to this type of auger and this standard provides additional information on their use.

7.5.7 *Sand Augers*—For dry, sandy soils it may be necessary to use a variation of the regular barrel auger that includes a specially-formed bit to retain the sample in the barrel (see Fig.

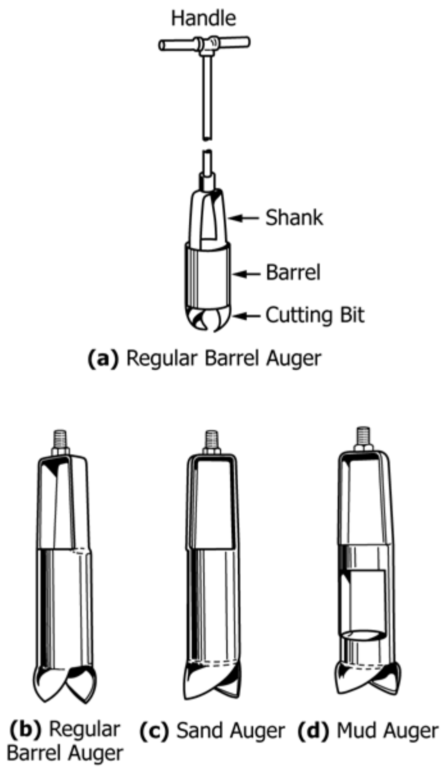

FIG. 5 Barrel Auger Variations

5(*c*)). Sand augers with 2, 3, or 4-in. (5.08, 7.62, or 10.16-cm) diameters are available (**5**).[4]

7.5.8 *Mud Augers*—Another variation on the regular barrel auger design is available for sampling wet, clayey soils. As shown in Fig. 5(*d*), the barrel is designed with open sides to facilitate extraction of samples. The bits are the same as those used on the regular barrel auger (**6**).[4] Mud augers with 2, 3, or 4-in. (5.08, 7.62, or 10.16-cm) diameters are available (**5**).[4]

7.6 *Tube-Type Samplers:*

7.6.1 Tube-type samplers generally have proportionally smaller diameters and greater body lengths than those of barrel augers.

7.6.2 For sampling, these units are perched into the soil causing the tube to fill with material from the interval penetrated. The assembly is then pulled to the surface and a sample can be collected from the tube. Since the device is not rotated, a nearly undisturbed sample can be obtained. Commercial units are available with foot lever attachments, a hydraulic apparatus, or drop-hammers to aid in driving the sampler into the ground (**5**).[4] Vibratory heads have also been developed to advance tube-type samplers (**9**).[4]

7.6.3 These units are not as suitable for sampling in compacted, gravelly soils as are the barrel augers. They are preferred if an undisturbed sample is required. Commonly used varieties of the tube type samplers include:

7.6.3.1 Soil sampling tubes (also called Lord samplers),

7.6.3.2 Veihmeyer tubes (also called King tubes),

7.6.3.3 Thin-walled tube samplers (also called Shelby tubes),

7.6.3.4 Ring-lined barrel samplers, and

7.6.3.5 Piston samplers.

7.6.4 *Soil Sampling Tubes:*

7.6.4.1 *Description*—As depicted in Fig. 6, the soil sampling tube consists of a hardened cutting tip, a cut-away barrel, and an uppermost threaded segment. The cut-away barrel allows textural examination and easy removal of soil samples. Generally, the tube is constructed from high strength alloy steel (**10**).[4] The samplers are available with 6, 12, 15, 18, and 24-in. (15.24, 30.48, 38.10, 45.72, and 60.96-cm) lengths (**5, 6**).[4] The tubes are available with 1.13 or 0.88-in. (2.87 or 2.22-cm) outside diameter. Two modified versions of the tip are available, for sampling in wet or dry soils. The sampling tube is attached to extension rods to attain the target sampling depth. A cross-handle is attached to the uppermost rod. Extension rods are made of lightweight, durable metal. They are available in a variety of lengths depending on the manufacturer. Markings on the extensions and the sampler facilitate determining sample depths.

7.6.4.2 *Sampling Method*—The sampler is pushed into the ground by leaning on the unit's handle. Once the sampler has reached the bottom of the sampling interval, it is twisted to break soil continuity at the tip. Depending on the type of cutting edge, the tube sampler may obtain samples varying in diameter from 0.69 to 0.75 in. (1.75 to 1.91 cm).

7.6.4.3 *Comments*—The soil sampling tube works best in soft, clayey, cohesive soils. If the soil contains cobbles or rock fragments larger than about one-half the cutting tip diameter, satisfactory sampling may not be possible. If the soil is cohesionless, it will not be retained in the tube. With time, the cutting tip will be damaged and worn dull. Most units are designed so that this part can be replaced.

7.6.5 *Veihmeyer Tubes:*

7.6.5.1 *Description*—The Veihmeyer tube is a long, complete cylinder. As shown in Fig. 6, this unit consists of a bevelled tip, which is threaded into the lower end of the tube,

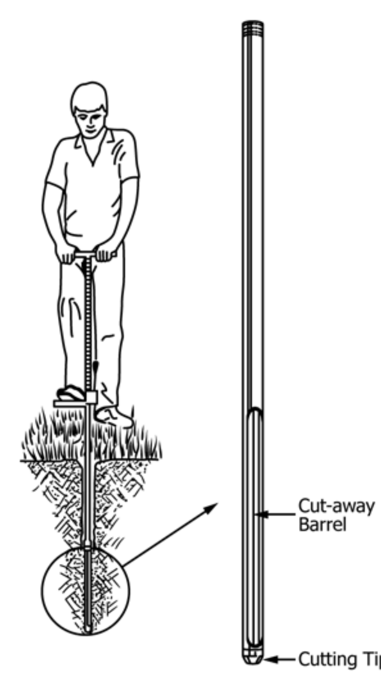

FIG. 6 Tube-type Sampler—Soil Sampling Tube

and a drive head threaded onto the upper end of the tube. The sampler is constructed of hardened steel. The tube is generally marked in even increments (for example, 1 ft or 0.30 m). These samplers are available in 4 to 16-ft (1.22 to 4.88-m) lengths with a 0.75-in. (1.91-cm) inside diameter.

7.6.5.2 *Sampling Method*—The lower guide rod of the drop hammer is slipped into the upper tube, through the drive head (see Fig. 7). The hammer is used to pound the sampler into the ground. The sampler is then retrieved by pulling or jerking up on the hammer to force the sampler out of the soil cavity. Samples are extruded by forcing a rod through the tube.

7.6.5.3 *Comments*—Prior to sampling, the inside of the tube is sometimes coated with a lubricant to facilitate extrusion. However, the types of analyses to be performed on the samples should be considered to determine if the presence of lubricant will cause interference. Because the Veihmeyer sampler is a solid-walled tube and is fitted with a drop hammer, it can generally be used in more resistant soils than the soil sampling tube.

7.6.6 *Thin-Walled Tube Samplers (Practice D1587):*

7.6.6.1 *Description*—Thin-walled tube (Shelby Tube) samplers are readily available with 2, 3, and 5-in. (5.08, 7.62, and 12.70-cm) outside diameters and are commonly 30 in. (76.20 cm) long. The 3 by 30-in. (7.62 by 76.20-cm) outside diameter long sampler is most common. The advancing end of the sampler is rolled inwardly and has a cutting edge with a smaller diameter than the tube inside diameter. The cutting edge inside diameter reduction, defined as a "clearance ratio," is usually in the range of 0.0050 to 0.0150 or 0.50 to 1.50 % (Refer to Practice D1587). The sampler tube is usually connected with set screws to a sampler head that in turn is threaded to connect with extension rods. Plastic and PTFE sealing caps for use after sampling are readily available for the 2, 3, and 5-in. (5.08, 7.62, and 12.70-cm) diameter tubes (refer to Practices D4220). Shelby tubes are commonly available in carbon steel but can be manufactured from other metal (see Fig. 8).

7.6.6.2 *Sampling Method*—The Shelby tube is pushed into soil by hand, with a jack-like system or with a hydraulic piston. The sample recovered is often less than the distance pushed, that is, the recovery ratio is less than 1.0. The recovery ratio is less than 1.0 because of soil compaction during sampling, and because friction between soil and the inner tube walls becomes greater than the shear strength of the soil in front of the tube. Consequently, soil in front of the advancing end of the tube is displaced laterally rather than entering the tube **(11)**. In general, shorter tubes provide less-disturbed samples than longer tubes. Samples are extruded from the Shelby tube with a hydraulic ram. As with all sampling devices, the most disturbed portion of the sample in contact with the tube is considered unrepresentative. Wilson et al. **(12)** developed a paring device to remove this outer layer of the core during extrusion.

7.6.6.3 *Comments*—Shelby tubes are best used in clays, silts, and fine-grained sands. If the soils are cohesionless, they may not be retained in the tube. If firm to very hard soils are encountered, driving (hammering) the sampler may be required. However, this should be avoided as the tube may buckle under the drive stress.

7.6.7 *Ring-Lined Barrel Samplers:*

7.6.7.1 *Description*—As described in Practice D3550, the ring-lined barrel sampler consists of a one piece barrel or two split barrel halves, a drive shoe, rings, and a sampler head (see Fig. 9). The rings, that are usually brass, fit snugly inside the barrel and are designed to be directly inserted into geotechnical testing apparatuses when removed from the barrel. Most samplers are designed to hold at least two rings. The barrel is commonly 3.5 in. (8.89 cm) inside diameter and 3.94 to 5.91 in. (10 to 15 cm) long **(5)**.[4] With these lengths, the barrel can be fitted with a variety of liners ranging in length from 1 to 2.36 in. (2.54 to 6 cm).

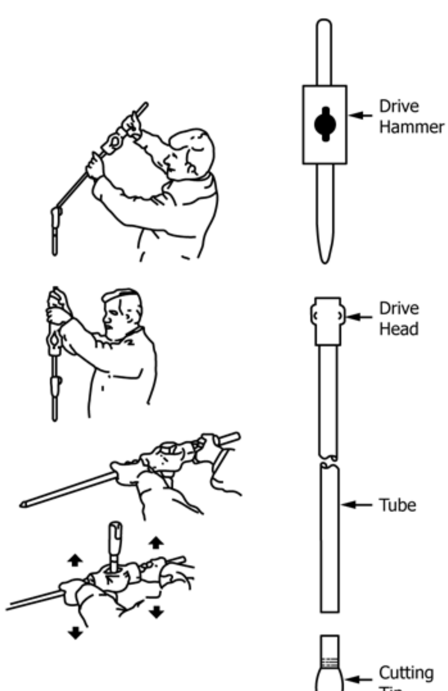

FIG. 7 Veihmeyer Tube

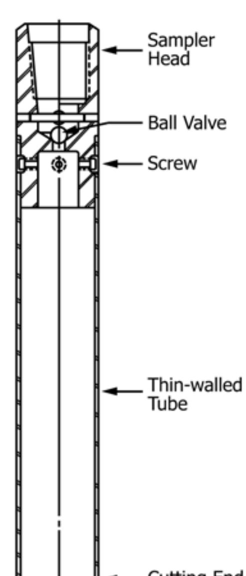

FIG. 8 Thin-Walled Tube Sampler

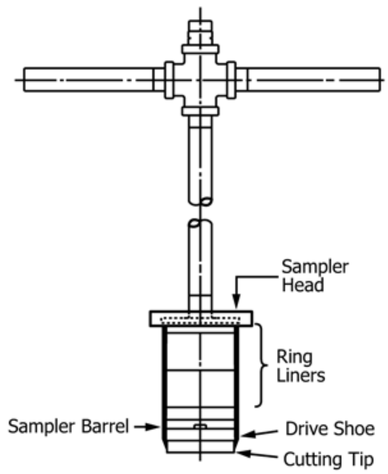

FIG. 9 Hand Operated Ring-Lined Barrel Sampler

7.6.7.2 *Sampling Method*—The ring-lined barrel sampler can be driven or pushed into soil. Once retrieved, the sampler is disassembled, and the sample-filled rings are removed. The rings are usually removed as one unit and placed into a capped container. Alternately, the individual soil-filled rings can be capped with plastic or PTFE and then sealed with wax or adhesive tape (refer to Practices D4220).

7.6.7.3 *Comments*—Because barrel samplers are more rigid than thin-walled tubes, they can be driven into hard soils and soils containing sands and gravels that might damage thin-walled tubes. The sampler provides samples in rings which can be handled without further disturbance of the soil. Because of this, these devices are most often used when geotechnical or chemical analyses are to be performed.

7.6.8 *Piston Samplers:*

7.6.8.1 *Description*—Locally saturated (for example, by perched ground water), or cohesionless soils, and very soft soils or sludges may not be retained in most samplers, even when fitted with retainer baskets or flap valves. Piston samplers can be used in these situations. The sampler consists of a sampling tube, extension pipe attached to the tube, an internal piston, and rods connected to the piston and running through the extension pipe (see Fig. 10). These samplers are often built, as needed, out of common PVC (for use in sludge) or steel pipe fittings. The sampling tube commonly has a 0.75 to 3-in. (1.91 to 7.62-cm) inside diameter and is 8 in. to 9 ft (20.32 cm to 2.74 m) long **(13)**. A variation designed for sampling peat has a cone shaped piston **(8)**.

7.6.8.2 *Sampling Method*—The sampler can be pushed into the ground with the handle or driven into the ground with a drop hammer **(13)**. As the tube is advanced, the piston is held stationary or pulled upward with the attached rods. Once the tube has been advanced through the sampling interval, it is rotated to break suction that might have developed between the soil and the outside wall of the tube. The sampler is then pulled to the surface keeping the piston rod fixed with respect to the extension pipe. The sample is retained because of suction that develops between the piston and the sample. Upon retrieval, the sample is extruded by using the piston to force the sample out of the tube. Sharma and De Dalta **(14)** described a cylindrical sampler for use in very wet soils that would flow back out of most samplers. The design includes a basal shutter that retains the sample while the sampler is withdrawn from the soil.

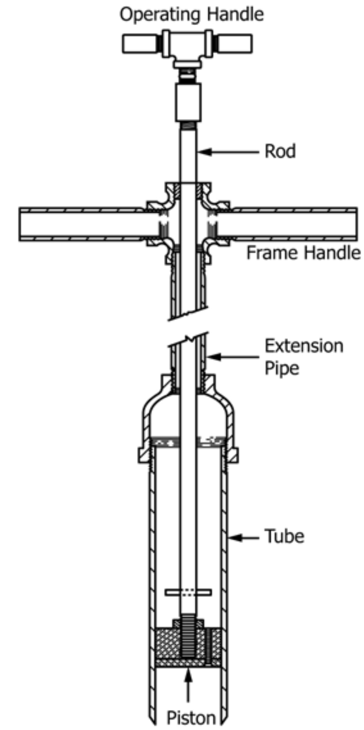

FIG. 10 Hand Operated Piston Sampler

7.6.8.3 *Comments*—Because the sampler depends on development of suction between the sample and the piston, it may not work in unsaturated, coarse-grained sands and gravels. This is due to the high air permeability of such material that prevents the creation of high suction.

7.7 *Hand Held Power Augers:*

7.7.1 *Description*—A very simple, commercially available auger consists of a solid flight auger attached to and driven by a small air-cooled engine (see Fig. 11). Two handles on the head assembly allow two operators to guide the auger into the soil. Throttle and clutch controls are integrated into grips on the

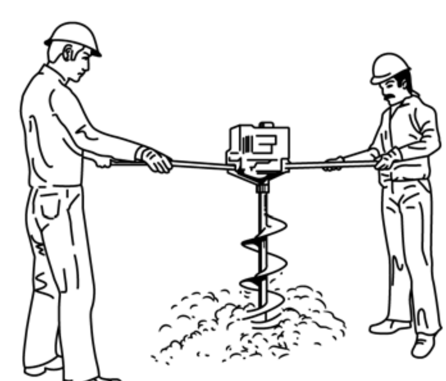

FIG. 11 Hand Held Power Auger

handles. Augers are available with diameters ranging from 2 to 16 in. (5.08 to 40.64 cm). The auger sections are commonly 3 ft (0.91 m) long.

7.7.2 *Sampling Method*—As the auger rotates into soil, cuttings advance up the flights and are discharged at the surface. Soil samples can be collected from the surface discharge or from the auger flights after pulling the auger out of the ground. Alternatively, samples can be collected with other samplers (for example, a thin-walled tube) after auger removal.

7.7.3 *Comments*—As discussed in 7.4, if samples are collected from surface discharge or from the flights, they are disturbed and are not suitable for some uses. In addition, if samples are collected from surface discharge, it is difficult to determine the depth from which the soil came and uncontrolled mixing of soil from different depth intervals can occur. The auger operates well in most soils. However, if the soil is cohesionless, it may not be retained on the flights and sampling in that fashion may not be possible. If the soil contains cobbles or boulders, drilling may not be possible. If the auger "hangs up" on an obstruction, the machine will start to rotate at the surface. Otherwise, the operator should not attempt to stop rotation of the machine by grabbing the handles. An alternate design that transfers the torque to a separate engine prevents this problem (**15**).[4] As previously stated, it is prudent to perform the field work with at least two people present.

7.8 *Trench Sampling:*

7.8.1 *Description*—Soils may be sampled from a trench or pit excavated for that purpose. Excavation is usually performed by a backhoe, and samples are collected with knives, trowels, or shovels. Occasionally, samples are collected from the sides or the bottom of the trench or pit with hand augers or tube-type samplers.

7.8.2 *Sampling Method*—Excavation is performed under the guidance of the sampling technician. Sampling is performed only after the backhoe has moved away from the trench or pit. When the trench or pit is in unstable material or is more than a few feet deep, the sampling technician should only enter the trench or pit after it has been shored or the sidewalls have been cut back to within the angle of repose (see Occupational Safety and Health Administration regulations). Otherwise, samples are more commonly collected at the surface from the bucket of the backhoe as excavation occurs.

7.8.3 *Comments*—The maximum sampling depth for the trench or pit method is dictated by the reach of the backhoe, the soil type and the moisture content of the soil. Maximum depths of up to 20 ft (6.10 m) can be obtained in moist clays. Maximum depths of less than 10 ft (3.05 m) are common in dry sands. Samples collected from the backhoe bucket should be taken from the center of the material to prevent collecting soil contaminated by the bucket surface, and to prevent inclusion of materials that may have fallen from above the desired sampling interval. However, when this is done, it is difficult to accurately estimate the depth from which the sample was obtained. Trenches are useful for obtaining lithologic information since cross sections of the vadose zone can be studied and photographed. Trench or pit sampling is often used in areas with difficult access since backhoes are designed to travel on rough terrain. However, because the process involves excavating a much larger hole than drilling methods, chances of encountering underground utilities are increased and proper backfilling and compaction of the trench is often very difficult.

8. Multipurpose, Auger, Direct Push, and Sonic Drill Rigs (see Guide D6286)

8.1 Vadose zone samplers used in conjunction with drill rigs are identical to those used to sample below the water table. However, commonly used drill rigs such as cable tool and rotary units are not recommended as they generally require the introduction of drilling fluids to the soils to be sampled. Air rotary drilling is also undesirable for obtaining samples for pore liquid or gas extraction. In most cases, hollow-stem augers, direct push, or sonic drilling with some type of cylindrical sampler provide the greatest level of assurance that soil sampled within the vadose zone was not carried downward by the drilling or sampling process. For some geologic circumstances the use of solid stem augers will provide an adequate drilling method.

8.2 *Multipurpose Auger-Core-Rotary Drill Rigs:*

8.2.1 Multipurpose auger-core-rotary drill rigs are generally equipped with rotary power and vertical feed control to advance both hollow-stem augers and continuous flight (solid stem) augers to depths greater than 100 ft (30.48 m). These same drills have secondary capability for rotary and core drilling. The larger of these drills are typically mounted on 20 000 to 30 000-lb (9070 to 13605-kg) GVW trucks. The same multipurpose drill rigs are available on both rubber-tired and track-driven all-terrain carriers. The smaller of the multipurpose drills are typically mounted on trailers or one-ton, 4 by 4 trucks.

8.2.2 When equipped with augers, the sampling process is identical to that for auger drill rigs. When multipurpose auger-core-rotary drill rigs or auger drill rigs are used, the speed of drilling and sampling is much greater than with hand operated equipment. Therefore it is useful to have a larger crew to efficiently handle, log, identify, and preserve the samples.

8.3 *Auger Drill Rigs*—Auger drill rigs are similar to multipurpose auger-core-rotary drill rigs. They are manufactured specifically for efficient auger drilling but do not have the pumps and hoists that are required for efficient core or rotary drilling. The rigs can be equipped with either solid stem or hollow stem augers. There are relatively few auger drills available in comparison to multipurpose auger-core-rotary drills.

8.4 *Direct Push Rigs*—Direct push rigs use hydraulic hammer systems to drive and push the drill string and sampler. They have an advantage over Rotary auger drills in sections 8.2 and 8.3 because cuttings are not generated. They are used widely for soil core sampling for environmental exploration.

8.5 *Sonic Drill Rigs (Practice D6914)*—Sonic drills use a strong drill string vibrator to advance the drill string in addition to some rotary action. Like direct push rigs they also do not generate cuttings in the drilling process and are used for soil core sampling for environmental exploration. They do generate large diameter soils cores very rapidly.

9. Auger Drilling and Sampling

9.1 *Solid Stem Auger Drilling and Sampling (see Practice D1452):*

9.1.1 *Description*—The tools used for solid-stem auger drilling include: auger sections, the drive cap, and the cutter head (see Fig. 12). Auger sections are typically 5 ft (1.52 m) long and are interchangeable for assembly in an articulated but continuously flighted column. Augers are available in diameters up to 24 in. (60.96 cm). The cutter head is attached to the lowermost or leading flight of the auger column. It is about 0.5 in. (1.25 cm) larger in diameter than the flights to reduce friction and torque for greater depth capability. Head types include fish tail or drag bits for use in cohesionless materials, and clay or stinger bits for use in more consolidated material (**16**).

9.1.2 *Sampling Method*—As the auger column is rotated into soil, cuttings are retained on the flights. The augers are then removed from the hole and samples are taken from the retained soil. Samples obtained with solid stem augers are disturbed and are not core samples. Therefore, the samples are not suitable for analyses requiring undisturbed samples, such as hydraulic conductivity tests. This drilling and sampling method can provide an adequately clean, open borehole in some clayey and silty soils. However, when using the solid stem auger drilling method in caving or squeezing ground, the quality and the origin of the recovered samples are questionable because soils from different intervals may have mixed. Therefore, when representative samples from discrete depths are desired, the borehole should be made large enough to insert a smaller diameter auger or another sampler (for example, a thin-walled tube) to the bottom of the borehole, without touching the sides of the borehole (see Fig. 11), to collect a discrete sample from the interval ahead.

9.1.3 *Comments*—Typical drilling depths with solid stem augers range from 50 to 120 ft (15.24 to 36.58 m). The greater drilling depths are attained in firm, silty and clayey soils. However, the depth to which the hole will remain open for sampling once the auger column has been removed is usually less than the maximum drilling depth. If cascading water or cohesionless soils are encountered, it can be expected that the hole will cave at that depth. The sample depth measurement, as taken from its location on an auger, is not precise. This is because soil may move up the flights in an uneven fashion as the auger column is advanced. As with hollow-stem augers, solid stem augers are often painted by the driller or manufacturer. It is prudent to remove this paint before drilling. The majority of the paint can be removed by drilling through sandy soils or by sand blasting. As with all sampling devices, decontamination (for example, steam cleaning) should be performed between holes when chemical analyses are to be performed on the samples. This is especially important with the solid stem auger as it doubles as the drilling and sampling tool.

9.2 *Bucket Auger Drilling and Sampling (see Practice D1452):*

9.2.1 *Description*—The bucket auger is a large diameter cylindrical bucket with auger-type cutting blades on the bottom. The bucket can have a diameter ranging from 12 in. (30.48 cm) up to 6 ft (1.83 m) with lengths varying from 24 to 48 in. (60.96 to 121.92 cm) (**17**). The bottom is hinged to allow cuttings to be emptied out (see Fig. 13).

9.2.2 *Sampling Method*—The bucket is rotated to depth in the vadose zone until the bucket is full. Therefore, depending on the bucket length, sampling intervals can range from 24 to 48 in. (60.96 to 121.92 cm). Sampling consists of extracting small diameter core samples from the interior of the bucket after lowering the full bucket to the ground (see Section 7). This approach minimizes problems with undiscrete mixing of discrete portions to be sampled.

9.2.3 *Comments*—The bucket auger is best suited for sampling from relatively stable clays as the caving problems discussed in 9.1.3 are amplified by the larger hole diameter. Boulders can impede drilling and may have to be individually

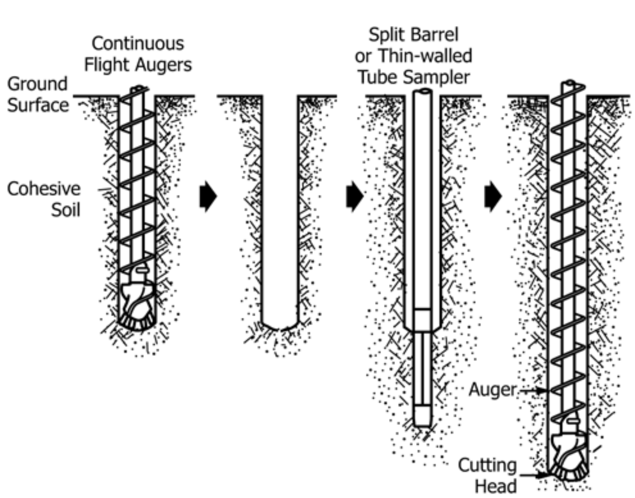

FIG. 12 Solid Stem Auger Sampling

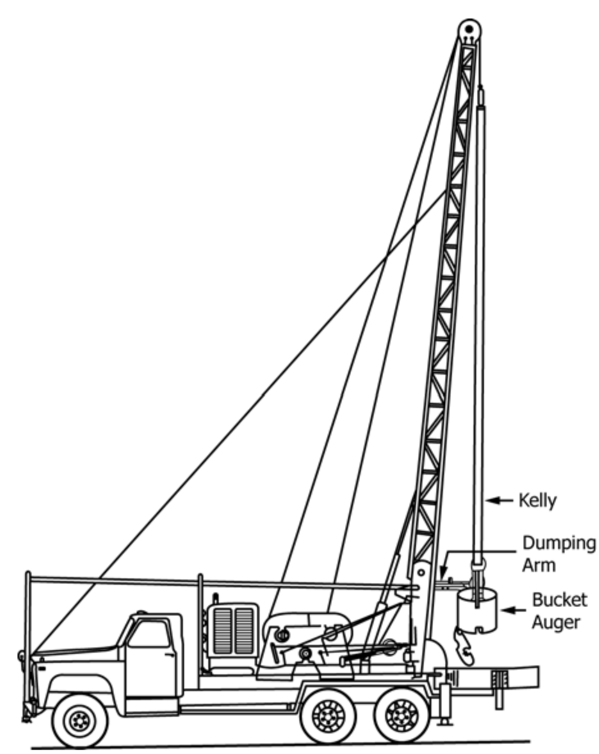

FIG. 13 Bucket Auger and Drilling Rig

removed from the hole before sampling can continue (15)[4]. Generally, boulders up to one-third or one-fourth the bucket diameter can be picked up by the bucket. Common sampling depths are less than 50 ft (15.24 m) but holes up to 250 ft (76.20 m) deep have been drilled (16, 17).

9.3 *Hollow Stem Auger Drilling and Sampling (see Practice D6151):*

9.3.1 *Description*—Outer components of the hollow stem auger system include: hollow auger sections, the hollow auger head, and the drive cap. Inner components include: the pilot assembly, the center rod column, and the rod-to-cap adaptor (see Fig. 14). The auger head contains replaceable carbide teeth that cut and pulverize the formation during flight column rotation. The cutting diameter is somewhat greater than the flighting diameter because of the protruding teeth to reduce friction/torque during drilling. Auger sections are typically 5 ft (1.52 m) long and are interchangeable for assembly in an articulated but continuously flighted column. Drilling progresses in 5 ft (1.52 m) or shorter increments and sampling can be accomplished at any depth within that increment. Upon advancement of a 5 ft (1.52 m) increment, another 5 ft (1.52 m) section of hollow-stem auger and center rod is added. Hollow-stem augers are readily available with 2.25, 2.75, 3.25, 3.75, 4.25, 6.25, and 8.25-in. (5.72, 6.99, 8.26, 9.53, 10.80, 15.88, and 20.96-cm) inside diameters.

9.3.2 *Sampling Method*—The auger column and pilot assembly are advanced to the top of the desired sampling interval. Sampling is accomplished by removing the pilot assembly and center rod, if they are used, and inserting the sampler through the hollow stem of the auger column (see Fig. 15). The sampler may be lowered to the sampling depth by attaching it to center rods or by using a wireline assembly (12). When the sampler is attached to center rods, a sample is collected by pushing or driving the sampler into undisturbed soil with the rig hydraulic system or with a drop hammer. When a wireline is used, the sampler is locked into place ahead of the lower-most auger and advanced into the sampling interval by rotating the auger column (18).[4] Hollow stem augers with a 6.25-in. (15.88-cm) inside diameter allow the use of 5-in. (12.70-cm) outside diameter Shelby tubes and 4.5-in. (11.43-cm) outside diameter split barrel samplers (see 9.4).

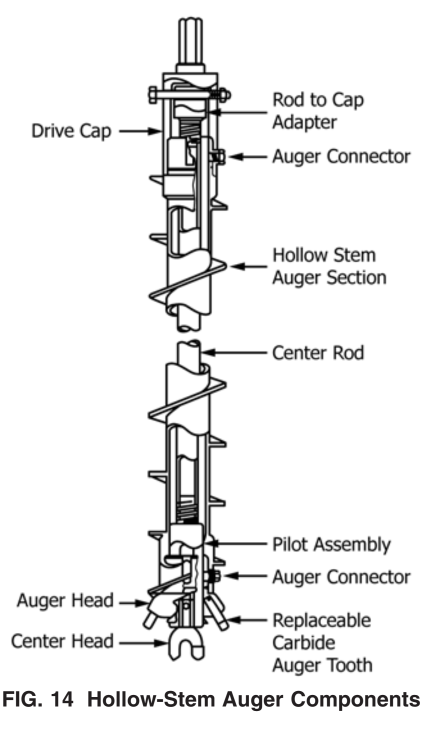

FIG. 14 Hollow-Stem Auger Components

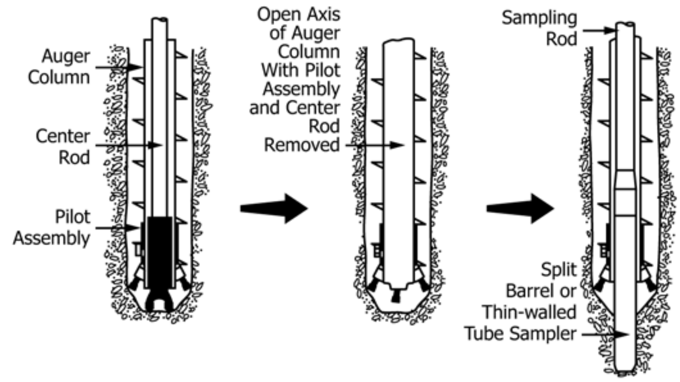

FIG. 15 Hollow-Stem Auger Sampling

9.3.3 *Comments*—The purpose of the center head (pilot) assembly is to prevent soils from entering the auger column as it is advanced (19). Driscoll (17) suggests that the assembly may be omitted when drilling through hard, silty and clayey soils as these materials will usually form a 2 to 4 in. (5.08 to 10.16 cm) long plug at the auger opening. However, Hackett (19) recommends that the pilot assembly be used when detailed samples are required. When perched water is encountered, "heaving sands" that move up into the auger column upon pilot assembly removal during sampling, may be a concern. Various one-way plugs that allow sampling, but that prevent sand from moving into the auger column, are described in Hackett (19). The important capability of being able to obtain samples that do not contain mixed material from shallow sources in the hole is enhanced by using the hollow-stem auger method. However, because the sections are hollow, decontamination of the auger interiors between holes to prevent cross contamination is difficult. High pressure steam cleaners are usually necessary to remove caked-on soils and contaminants. Hollow stem augers may advance rapidly through unconsolidated materials.

9.4 *Sampling Devices:*

9.4.1 Sampling devices used in conjunction with hollow stem augers and occasionally in holes advanced by solid stem augers include:

9.4.1.1 Thin-walled tube samplers (also called Shelby tubes),

9.4.1.2 Split-barrel drive samplers (also called Split spoons),

9.4.1.3 Ring-lined barrel samplers,

9.4.1.4 Continuous sample tube systems, and

9.4.1.5 Piston samplers.

9.4.2 These samplers are either pushed or driven in sequence with an increment of drilling or advanced simultaneously with the advance of a hollow stem auger column.

9.4.3 *Thin-Walled Tube Samplers (see Practice D1587):*

9.4.3.1 *Description*—The thin-walled tube sampler consists of a tube connected to a head with screws. The head is threaded to connect with standard drill rods. The head contains a ball check valve. Thin-walled tube (Shelby tube) samplers are readily available with 2, 3, and 5-in. (5.08, 7.62, and 12.70-cm) outside diameter and are commonly 30 in. (76.20 cm) long. The 3 by 30 in. (7.62 by 76.20 cm) outside diameter long sampler is most common. The advancing end of the sampler is constructed with an inward lip, machined to a cutting edge, which has a smaller diameter than the tube inside diameter. The cutting edge inside diameter reduction, defined as a "clearance ratio," is usually in the range of 0.0050 to 0.0150 or 0.50 to 1.50 % (refer to Practice D1587). PTFE or plastic sealing caps and other sealing devices for use after sampling are readily available for the 2, 3, and 5-in. (5.08, 7.62 and 12.70-cm) diameter tubes (refer to Practices D4220). Shelby tubes are commonly available in carbon steel but can be manufactured from other metal (see Fig. 8).

9.4.3.2 *Sampling Methods*—When a Shelby tube is pushed into soil, the length of the sample recovered is often less than the distance pushed, that is, the recovery ratio is less than 1.0 (see 7.6.6.2). In addition, a portion of the sample frequently remains in the borehole after retrieval of the sampler. This is due to suction that develops at the sampler-soil interface. This suction may be broken by twisting the sampler prior to retrieval or by advancing the auger column below the base of the sampler before retrieval **(20)**. Samples are extruded from the Shelby tube with a hydraulic ram. As with all sampling devices, the portion of the sample in contact with the tube is considered disturbed and unrepresentative. Wilson et al. **(12)** developed a paring device to remove this outer layer of the core during extrusion.

9.4.3.3 *Comments*—The ball check valve was originally intended to provide a vent for drilling fluids when pushing the tube into soil, and also to prevent the column of fluid within the drill stem from forcing the sample out of the tube during retrieval. Since drilling fluids are not used when sampling in the vadose zone, these considerations are not important. However, the valve does provide a vent for air displaced as the sampler is pushed into soil. Shelby tubes are best used in clays, silts, and fine grained sands. They can be pushed with the hydraulic system of most drill rigs in fine grained sands that are loose to moderately consolidated or in clays and silts that are soft to firm. If the soils are cohesionless, they may not be retained in the tube. If consolidated or hard soils are encountered, driving the sampler may be required. However, some tubes may buckle under the drive stress. A spring-loaded barrel has been developed to protect the Shelby tube from buckling when sampling these soils **(21)**.[4]

9.4.4 *Split-Barrel Drive Samplers:*

9.4.4.1 *Description*—The split-barrel drive sampler consists of two split-barrel halves, a drive shoe, and a sampler head containing a ball check valve, all of which are threaded together (see Fig. 16). The most common size has a 2-in. (5.08-cm) outside diameter and a 1.5-in. (3.81-cm) inside diameter split barrel with a 1.375-in. (3.49-cm) inside diameter drive shoe. This sampler is used extensively in geotechnical exploration (Refer to Test Method D1586). When fitted with a

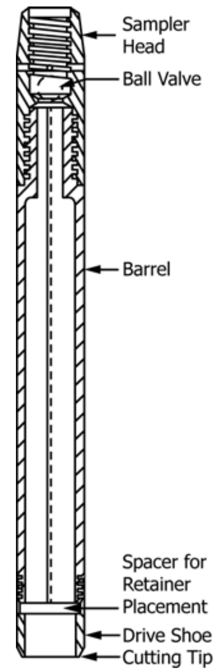

FIG. 16 Split-Barrel Drive Sampler

16 gauge liner for encased cores, the sampler has a 1.375-in. (3.49-cm) inside diameter throughout. A 3-in. (7.62-cm) outside diameter by 2.5-in. (6.35-cm) inside diameter split-barrel sampler with a 2.375-in. (6.03-cm) inside diameter drive shoe is also available **(22)**.[4] Other split-barrel samplers in the size range of 2.5-in. (6.35-cm) to 4.5-in. (11.43-cm) outside diameter are manufactured but are less common. A plastic or metal retainer basket or a flap valve is often fitted into the drive shoe to prevent samples from falling out during retrieval.

9.4.4.2 *Sampling Method*—As described in Test Method D1586 the sampler is threaded onto drilling rods and is lowered to the bottom of the boring. The sampler is then driven into the soil with blows from a drop hammer attached to the drill rig. The hammer usually weighs 140 lb and is operated by the driller. The sampler is extracted from the soil in a manner that will ensure maximum sample recovery. A sample is obtained by disassembling the drive shoe and head, and splitting the barrel to expose the core of soil. Material disturbed by contact with the barrel can be scraped away, or a less disturbed interior portion collected with a spatula.

9.4.4.3 *Comments*—Split barrel drive samplers can be used in all soil types if the larger grain sizes can enter through the opening of the drive shoe. Because the sampler can be fitted with a retainer basket, it is typically used in place of thin-walled tubes when cohesionless soils are to be sampled.

9.4.5 *Ring-Lined Barrel Samplers:*

9.4.5.1 *Description*—As described in Practice D3550, the ring-lined barrel sampler consists of a one piece barrel or two split-barrel halves, a drive shoe, rings, a waste barrel and a sampler head containing a ball check valve (see Fig. 17). The rings fit snugly inside the barrel and are designed to be directly inserted into geotechnical testing apparatus when removed from the barrel. Most samplers are designed to hold at least six rings. The waste barrel provides a space above the rings into

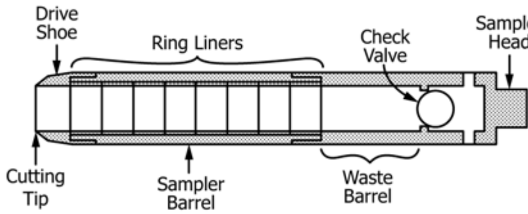

FIG. 17 Ring-Lined Barrel Sampler

which disturbed soil, originally at the bottom of the hole, can move. The samplers are commonly available with 2, 3, and 4-in. (5.08, 7.62, and 10.16-cm) outside diameter.

9.4.5.2 *Sampling Method*—The ring-lined barrel sampler can be driven or pushed into soil. It is important to insert the sampler deep enough to allow all disturbed soil to move through the rings and into the waste barrel. Once retrieved, the sampler is disassembled, and the sample filled rings are carefully removed. The rings are usually removed as one unit and placed into a capped container. Alternately, the individual soil filled rings can be capped with plastic or PTFE and even sealed with wax or adhesive tape (refer to Practices D4220).

9.4.5.3 *Comments*—Because ring-lined barrel samplers are more rigid than thin-walled tubes, they can be driven into soils containing sands and gravels that might damage thin-walled tubes. The sampler provides samples in rings that can be handled without further disturbance of the soil. Because of this, these devices are most often used when geotechnical or chemical analyses are to be performed.

9.4.6 *Continuous Sample Tube System (see Practice D6151):*

9.4.6.1 *Description*—Continuous sample tube systems that fit within a hollow-stem auger column are readily available in North America. The barrel is typically 5 ft (1.52 m) long, and fits within the lead auger of the hollow auger column. The sampler is prevented from rotating as the auger column is turned **(20)**. For many conditions the sampler provides continuous, 5-ft (1.52-m) samples (see Fig. 18). The assembly can be split- or solid-barrel and can be used with or without liners of various metallic and nonmetallic materials **(20)**. Two clear, plastic, 30 in. (76.20 cm) long liners are often used. The sampler may also be fitted with a plastic or metal retainer basket, or a flap valve to prevent cohesionless soils from falling out of the sampler during retrieval **(20)**.

9.4.6.2 *Sampling Method*—The sampler is locked in place inside the auger column with its open end protruding a short distance beyond the end of the column. While advancing the column, soil enters the non-rotating sampling barrel. After a 5-ft (1.52-m) advance, the sampler is withdrawn, and the liner (if used) is removed and capped.

9.4.6.3 *Comments*—The continuous sample tube system replaces the pilot head assembly in the hollow-stem auger column. Because of this, sampling speed is greatly increased since the pilot assembly does not have to be removed before taking a sample. The continuous sample tube system is best used in clays, silts, and in fine grained sands. It can be used to sample soils that are much more consolidated or harder than can be sampled with Shelby tubes.

9.4.7 *Piston Samplers (see Practice D6519):*

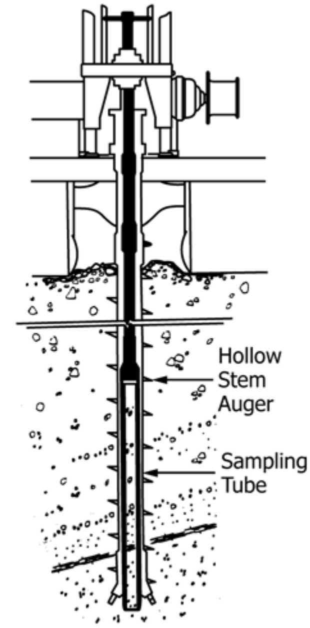

FIG. 18 Continuous Sample Tube System

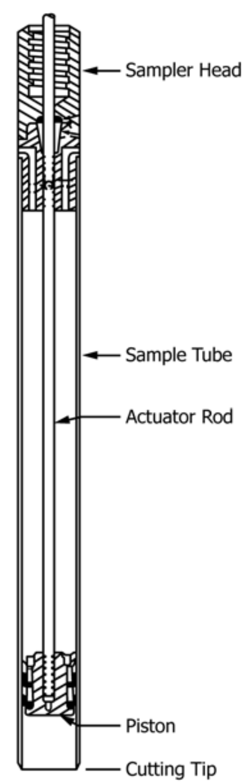

FIG. 19 Piston Sampler

9.4.7.1 *Description*—Locally saturated (for example, perched ground water), or cohesionless soils, and very soft soils or sludges may not be retained in most samplers, even when they have been fitted with retainer baskets or flap valves. Piston samplers are often used under these conditions. The sampler consists of a sampling tube, an internal piston, and a drive head. The piston fits snugly inside the tube. The piston is attached to a rod assembly or a cable that leads to the surface. Tubes made of steel are available in 5.5 and 30-in. (13.97 and 76.20-cm) and 5-ft (1.5-m) lengths with 0.75, 2, 3, 4, and 5-in. (1.91, 5.08, 7.62, 10.16, and 12.70-cm) inside diameter (**22, 23**). When equipped with a hardened steel drive shoe, the tube can be fitted with a liner made of aluminum clear PVC, or another material (see Fig. 19) (**24**). A version of the sampler designed for peat sampling has a cone shaped piston (**8**).

9.4.7.2 *Sampling Method*—Prior to sampling, the piston is placed at the base (advancing end) of the tube. The sampler is then attached to drill rods and lowered down the borehole or hollow-stem auger column to the bottom of the hole (top of the sampling interval). The sampler is then pushed or driven into the sampling interval. As the tube moves downward, the piston remains stationary and in contact with the top of the soil sample. When the sampler is withdrawn, soil is retained because of suction that develops between the piston and the soil core within the sampler. This suction is stronger than the suction at the bottom of the sampler that would tend to extract soil from the sampler. Even so, it is often useful to twist the sampler with the drill rods prior to retrieval, to break suction at the bottom end and ensure that the sample will not be pulled out of the sampler.

9.4.7.3 *Comments*—Average recovery ratios greater than 0.9 can be attained with this sampling tool (**24, 25**). However, because the sampler depends on development of suction between the sample and the piston, it may not work in unsaturated, coarse grained sands and gravels. This is due to the high air permeability of such material that prevents the creation of suction with the sampler. Samples collected with piston samplers are relatively undisturbed. Zapico et al. (**24**) described techniques for extracting fluid samples directly from liners, and for converting liners into permeameters.

9.4.8 *Direct Push Piston Samplers (Guide D6282),* as discussed below, can be used inside of augers to obtain a sample at the base of the boring. For depth discrete soil sampling applications for chemical analysis of soils collected, in a caving, swelling, or heaving lithology, it is recommended to use a single tube sealed piston sampler that will displace soils while being driven to the depth where soil sampling is to begin, to prevent collection of soils prior to the target sampling depth. A center rod and internal drive tip displace soils while simultaneously preventing soils from entering the sampler. This prevents premature sample collection and eliminates or minimizes the chance for cross-contamination. Depth specific piston sampler also uses a core catcher within the drive tip to prevent sample loss in fine, dry sandy, or slippery clays soils. This type of piston sampler allows for repeated depth-specific sample collection in boreholes that may be caving, swelling, or heaving. (see Figs. 20 and 21).

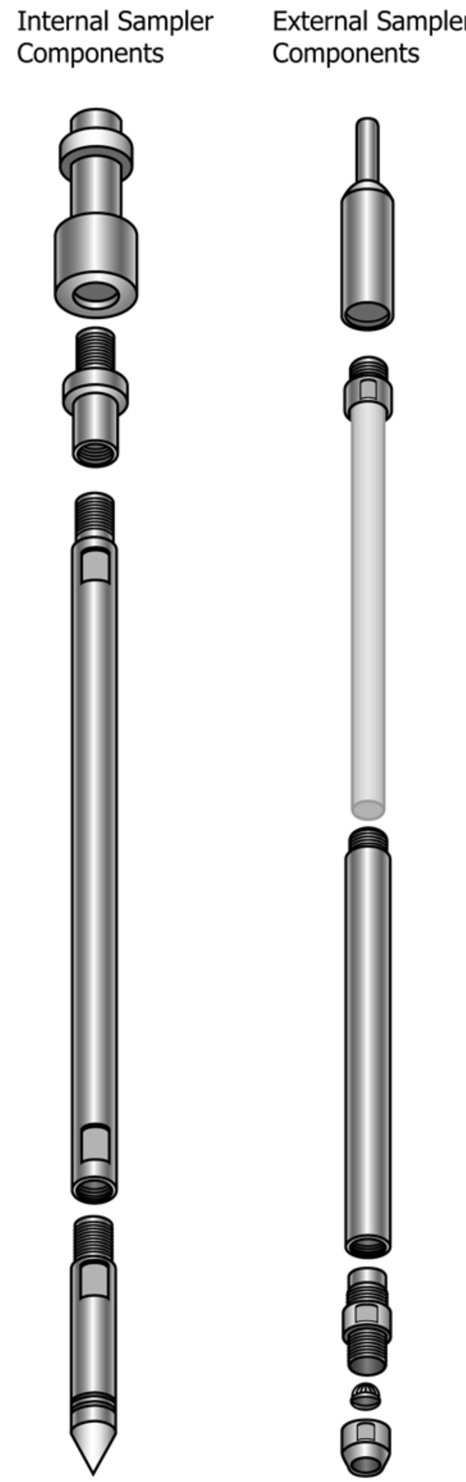

FIG. 20 Depth-Specific Piston Sampler (Guide D6282)

10. Direct Push Soil Sampling

10.1 Direct push soil sampling is addressed in detail in Guide D6282. There are dual tube systems and single tube systems. The single tube system normally uses the piston sampler discussed above and shown on Figs. 20 and 21. Dual tube systems have an advantage that the outer tube acts as a casing assuring stable cased boring and allows for other sampling, testing, or installation of wells inside the casing. Dual tube system is most often used in a continuous sampling mode as illustrated on Fig. 22.

11. Sonic Drilling

11.1 Sonic drills deploy a two casing system where the inner barrel is a core sampler. It is most often used in a continuous

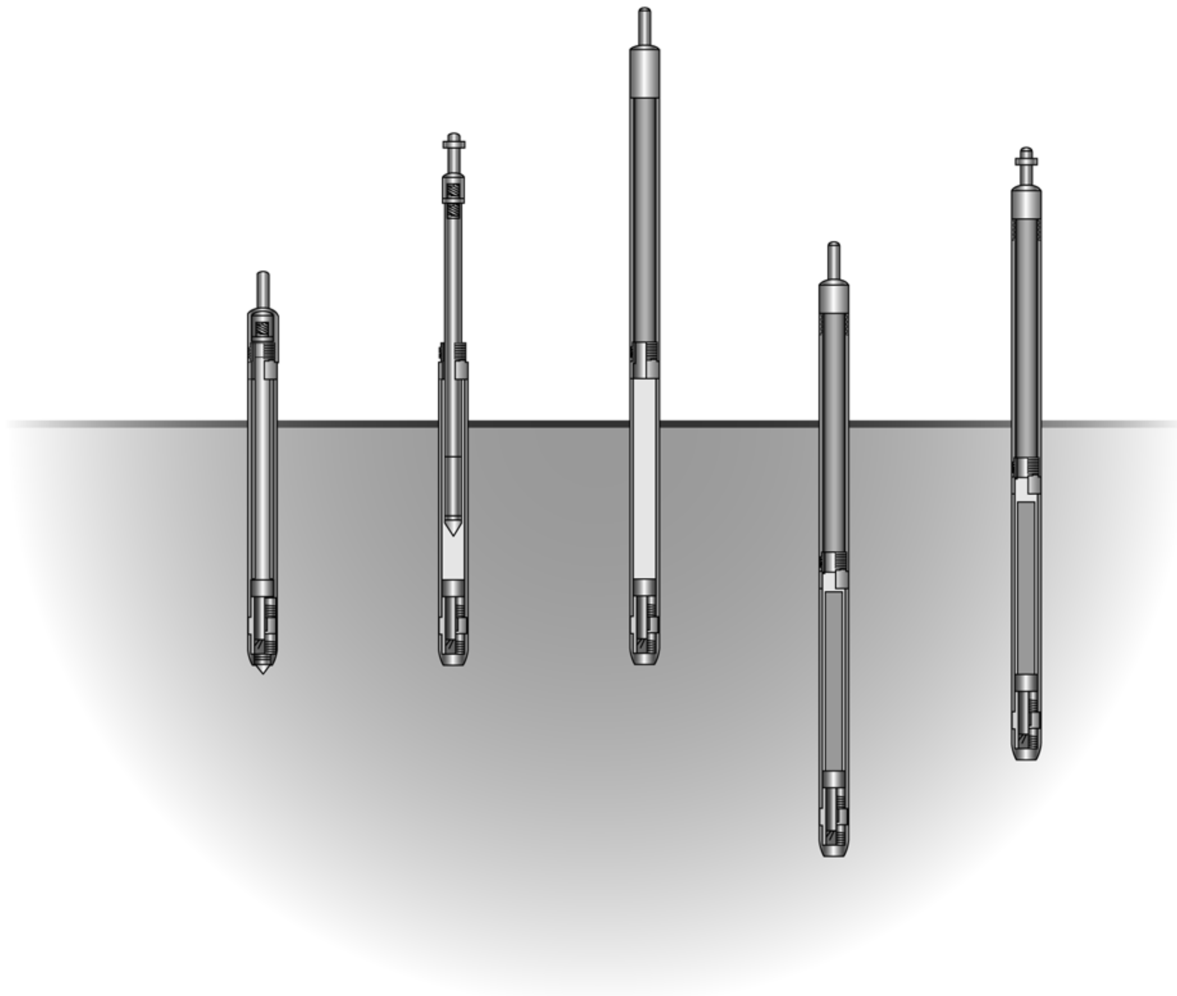

FIG. 21 Stages of Depth-Specific Piston Sampler (see Guide D6282 for sequence)

sampling mode with long sample lengths. The outer casing keeps the borehole protected and allows for other sampling methods to be used at the base of the boring. For more information on this drilling and sampling system consult Practice D6914.

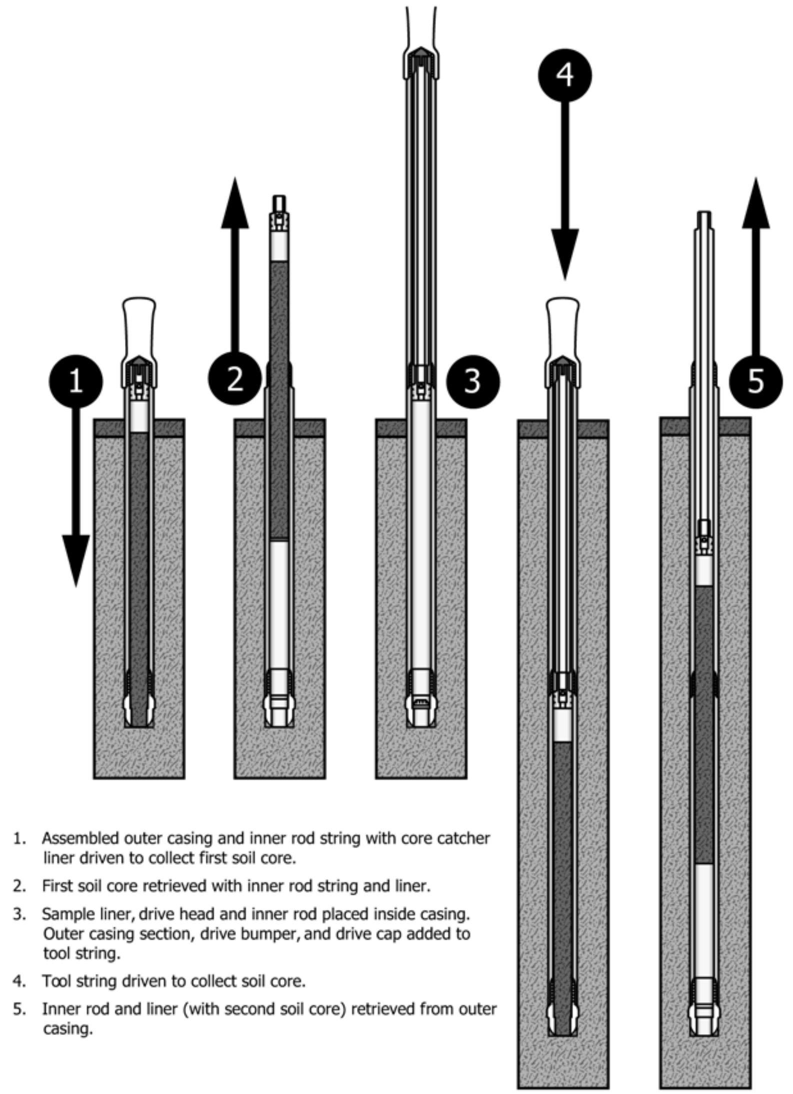

FIG. 22 Dual Tube Direct Push Soil Sampler Operation (from Guide D6282)

REFERENCES

Note: As noted in Section 1 and Footnote 4, this historical standard was minimally revised in 2015. The references were not changed from the historical standard. Many of the citations, especially manufacturer sales catalogs may no longer be available. For more information, refer to newer ASTM standards cited in Section 1.

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