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Standard Guide for Direct Push Soil Sampling for Environmental Site Characterizations¹

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1. Scope

1.1 This guide addresses direct push soil samplers, which also may be driven into the ground from the surface or through prebored holes. The samplers can be continuous or discrete interval units. Samplers are advanced by a combination of static push, or impacts from hammers, or vibratory methods, or a combination thereof, to the depth of interest. The guide does not cover open chambered samplers operated by hand such as augers, agricultural samplers operated at shallow depths, or side wall samplers. This guide does not address single sampling events in the immediate base of the drill hole using rotary drilling equipment with incremental drill hole excavation. Other sampling standards, such as Test Methods D 1586 and D 1587 and Practice D 3550 apply to rotary drilling activities. This guide does not address advancement of sampler barrel systems with methods that employ cuttings removal as the sampler is advanced. Other drilling and sampling methods may apply for samples needed for engineering and construction applications.

1.2 Guidance on preservation and transport of samples, as given in Guide D 4220, may or may not apply. Samples for chemical analysis often must be subsampled and preserved for chemical analysis using special techniques. Practice D 3694 provides information on some of the special techniques required. Additional information on environmental sample preservation and transportation is available in other references (1, 2).² Samples for classification may be preserved using procedures similar to Class A. In most cases, a direct push sample is considered as Class B in Practice D 4220 but is protected, representative, and suitable for chemical analysis. The samples taken with this practice do not usually produce Class C and D (with exception of thin wall samples of standard size) samples for testing for engineering properties, such as shear strength and compressibility. Guide D 4700 has some information on mechanical soil sampling devices similar to direct push techniques, however, it does not address most direct push sampling

methods. If sampling is for chemical evaluation in the Vadose Zone, consult Guide D 4700 for any special considerations.

1.3 Field methods described in this guide, include the use of discreet and continuous sampling tools, split and solid barrel samplers and thin walled tubes with or without fixed piston style apparatus.

1.4 Insertion methods described include static push, impact, percussion, other vibratory/sonic driving, and combinations of these methods using direct push equipment adapted to drilling rigs, cone penetrometer units, and specially designed percussion/direct push combination machines. Hammers providing the force for insertion include drop style, hydraulically activated, air activated and mechanical lift devices.

1.5 Direct push soil sampling is limited to soils and unconsolidated materials that can be penetrated with the available equipment. The ability to penetrate strata is based on hammer energy, carrying vehicle weight, compactness of soil, and consistency of soil. Penetration may be limited or damage to samplers and conveying devices can occur in certain subsurface conditions, some of which are discussed in 5.5. Successful sample recovery also may be limited by the ability to retrieve tools from the borehole. Sufficient retract force must be available when attempting difficult or deep investigations.

1.6 This guide does not address the installation of any temporary or permanent soil, ground water, vapor monitoring, or remediation devices.

1.7 The practicing of direct push techniques may be controlled by local regulations governing subsurface penetration. Certification, or licensing requirements, or both, may need to be considered in establishing criteria for field activities.

1.8 The values stated in SI units are to be regarded as standard; however, dimensions used in the drilling industry are given in inch-pound units by convention. Inch-pound units are used where necessary in this guide.

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*

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² The boldface numbers in parentheses refer to the list of references at the end of this standard.

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.

2. Referenced Documents

2.1 ASTM Standards:

- D 420 Guide to Site Characterization for Engineering, Design and Construction Purposes³
- D 653 Terminology Relating to Soil, Rock and Contained Fluids³
- D 1452 Practice for Soil Investigation and Sampling by Auger Boring³
- D 1586 Test Method for Penetration Test and Split-Barrel Sampling of Soils³
- D 1587 Practice for Thin-Wall Tube Sampling of Soils³
- D 2488 Practice for Description and Identification of Soils (Visual-Manual Method)³
- D 3550 Practice for Ring-Lined Barrel Sampling of Soils³
- D 3694 Practices for Preparation of Sample Containers and for Preservation of Organic Constituents⁴
- D 4220 Practices for Preserving and Transporting Soil Samples³
- D 4700 Guide for Soil Sampling from the Vadose Zone³
- D 4750 Test Method for Determining Subsurface Liquid Levels in a Borehole or Monitor Well (Observation Well)³
- D 5088 Practice for Decontamination of Field Equipment Used at Nonradioactive Waste Sites³
- D 5092 Practice for Design and Installation of Ground Water Monitoring Wells in Aquifers³
- D 5299 Guide for Decommissioning of Ground Water Wells, Vadose Zone Monitoring Devices, Boreholes, and Other Devices for Environmental Activities³
- D 5314 Guide for Soil Gas Sampling in the Vadose Zone³
- D 5434 Guide for Field Logging of Subsurface Explorations of Soil and Rock³
- D 5730 Guide to Site Characterization for Environmental Purposes with Emphasis on Soil, Rock, the Vadose Zone, and Ground Water⁵
- D 5778 Test Method for Performing Electronic Friction Cone and Piezocone Penetration Testing of Soils⁵
- 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 Devices⁵
- D 5784 Guide for Use of Hollow-stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality and Monitoring Devices⁵
- D 6001 Guide for Direct-Push Water Sampling for Geoen-

vironmental Investigations⁵

3. Terminology

3.1 *Definitions*—General definitions for terminology used in this guide are in accordance with Terminology D 653. Definitions for terms related to direct push water sampling for geoenvironmental investigations are in accordance with Guide D 6001.

3.1.1 *assembly length, n*—length of sampler body and riser pipes.

3.1.2 *borehole, n*—a hole of circular cross-section made in soil or rock.

3.1.3 *casing, n*—pipe furnished in sections with either threaded connections or bevelled edges to be field-welded, which is installed temporarily or permanently to counteract caving, to advance the borehole, or to isolate the interval being monitored, or combination thereof.

3.1.4 *caving/sloughing, n*—the inflow of unconsolidated material into an unsupported borehole that occurs when the borehole walls lose their cohesive strength.

3.1.5 *decontamination, n*—the process of removing undesirable physical or chemical constituents, or both, from equipment to reduce the potential for cross-contamination.

3.1.6 *direct push sampling, n*—sampling devices that are advanced into the soil to be sampled without drilling or borehole excavation.

3.1.7 *extension rod, n*—hollow steel rod, threaded, in various lengths, used to advance and remove samplers and other devices during direct pushing boring. Also known as *drive rod*. In some applications, small diameter solid extension rods are used through hollow drive rods to activate closed samples at depth.

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

3.1.9 *percussion driving, n*—insertion method where rapid hammer impacts are performed to advance the sampling device. The percussion normally is accompanied with the application of a static down-force.

3.1.10 *push depth, n*—the depth below a ground surface datum to which the lower end, or tip, of the direct-push sampling device is inserted.

3.1.11 *sample interval, n*—defined zone within a subsurface strata from which a sample is gathered.

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

3.1.13 *soil core, n*—cylindrical shaped specimen of sediments or other unconsolidated accumulations of solid particles produced by the physical and chemical disintegration of rocks and which may or may not contain organic matter recovered from a soil sampler.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *closed barrel sampler, n*—a sampling device with a piston or other secured device that is held to block the movement of material into the barrel until the blocking device is removed or released. Liners are required in closed barrel samplers. Also may be referred to as a *protected sampler*.

³ Annual Book of ASTM Standards, Vol 04.08.

⁴ Annual Book of ASTM Standards, Vol 11.02.

⁵ Annual Book of ASTM Standards, Vol 04.09.



3.2.2 *impact heads/drive heads*, *n*—pieces or assemblies that fit to top of the above ground portion of the direct push tool assembly to receive the impact of the hammering device and transfer the impact energy to sampler extensions.

3.2.3 *open barrel sampler*, *n*—sampling barrel with open end allowing material to enter at any time or depth. Also may be referred to as an *unprotected type sampler*.

3.2.4 *piston lock*, *n*—device to lock the sampler piston in place to prevent any entry of a foreign substance into the sampler chamber prior to sampling.

3.2.5 *single tube system*, *n*—a system whereby single extension/drive rods with samplers attached are advanced into the subsurface strata to collect a soil sample.

3.2.6 *solid barrel sampler*, *n*—a soil sampling device consisting of a continuous or segmented tube with a wall thickness sufficient to withstand the forces necessary to penetrate the strata desired and gather a sample. A cutting shoe and a connecting head are attached to the barrel.

3.2.7 *split barrel sampler*, *n*—a soil sampling device consisting of the two half circle tubes manufactured to matching alignment, held together on one end by a shoe and on the other by a connecting head.

3.2.8 *two tube systems*, *n*—a system whereby inner and outer tubes are advanced simultaneously into the subsurface strata to collect a soil sample. The outer tube is used for borehole stabilization. The inner tube for sampler recovery and insertion.

4. Summary of Guide

4.1 Direct push soil sampling consists of advancing a sampling device into subsurface soils by applying static pressure, by applying impacts, or by applying vibration, or any combination thereof, to the above ground portion of the sampler extensions until the sampler has been advanced to the desired sampling depth. The sampler is recovered from the borehole and the sample removed from the sampler. The sampler is cleaned and the procedure repeated for the next desired sampling interval. Sampling can be continuous for full depth borehole logging or incremental for specific interval sampling. Samplers used can be protected type for controlled specimen gathering or unprotected for general soil specimen collection.

5. Significance and Use

5.1 Direct push methods of soil sampling are used for geologic investigations, soil chemical composition studies, and water quality investigations. Examples of a few types of investigations in which direct push sampling may be used include site assessments, underground storage tank investigations, and hazardous waste site investigations. Continuous sampling is used to provide a lithological detail of the subsurface strata and to gather samples for classification and index or for chemical testing. These investigations frequently are required in the characterization of hazardous waste sites. Samples, gathered by direct push methods, provide specimens necessary to determine the chemical composition of soils, and in most circumstances, contained pore fluids (3).

5.2 Direct push methods can provide accurate information on the characteristics of the soils encountered and of the

chemical composition if provisions are made to ensure that discrete samples are collected, that sample recovery is maximized, and that clean decontaminated tools are used in the sample gathering procedure. For purposes of this guide, “soil” shall be defined in accordance with Terminology D 653. Using sealed or protected sampling tools, cased boreholes, and proper advancement techniques can assure good representative samples. Direct push boreholes may be considered as a supplementary part of the overall site investigation or may be used for the full site investigation if site conditions permit. As such, they should be directed by the same procedural review and quality assurance standards that apply to other types of subsurface borings. A general knowledge of subsurface conditions at the site is beneficial.

5.3 Soil strata profiling to shallow depths may be accomplished over large areas in less time than with conventional drilling methods because of the rapid sample gathering potential of the direct push method. More site time is available for actual productive investigation as the time required for ancillary activities, such as decontamination, rig setup, tool handling, borehole backfill, and site clean-up is reduced over conventional drilling techniques. Direct push soil sampling has benefits of smaller size tooling, smaller diameter boreholes, and minimal investigative derived waste.

5.4 The direct push soil sampling method may be used as a site characterization tool for subsurface investigation and for remedial investigation and corrective action. The initial direct push investigation program can provide good soil stratigraphic information depending on the soil density and particle size, determine ground water depth, and provide samples for field screening and for formal laboratory analysis to determine the chemical composition of soil and contained pore fluids. Use of this method, results in minimum site disturbance and no cuttings are generated.

5.5 This guide may not be the correct method for investigations in all cases. As with all drilling methods, subsurface conditions affect the performance of the sample gathering equipment and methods used. Direct push methods are not effective for solid rock and are marginally effective in partially weathered rock or very dense soils. These methods can be utilized to determine the rock surface depth. The presence or absence of ground water can affect the performance of the sampling tools. Compact gravelly tills containing boulders and cobbles, stiff clay, compacted gravel, and cemented soil may cause refusal to penetration. Certain cohesive soils, depending on their water content, can create friction on the sampling tools which can exceed the static delivery force, or the impact energy applied, or both, resulting in penetration refusal. Some or all of these conditions may complicate removal of the sampling tools from the borehole as well. Sufficient retract force should be available to ensure tool recovery. As with all borehole advancement methods, precautions must be taken to prevent cross contamination of aquifers through migration of contaminants up or down the borehole. Regardless of the tool size, the moving of drilling and sampling tools through contaminated strata carries risks. Minimization of this risk should be a controlling factor in selecting sampling methods and drilling procedures. The user should take into account the possibility

chemical reaction between the sample and the sampling tool itself, sample liners, or other items that may come into contact with the sample (3, 4).

5.6 In some cases this guide may combine water sampling, or vapor sampling, or both, with soil sampling in the same investigation. Guides D 6001 and D 4700 can provide additional information on procedures to be used in such combined efforts.

6. Criteria for Selection

6.1 Important criteria to consider when selecting sampling tools include the following:

- 6.1.1 Size of sample.
- 6.1.2 Sample quality (Class A,B,C,D) for physical testing. Refer to Practice D 4220.
- 6.1.3 Sample handling requirements, such as containers, preservation requirements.
- 6.1.4 Soil conditions anticipated.
- 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 Probability of cross contamination.
- 6.1.9 Available funds.
- 6.1.10 Estimated cost.
- 6.1.11 Time constraints.
- 6.1.12 History of tool performance under anticipated conditions (consult experienced users and manufacturers).
- 6.2 Important criteria to consider when selecting direct push equipment include the following:
 - 6.2.1 Site accessibility.
 - 6.2.2 Site visibility.
 - 6.2.3 Soil conditions anticipated.
 - 6.2.4 Boring depth required.
 - 6.2.5 Borehole sealing requirements.
 - 6.2.6 Equipment performance history.
 - 6.2.7 Personnel requirements.
 - 6.2.8 Decontamination requirements.
 - 6.2.9 Equipment grouting capability.
 - 6.2.10 Local regulatory requirements.

7. Apparatus

7.1 *General*—A direct push soil sampling system consists of a sample collection tool, hollow extension rods for advancement, retrieval, and transmission of energy to the sampler, and an energy source to force sampler penetration. Auxiliary tools are required to handle, assemble and disassemble, clean, and repair the sample collection tools and impact surfaces. Necessary expendable supplies are sample containers, sample container caps, sample liners, sample retainers, appropriate lubricants, and personal safety gear.

7.2 Direct Push Tool Systems:

7.2.1 *Two Tube System*—An outer casing and an inner extension rod with a sampler attached (see Fig. 1) are advanced simultaneously into the soil for the length capacity of the sampler. The sampler is removed from the borehole and a new sampler barrel or plug bit is inserted for each increment of depth. Two-tube sampling systems also may incorporate sample gathering chambers that are fitted into the outer casing

shoe. These sample barrels are designed to create a minimum of sample disturbance while gathering high quality specimens (see Fig. 2). Samplers are held in the proper position by different methods, such as extension rods, pneumatic or mechanical packers, spring activated latches, or other devices (see Figs. 1 and 2). Locking devices must be strong enough to hold the sampler while penetrating the sample strata. The outer casing supports the borehole wall. Sample retrieval is expedited by the cased hole and continuous sampling is simplified. Continuous sampling may be a benefit to lithological logging. A cased borehole can be sealed from the bottom up as the casing is extracted (see Section 10). A cased hole may reduce the risk of contamination migration down the borehole and sample cross contamination. The two-tube system is more susceptible to soil friction because of its larger diameter and may require larger direct push energy than single-tube systems. An oversized drive shoe is sometimes used to reduce friction and buckling but may increase the risk of contamination migration down the borehole.

7.2.2 *Single Tube System*—The single tube system (see Fig. 3), uses a hollow extension/drive rod to advance and retrieve the sampler. The sampler is attached to the bottom of the extension/drive rod. A drive cap is added to the top of the extension/drive rod and the sampler is pushed into the soil. Extension/drive rods generally are smaller in diameter than the sampler. The single tube system minimizes effort for discrete interval sampling under many subsurface conditions. Tool connection time per interval is reduced. Time of removal and reinsertion of samplers into the borehole is affected by soil conditions. Repeated movement of the sampler through contaminated subsurface strata may increase the risk of contamination migration down the borehole. Bottom up borehole sealing may require re-entry in soil formations that collapse (see Section 10).

7.3 Samplers:

7.3.1 *Split Barrel Samplers*—Split barrel samplers (see Fig. 4) are available for use with direct push drilling methods and are available in various sizes up to 3.0 in. (76.2-mm) inside diameter. The inside tolerance should allow for use of liners. Split barrel sampler shoes used in two tube systems must be of sufficient diameter to prevent the intrusion of soil between the outer diameter of the shoe and the inside wall of the outer tube. Split barrel shoes should be replaced when the leading edge is damaged. Damaged shoes can negatively affect sample recovery. Samplers can be used with or without ball check value fitted split barrel heads. The ball check prevents uphole fluids from flowing down through the sample. Where soil sampling will be performed below the water table, the split barrel head, equipped with a ball check, should be used. The open split barrel is best used with the two tube system because the outer casing protects the borehole against cave-in or sloughing, or in soils in which the borehole wall will not collapse. Split barrel sealing systems are available. Split barrel sections can be joined to create a sampler with a nominal sample length capacity of 48 in. (1.22 m). It is understood that samplers with usable lengths beyond 24 in. (0.61 m) are used to advantage in certain soil types; however, the added weight of the soil sample in the chamber and the added friction within the sample chamber

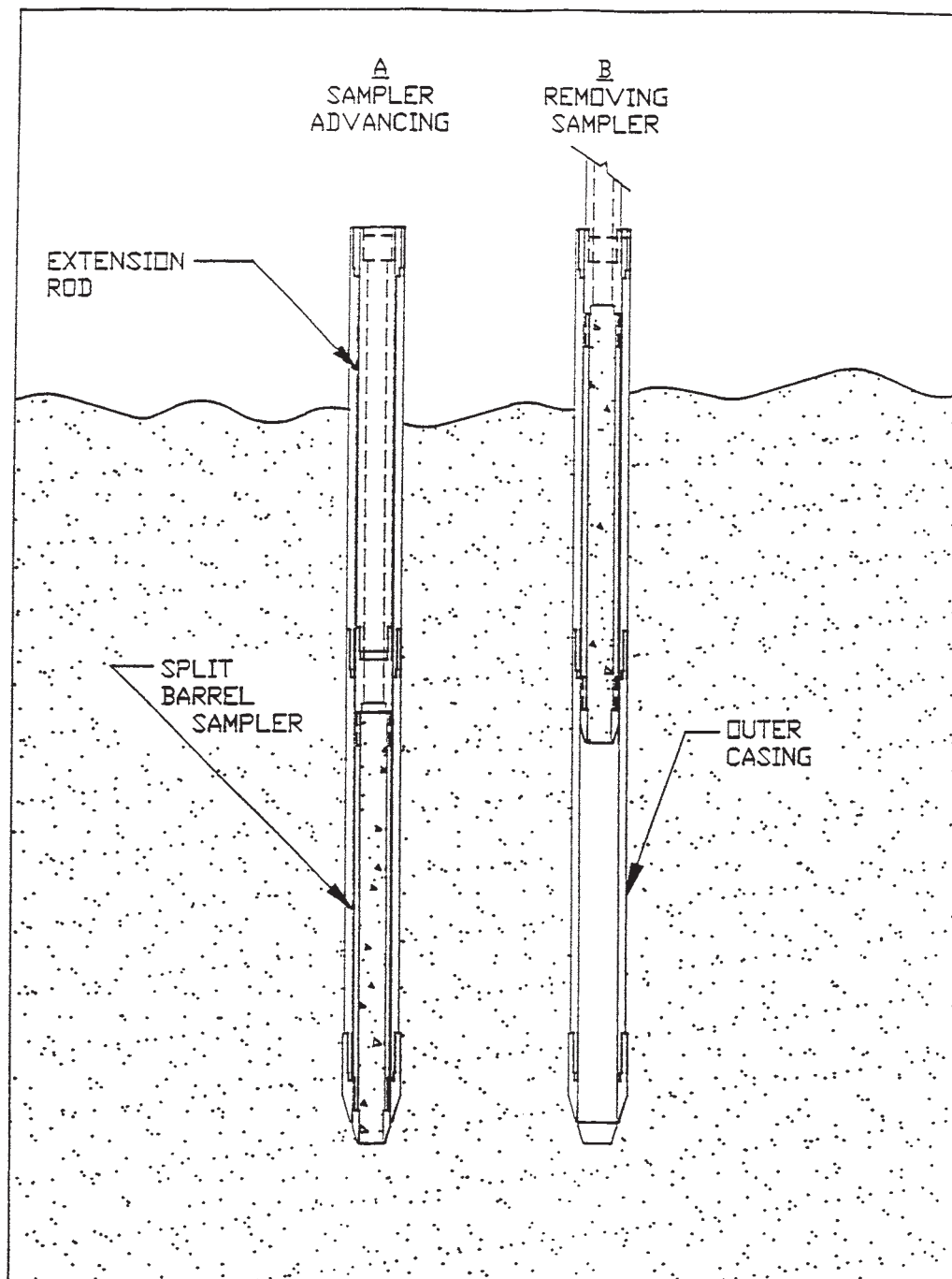


FIG. 1 Split Spoon Sampling, Two Tube System

prevent loose soils from entering the sampler, affecting sample recovery and representativeness. Split barrel samplers can be fitted with a basket to improve recovery in cohesionless soils. Retainers are available in many styles and materials. Retainers should allow the passage of softer soils. Stiff retainers can reduce specimen recovery in soft soils.

7.3.2 Solid Barrel Samplers:

7.3.2.1 *Open Solid Barrel Samplers*—Open solid barrel (see Fig. 5) samplers are used with all types of direct push sampling systems. Solid barrels can have inside diameters ranging up to 3 in. (76.2 mm). Barrel lengths range from 6 in. (152.4 mm) to

5 ft (1.53 m). Solid barrel samplers may be one piece or segmented. Sample liners should be used to facilitate removal of the sample from the solid barrel. Without the use of liners, samples are extruded mechanically. Liner lengths should fit sampler barrel lengths. Solid barrel samplers are generally assembled with a removable cutting shoe and a drive head (see Fig. 6). The head provides a backing to hold the liner stationary while the sampler is advanced and serves as a connector to the extension/drive rods. The shoe is manufactured to hold the liner stationary during the soil collection procedure. The liner should be slightly larger than the inner diameter of the cutting

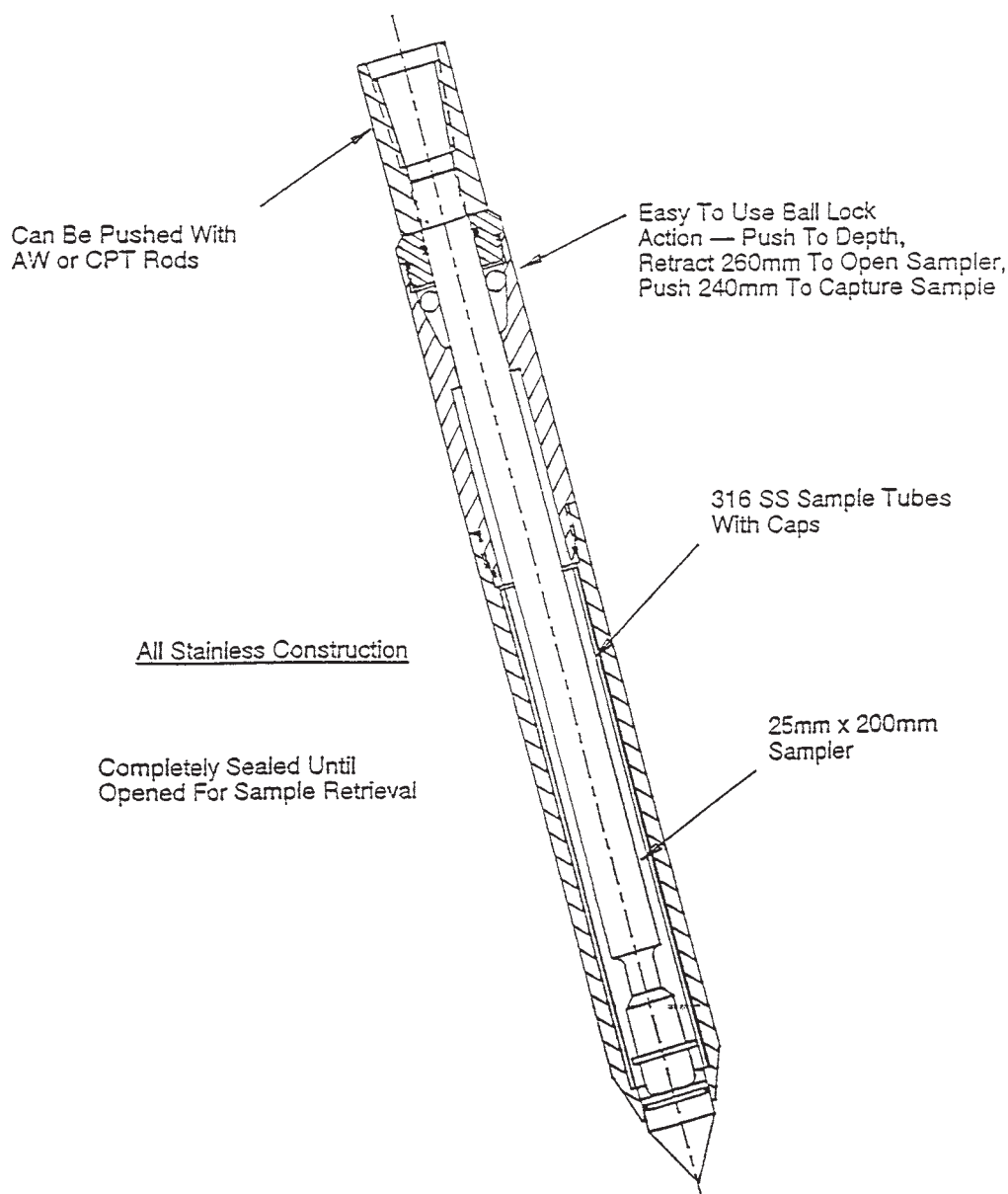


FIG. 2 Sealed Sample Barrel, Single Tube System

shoe. It may be slipped over the cutting shoe (see Fig. 6) or nested inside of the cutting shoe (see Fig. 7). The shoe is manufactured to cut the sample to a slightly undersized diameter allowing it to pass into the sample liner with a minimum of side friction to reduce sample disturbance. The amount of specimen contact with the inside of the shoe should be held to the minimum distance possible to aid in achieving the maximum amount of recovery.

7.3.3 Closed Barrel Sampler—Closed barrel samplers (see Figs. 2 and 3, Figs. 5-8) are devices, which remain sealed shut until an action is taken to open the sample receiving chamber. These samplers are used most often for single events (discrete point sampling) where a sealed sampler is required to avoid cross contamination or in circumstances where borehole wall stability cannot be assured. The shoe sealing device generally is a point designed to allow the continuous flow of soil around and past the sampler until such time as it is removed or

released. The piston point can be fitted with seals, such as “O” rings at top and bottom to hold fluid out until sampling the desired interval. The piston rod extends through the sample retaining liner and must be released or removed for the soil to enter (see Fig. 3, Fig. 5, Fig. 7). The piston can be removed manually before sampling or be displaced by the soil entering the sampler chamber. Using the displacement method can result in reduced recovery if sampled soils do not have sufficient strength to displace the piston. Pistons are locked in place by several methods, such as a spring loaded latch. The latch holds several balls (see Fig. 2, Fig. 7, Fig. 8) into a groove in the latch coupling. When the latch is released by lifting up on the latch stem, the balls slip back into the latch chamber allowing the piston to be removed. Another method uses a locking screw. A reverse thread pin (Fig. 3, Fig. 6) is positioned in the sampler head to prevent the piston from being displaced by the soil when advancing the sampler. At the sampling