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Standard Guide for Selection of Sampling Equipment for Waste and Contaminated Media Data Collection Activities[1]

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1. Scope

1.1 This guide covers criteria which should be considered when selecting sampling equipment for collecting environmental and waste samples for waste management activities. This guide includes a list of equipment that is used and is readily available. Many specialized sampling devices are not specifically included in this guide. However, the factors that should be weighed when choosing any piece of equipment are covered and remain the same for the selection of any piece of equipment. Sampling equipment described in this guide includes automatic samplers, pumps, bailers, tubes, scoops, spoons, shovels, dredges, coring and augering devices. The selection of sampling locations is outside the scope of this guide.

1.1.1 Table 1 lists selected equipment and its applicability to sampling matrices, including water (surface and ground), sediments, soils, liquids, multi-layered liquids, mixed solid-liquid phases, and consolidated and unconsolidated solids. The guide does not address specifically the collection of samples of any suspended materials from flowing rivers or streams. Refer to Guide D4411 for more information.

1.2 Table 2 presents the same list of equipment and its applicability for use based on compatibility of sample and equipment; volume of the sample required; physical requirements such as power, size, and weight; ease of operation and decontamination; and whether it is reusable or disposable.

1.3 Table 3 provides the basis for selection of suitable equipment by the use of an Index.

1.4 Lists of advantages and disadvantages of selected sampling devices and line drawings and narratives describing the operation of sampling devices are also provided.

1.5 The values stated in both inch-pound and SI units are to be regarded separately as the standard units. The values given in parentheses are for information only.

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

1.7 *This 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.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

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 Fine-Grained Soils for Geotechnical Purposes

D3550 Practice for Thick Wall, Ring-Lined, Split Barrel, Drive Sampling of Soils (Withdrawn 2016)[3]

D4136 Practice for Sampling Phytoplankton with Water-Sampling Bottles

D4342 Practice for Collecting of Benthic Macroinvertebrates with Ponar Grab Sampler (Withdrawn 2003)[3]

D4343 Practice for Collecting Benthic Macroinvertebrates with Ekman Grab Sampler (Withdrawn 2003)[3]

D4348 Practice for Collecting Benthic Macroinvertebrates with Holme (Scoop) Grab Sampler (Withdrawn 2003)[3]

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

[3] The last approved version of this historical standard is referenced on www.astm.org.

D4387 Guide for Selecting Grab Sampling Devices for Collecting Benthic Macroinvertebrates (Withdrawn 2003)[3]
D4411 Guide for Sampling Fluvial Sediment in Motion
D4448 Guide for Sampling Ground-Water Monitoring Wells
D4547 Guide for Sampling Waste and Soils for Volatile Organic Compounds
D4687 Guide for General Planning of Waste Sampling
D4696 Guide for Pore-Liquid Sampling from the Vadose Zone
D4700 Guide for Soil Sampling from the Vadose Zone
D4823 Guide for Core Sampling Submerged, Unconsolidated Sediments
D5013 Practices for Sampling Wastes from Pipes and Other Point Discharges
D5079 Practices for Preserving and Transporting Rock Core Samples
D5088 Practice for Decontamination of Field Equipment Used at Waste Sites
D5283 Practice for Generation of Environmental Data Related to Waste Management Activities: Quality Assurance and Quality Control Planning and Implementation
D5314 Guide for Soil Gas Monitoring in the Vadose Zone (Withdrawn 2015)[3]
D5358 Practice for Sampling with a Dipper or Pond Sampler
D5451 Practice for Sampling Using a Trier Sampler
D5495 Practice for Sampling With a Composite Liquid Waste Sampler (COLIWASA)
D5633 Practice for Sampling with a Scoop
D5679 Practice for Sampling Consolidated Solids in Drums or Similar Containers
D5680 Practice for Sampling Unconsolidated Solids in Drums or Similar Containers
D5730 Guide for Site Characterization for Environmental Purposes With Emphasis on Soil, Rock, the Vadose Zone and Groundwater (Withdrawn 2013)[3]
D5743 Practice for Sampling Single or Multilayered Liquids, With or Without Solids, in Drums or Similar Containers
D5778 Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils
D5781 Guide for Use of Dual-Wall Reverse-Circulation Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
D5782 Guide for Use of Direct Air-Rotary Drilling for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
D5783 Guide for Use of Direct Rotary Drilling with Water-Based Drilling Fluid for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
D5784 Guide for Use of Hollow-Stem Augers for Geoenvironmental Exploration and the Installation of Subsurface Water-Quality Monitoring Devices
D5875 Guide for Use of Cable-Tool Drilling and Sampling Methods for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices
D5876 Guide for Use of Direct Rotary Wireline Casing Advancement Drilling Methods for Geoenvironmental Exploration and Installation of Subsurface Water-Quality Monitoring Devices
D6001 Guide for Direct-Push Groundwater Sampling for Environmental Site Characterization
D6009 Guide for Sampling Waste Piles
D6044 Guide for Representative Sampling for Management of Waste and Contaminated Media
D6051 Guide for Composite Sampling and Field Subsampling for Environmental Waste Management Activities
D6063 Guide for Sampling of Drums and Similar Containers by Field Personnel
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
D6418 Practice for Using the Disposable En Core Sampler for Sampling and Storing Soil for Volatile Organic Analysis
D6538 Guide for Sampling Wastewater With Automatic Samplers
D6634 Guide for Selection of Purging and Sampling Devices for Groundwater Monitoring Wells
D6640 Practice for Collection and Handling of Soils Obtained in Core Barrel Samplers for Environmental Investigations
D6699 Practice for Sampling Liquids Using Bailers
D6759 Practice for Sampling Liquids Using Grab and Discrete Depth Samplers
D6771 Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations (Withdrawn 2011)[3]
D6907 Practice for Sampling Soils and Contaminated Media with Hand-Operated Bucket Augers
E300 Practice for Sampling Industrial Chemicals
E1391 Guide for Collection, Storage, Characterization, and Manipulation of Sediments for Toxicological Testing and for Selection of Samplers Used to Collect Benthic Invertebrates

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *consolidated, adj*—a compact solid not easily compressed or broken into smaller particles.

3.1.2 *decontamination, n*—the process of removing or reducing to a known level undesirable physical or chemical constituents, or both, from a sampling apparatus to maximize the representativeness of physical or chemical analyses proposed for a given sample.

3.1.3 *data quality objectives (DQOs), n*—qualitative or quantitative statement(s) derived from the DQO process describing the problem(s), the decision rule(s) and the uncertainties of the decision(s) stated in the con text of the problem.

3.1.4 *environmental data, n*—defined for use in this document to mean data in support of environmental activities.

3.1.5 *matrix, n*—the principal constituent(s) or phase(s) of a material.

3.1.6 *unconsolidated, adj*—defined for use in this document to mean uncemented or uncompacted material that is easily separated into smaller portions.

3.1.7 *representative sample, n*—a sample collected in such a manner that it reflects one or more characteristics of interest (as defined by the project objectives) of a population from which it was collected. **(D6044)**

4. Summary of Guide

4.1 This guide discusses important criteria which should be considered when choosing sampling equipment.

4.1.1 Criteria discussed in this document include physical and chemical compatibility, sample matrix, sample volume, physical requirements, ease of operation and decontamination. Costs are considered, where appropriate.

4.2 A limited list of sampling equipment is presented in two separate tables. The list attempts to include a variety of different types of equipment. However, this list is in no way all inclusive, as there are many excellent pieces of equipment not included. Table 1 lists matrices (surface and ground water, stationary sediment, soil and mixed phase wastes) and indicates which sampling devices are appropriate for use with these matrices. It also includes ASTM method references (draft standards are not included). Table 2 indicates physical requirements (such as battery), electrical power, and weight; physical and chemical compatibility; effect on matrix; range of volume; ease of operation; decontamination; and reusability. Table 3 provides sampler type selection process based upon the sample type and matrix to be sampled.

5. Significance and Use

5.1 Although many technical papers address topics important to efficient and accurate sampling investigations (DQO's, study design, QA/QC, data assessment; see Guides D4687, D5730, D6009, D6051, and Practice D5283), the selection and use of appropriate sampling equipment is assumed or omitted.

5.2 The choice of sampling equipment can be crucial to the task of collecting a sample appropriate for the intended use.

5.3 When a sample is collected, all sources of potential bias should be considered, not only in the selection and use of the sampling device, but also in the interpretation and use of the data generated. Some major considerations in the selection of sampling equipment for the collection of a sample are listed below.

5.3.1 The ability to access and extract from every relevant location in the target population,

5.3.2 The ability to collect a sufficient mass of sample such that the distribution of particle sizes in the population are represented, and

5.3.3 The ability to collect a sample without the addition or loss of constituents of interest.

5.4 The characteristics discussed in 5.3 are particularly important in investigations when the target population is heterogeneous such as when particle sizes vary, liquids are present in distinct phases, a gaseous phase exists or material from different sources are present in the population. The consideration of these characteristics during the equipment selection process will enable the data user to make appropriate statistical inferences about the target population based on the sampling results.

6. Selection Criteria

6.1 Refer to Tables 1 and 2 for a summary of matrix compatibility and selection criteria. Refer to Table 3 for an index of sampling equipment based upon sample type and matrix to be sampled.

6.2 *Compatibility*—It is important that sampling equipment, other equipment which may come in contact with samples (such as gloves, mixing pans, knives, spatulas, spoons, etc.) and sample containers be constructed of materials that are compatible with the matrices and analytes of interest. Incompatibility may result in the contamination of the sample and the degradation of the sampling equipment. Appropriate sampling equipment must be compatible chemically and physically.

6.2.1 *Chemical Compatibility*—The effects of a matrix on the sampling equipment is usually considered in the light of the analytes, or groups of analytes of interest. For example, poly vinyl chloride (PVC) has been found to degrade in the presence of many separate phase organic compounds in water; therefore, it would be preferable to collect ground water samples for organic analyses using polytetrafluoroethylene (PTFE), stainless steel, or glass sampling equipment (**1, 2**).[4] Acids, bases, and high chloride ground water in coastal areas, and wastes with high concentrations of solvents may also degrade many types of sampling equipment over time. The residence or contact time, the time the sample is in contact with the sampling equipment may be significant in terms of chemical interaction between the sampled matrix and the equipment.

6.2.1.1 The choice of materials used in the construction of sampling devices should be based upon a knowledge of what constituents may be present in the sampling environment

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

TABLE 1 Equipment Selection—Matrix Guide

Equipment (May be used for discrete sample collection)	Water and Waste Water			Sediment	Soil	Waste				
	Surface Water	Ground Water	Point Discharge			Liquid	Multi-Layer Liquid	Mixed Phase Solid/Liquid	Consolidated Solid	Unconsolidated Solid
Pumps and Siphons										
Automatic Sampler—Non volatiles	√D6538^G	√D6538^G	-	-	N	N	N	-	-	-
Automatic Composite Sampler—Volatiles	√		√	-	-	-	-	-	-	-
Air/Gas Displacement Pump		√D4448^G	√	-	-	-	√	-	-	-
Piston Displacement Pump		√D4448^G	√	-	-		N	-	-	-
Bladder Pumps		√D4448^G	√	-	-	N	N	-	-	-
		D6771^P		-	-	-	-	-	-	-
Peristaltic Pump	√	√D4448^G	√	-	-	√	√	N	-	-
Centrifugal Submersible Pump	√	√D4448^G	√	-	-	N	N	-	-	-
Gear Drive Pump	√	√D6634^G	√	-	-	N	N	-	-	-
Progressing Cavity Pump	√	√D6634^G	√	-	-	N	N	-	-	-
Inertia Lift Pump	-	√D4448^G	-	-	-	-	-	-	-	-
Dredges										
Ekman Dredge	-	-	-	√D4387^G	-	-	-	-	-	-
				D4343^P						
Petersen Dredge	-	-	-	√D4387^G	-	-	-	-	-	-
Ponar Dredge	-	-	-	√D4387^G	-	-	-	-	-	-
				D4342^P						
Discrete Depth Samplers										
Bacon Bomb	√D6759^P	-	-	-	-	√D6759^P	N	-	-	-
Kemmerer Sampler	√D4136^P	-	-	-	-	√D6759^P	N	-	-	-
	D6759^P	-	-	-	-	-	-	-	-	-
Syringe Sampler	√D5743^G	-	N	-	-	√D6759^P	√D6759^P	√D6759^P	-	-
	D6759^P	-	-	-	-	-	-	-	-	-
Peristaltic Pump	√D6759^P	√D4448^G	√D6759^P	-	-	√D6759^P	√D6759^P	N	-	-
Lidded Sludge/Water Sampler	-	-	-	-	-	N	N	√D6759^P	-	N
Discrete Level Sampler	√D6759^P	√	√D6759^P	-	-	√D6759^P	√D6759^P	-	-	-
HYDRASleeve	N	√D4448^G	-	-	-	N	N	-	-	-
Snap Sampler	-	√D4448^G	-	-	-	N	N	-	-	-
Drive Push Samplers										
Direct Push Water Sampler	-	√	-	-	-	N	-	-	-	-
Probe Sampler, Hand Use	-	-	-	N	√	-	-	N	-	√
Probe Sampler, Rig Use	-	-	-	√D4823^G	√	√	√	N	-	N
Split Barrel Sampler	-	-	-	√	√D1586^{TM}	-	-	N	-	N
					√D4700^G					
Continuous Core Sampler	-	-	-	√	√D5784	-	-	√	-	N
Thin Walled Tube	-	-	-	√D4823^G	√D1587^P	-	-	-	-	√
					D4700^G					
Coring Type w/Valve (Hand Use)	-	-	-	N	√D4823^G	-	-	√	-	√
Concentric Tube Thief (Hand Use)	-	-	-	-	-	-	-	-	-	√
Trier (Hand Use)	-	-	-	-	√	-	-	N	-	√D5451^P
										√E300^P
Miniature Core Sampler (Hand Use)	-	-	-	N	D4700^G	-	-	-	-	N
					√D4547^G					
					D6418^P					
Modified Syringe Sampler (Hand Use)	-	-	-	N	√D4547^G	-	-	-	-	N
Rotating Coring Devices										
Screw Auger	-	-	-	-	-	-	-	-	√	-
Rotating Corer	-	-	-	√D4823^G	√D4700^G	-	-	-	√	-
Captive Screw Auger	-	-	-	-	-	-	-	-	N	√
Augers										
Hand Operated Bucket Auger	-	-	-	N	√D1452^P	-	-	-	-	√D1452^P
					D4700^G					
					√D6907^P					√D6907^P
Solid Stem Flighted Auger	-	-	-	-	√D1452^G	-	-	-	N	N
					√D6286^G					
Hollow Stem Flighted Auger	-	-	-	-	√D5784^G	-	-	-	N	N
					√D6151^G					
Peat Borer	-	-	-	√	√	-	-	-	-	N
Liquid Profile Devices										
COLIWASA	-	-	-	-	-	√D5495^P	√D5495^P	-	-	
						√D5743^G	D5743^G			
Reuseable Point Sampler	N	-	N	-	-	√D5743^G	√D5743^G	√	-	-
Drum Thief	-	-	-	-	-	√D5743^G	√D5743^G	√	-	-
Valved Drum Sampler	-	-	-	-	-	√D5743^G	√D5743^G	√	-	-
Plunger Type Sampler	N	-	N	-	-	√D5743^G	√D5743^G	√D5743^G	-	-

TABLE 1 *Continued*

Equipment (May be used for discrete sample collection)	Water and Waste Water			Sediment	Soil	Waste				
	Surface Water	Ground Water	Point Discharge			Liquid	Multi-Layer Liquid	Mixed Phase Solid/Liquid	Consolidated Solid	Unconsolidated Solid
Liquids Profiler	N	-	N	-	-	√D6759[P]	√D6759[P]	√D6759[P]	-	-
Surface Sampling Devices (Liquids)										
Bailer	N	√D4448[G]	-	-	-	N	N	-	-	-
		√D6699[P]	-	-	-	-	-	-	-	-
Point Sampling Bailer	N	√D4448[G]	-	-	-	N	N	-	-	-
		√D6699[P]	-	-	-	-	-	-	-	-
Differential Pressure Bailer	-	√D6699[P]	-	-	-	N	N	-	-	-
Dipper	√D5358[P]	-	√D5013[P]	-	-	√D5358[P]	-	√D5358[P]	-	-
Liquid Grab Sampler	√	-	N	-	-	√	√	√	-	-
Swing Jar Sampler	√	-	N	N	-	√	√	N	-	-
Passive Sampler, Bag Type	√	√	-	-	-	-	-	-	-	-
Passive Sampler, Chamber Type	-	√	-	-	-	-	-	-	-	-
Surface Sampling Devices (Solids)										
Impact Devices	-	-	-	-	-	-	-	-	√	-
Spoon	N	-	N	-	√D4700[G]	N	N	-	-	N
Scoops and Trowel	-	-	-	N	√D4700[G]	N	-	N	-	√
Shovels	-	-	-	N	√D4700[G]	-	-	N	-	√
Multi-Level Sampling Devices										
Dedicated Type 1	-	√	-	-	N	-	-	-	-	-
Dedicated Type 2	-	√	-	-	N	-	-	-	-	-
Portable	-	N	-	-	√	-	-	-	-	-
Vadose Zone Pore Sampling Devices										
Vacuum Lysimeter	-	N	-	N	√D4696[G]	-	-	-	-	-
Vacuum/Pressure Lysimeter	-	N	-	N	√D4696[G]	-	-	-	-	-
Gas Adsorber	N	N	-	N	√D5314[G]	-	-	-	-	-

√ = Equipment may be used with this matrix   N = Not equipment of choice but use is possible   - = Not recommended
[G] = ASTM Guide   [TM] = ASTM Test Method   [P] = ASTM Practice

because the constituents and materials may interact chemically or be incompatible. Consult available chemical compatibility charts.

6.2.2 *Physical Compatibility*—The sampling equipment should also be compatible with the physical characteristics of the matrices to be sampled. Equipment used to dig or core (shovels, augers, coring type samplers) should be constructed of material that will not deform during use, or be abraded by the material being sampled. Equipment abrasion may result in the contribution of contaminants to the sample being collected. For example, plastic or glass would not be appropriate for difficult to access matrices, and stainless steel equipment may contribute small amounts of metals if significantly abraded by the matrix.

NOTE 1—Information on sample containers and equipment used in sampling that is not used in the actual collection of the sample is not within the scope of this guide.

6.3 *Equipment Effects on the Matrix:*

6.3.1 *Equipment Design*—Samples collected using inappropriate sampling equipment may not provide *representative samples* (**1, 3**). An example of equipment design influencing sample results is a sampler which excludes certain sized particles from a soil matrix or waste pile sample. The shape of some scoops may influence the distribution of particle sizes collected from a sample (**1**). Dredges used to collect river or estuarine stationary sediments may also exclude certain sized particles, particularly the fines fraction which may contain a significant percentage of some contaminants such as polynuclear aromatic hydrocarbons (PAHs).

6.3.2 *Equipment Use*—Inappropriate use of sampling equipment can influence analytical results. For example, if a pump is used to purge a well and the intake is placed below the well screen, sediment in the sump can be put into suspension and become part of the water sample (**4**). Excessive vacuum generated by sampling pumps can cause loss of volatile constituents or change valence states of some ions. The use of bailers for well purging and sample collection may also cause increased turbidity levels in ground water samples. When sampling containerized liquids, insertion of a COLIWASA sampler at too fast a rate may prevent it from collecting a representative, depth integrated sample.

6.4 *Sample Volume Capabilities*—Most sampling devices will provide adequate sample volume. However, the sampling equipment volumes should be compared to the volume necessary for all required analyses including the additional amount necessary for quality control (QC), split and repeat samples (**4, 5**). Sampling devices which may not provide an adequate volume would be small diameter glass tubes, and triers. In this case, the investigator must consider the following options:

6.4.1 A similar device with an increased capacity,

6.4.2 An alternate device with an increased capacity, or

6.4.3 Modification of an existing device (often difficult or impractical).

6.4.4 If these alternatives are not acceptable or available, then the investigator must consider the collection of multiple aliquots to fulfill the sample volume requirement. The effect of multiple aliquots on the data quality objectives should be considered.

TABLE 2 Sampling Equipment Selection Guide

Equipment	Chemical	Physical	Effect on Sample	Volume Range	Physical	Ease of Operation	Decon	Disposal or Reuse
Pumps and Siphon								
Automatic Sampler–Nonvolatiles	X	X	√	U	B/P	√	X	R
Automatic Composite Sampler–Volatiles	X	X	√	U	B/P	X	X	R
Air/Gas Displacement Pump	√	X	X	U	P/S/W	X	X	R
Piston Displacement Pump	√	X	X	U	P/S/W	X	X	R
Bladder Pumps	√	X	√	U	P	X	X	R
Corrugated Bladder Pump	√	X	√	U	P	√	X	R
Peristaltic Pump	X	X	√	U	B/P	X	√	R
Centrifugal Submersible Pump	X	X	X	U	P/S/W	√	X	R
Gear Drive Pump	X	X	X	U	B/P	√	X	D/R
Progressive Cavity Pump	X	X	X	U	P	√	X	R
Inertia Lift Pump	X	X	X	U	B/N	√	√	R
Dredges								
Ekman Dredge	√	√	X	0.5-3.0	N	X	X	R
Petersen Dredge	√	√	X	0.5-3.0	W	X	X	R
Ponar Dredge	√	√	X	0.5-3.0	W	X	X	R
Discrete Depth Samplers								
Bacon Bomb	X	X	√	0.1-0.94	N	√	X	R
Kemmerer Sampler	X	X	X	1.0-2.0	N	X	X	R
Syringe Sampler	√	√	√	0.2-0.5	N	√	X	R
Lidded Sludge/Water Sampler	√	X	X	1.0	S/W	X	X	R
Discrete Level Sampler	√	X	√	0.2-0.5	N	√	√	R
Bailer	X	√	X	0.5-2.0	N	√	√	D/R
Point Sampling Bailer	X	√	√	0.5-2.0	N	√	√	R
Differential Pressure Bailer	√	√	√	0.04-1.0	N	√	X	R
Dipper	√	X	√	0.5-1.0	N	√	√	R
Liquid Grab Sampler	√	√	√	0.5-1.0	N	√	√	R
Swing Jar Sampler	X	√	√	0.5-1.0	N	√	√	R
HYDRASleeve	√	√	√	0.6-3.1	N	√	√	D
Snap Sampler	√	√	√	0.04-0.35	N	√	X	R
Drive/Push Samplers								
Direct Push Water Sampler	√	√	√	0.1-0.3	P/S/W	X	X	R
Probe Sampler	√	√	X	0.2-2.0	S/W	X	√	R
Split Barrel Sampler	√	√	X	0.5-30.0	S/W	X	√	R
Thin Walled Tube	√	√	X	0.5-5.0	S/W	√	√	R
Coring Type w/Valve	√	√	√	0.2-1.5	N	√	√	R
Concentric Tube Theif	√	√	√	0.5-1.0	N	√	√	R
Trier	√	√	√	0.1-0.5	N	√	√	R
Miniature Core Sampler	√	√	√	0.01-0.05	N	√	√	D
Modified Syringe Sampler	√	√	√	0.01-0.05	N	√	X	D
Rotating Coring Devices								
Screw Auger	√	X	X	0.1-0.3	N	X	√	R
Rotating Corer	√	√	X	0.5-1.0	B/P	√	√	R
Captive Screw Auger	X	√	X	1-2	P	√	√	R
Augers								
Bucket Auger	√	X	X	0.2-1.0	N	X	√	R
Solid Stem Flighted Auger	X	√	X	U	P/S/W	X	√	R
Hollow Stem Flighted Auger	X	√	X	U	P/S/W	X	√	R
Peat Borer	X	√	√	0.3	S	X	X	R
Liquid Profile Devices								
COLIWASA	√	X	√	0.5-3.0	N	√	X	D/R
Reuseable Point Sampler	√	√	√	0.2-0.6	N	√	√	R
Drum Thief	√	X	√	0.1-0.5	N	√	X	D/R
Valved Sampler	√	√	√	0.3-1.6	N	√	√	D/R
Plunger Type Sampler	√	X	√	0.2-U	N	√	√	D/R
Liquids Profiler	X	X	√	1.3-4.0	N	√	√	R
Passive Water Sampling Devices								
Passive Sampler, Bag Type	√	√	√	0.1-0.2	N	√	√	D/R
Passive Sampler, Chamber Type	√	√	√	1-4	W/S	X	X	D/R
Multi-Level Sampling Devices								
Dedicated Type 1	√	√	√	U	W/S	X	X	D/R
Dedicated Type 2	√	√	√	U	W/S	X	X	D
Portable	√	√	√	0.01	N	X	X	DR
Surface Sampling Devices (Solids)								
Impact Devices	X	X	X	N/A	B/P	√	√	R
Spoon	√	√	X	N/A	N	√	√	R
Scoops and Trowel	√	√	X	0.1-0.6	N	√	√	R
Shovels	√	√	X	1.0-5.0	N	√	√	R
Vadose Zone Pore Sampling Devices								
Vacuum Lysimeter	√	√	√	0.1-0.5	N	√	√	D/R
Vacuum/Pressure Lysimeter	√	√	√	0.1-0.5	S/P	√	√	D
Gas Adsorber	√	√	√	N/A	N	√	√	D

X = Significant operational consideration
√ = Not a significant operational consideration

Range of Volume (liters)
U = Unlimited
N/A = Not Applicable

Physical Requirements:
B = Battery W = Weight
P = Power S = Size
N = No limitations

Disposal and Reuse:
R = Reusable
D = Single-Use

TABLE 3 Index of Sampling Equipment

Media Type	Sampler Type	Section	Sample Type
Consolidated Solid	Rotating Corer	(7.6.2)	Surface or Depth, Undisturbed
	Screw Auger	(7.6.1)	Surface, Disturbed
	Impact Device	(7.11.1)	Surface, Disturbed
Unconsolidated Solid	Lidded Sludge	(7.4.4)	Discrete, Composite
	Probe Sampler	(7.5.2)	Discrete, Undisturbed
	Split Barrel	(7.5.3)	Discrete, Undisturbed
	Concentric Tube Thief	(7.5.7.1)	Surface, Disturbed, Selective
	Trier	(7.5.7.2)	Surface, Relatively Undisturbed, Selective
	Thin Walled Tube	(7.5.5)	Surface or Depth, Undisturbed
	Coring Type w/Valve	(7.5.6)	Surface or Depth, Disturbed
	Hand-Operated Bucket Auger	(7.7.1)	Surface or Depth, Disturbed
	Solid Stem Flighted Auger	(7.7.2.1)	Surface or Depth, Disturbed
	Hollow Stem Flighted Auger	(7.7.2.2)	Surface or Depth, Disturbed (if from flights)
	Captive Screw Auger	(7.6.3)	Discrete, Disturbed
	Peat Borer	(7.7.3)	Discrete, Relatively Undisturbed
	Spoon	(7.11.2)	Surface, Disturbed, Selective
	Scoops/Trowel	(7.11.3)	Surface, Disturbed, Selective
	Shovel	(7.11.4)	Surface, Disturbed
	Miniature Core	(7.5.8)	Surface, Undisturbed
	Modified Syringe	(7.5.9)	Surface, Undisturbed
Soil	Probe Sampler	(7.5.2)	Discrete, Undisturbed
	Split Barrel	(7.5.3)	Discrete, Undisturbed
	Trier	(7.5.7.2)	Surface, Relatively Undisturbed, Selective
	Thin Walled Tube	(7.5.5)	Surface or Depth, Undisturbed
	Coring Type w/Valve	(7.5.6)	Surface or Depth, Disturbed
	Hand-Operated Bucket Auger	(7.7.1)	Surface or Depth, Disturbed
	Solid Stem Flighted Auger	(7.7.2.1)	Surface or Depth, Disturbed
	Hollow Stem Flighted Auger	(7.7.2.2)	Surface or Depth, Disturbed (if from flights)
	Peat Borer	(7.7.3)	Discrete, Relatively Undisturbed
	Spoon	(7.11.2)	Surface, Disturbed, Selective
	Scoops/Trowel	(7.11.3)	Surface, Disturbed, Selective
	Shovel	(7.11.4)	Surface, Disturbed
	Miniature Core	(7.5.8)	Surface, Undisturbed
	Modified Syringe	(7.5.9)	Surface, Undisturbed
	Vacuum Lysimeter	(7.12.1)	Surface to Depth, Pore Liquid
	Vacuum/Pressure Lysimeter	(7.12.2)	Depth, Pore Liquid
	Gas Adsorber	(7.12.3)	Surface to Depth, Soil Gas
Mixed Solid/Liquid	AutoSampler, Non V.	(7.2.1)	Shallow, Composite-Suspended Solids only
	Peristaltic Pump	(7.2.5)	Shallow, Discrete or Composite-Suspended Solids Only
	Syringe Sampler	(7.4.3)	Shallow, Discrete, Disturbed
	Lidded Sludge/Water	(7.4.4)	Discrete, Composite
	Probe Sampler	(7.5.2)	Depth, Discrete, Undisturbed
	Split Barrel	(7.5.3)	Depth, Discrete, Undisturbed
	Peat Borer	(7.7.3)	Discrete, Relatively Undisturbed
	Trier	(7.5.7.2)	Surface, Semi-solid only, Selective
	Coring Type w/Valve	(7.5.6)	Depth, Disturbed
	COLIWASA	(7.8.1)	Shallow, Composite, Semi-liquid only
	Reuseable Point	(7.8.1.2)	Shallow, Discrete
	Plunger Type	(7.8.4)	Shallow, Discrete
	Liquids Profiler	(7.8.5)	Depth, Composite-Suspended Solids only
	Drum Thief	(7.8.2)	Shallow, Composite-Semi-Liquid only
	Valved	(7.8.3)	Shallow, Composite-Semi-Liquid only
	Dipper	(7.4.9)	Shallow, Composite
	Liquid Grab	(7.4.10)	Shallow, Composite-Suspended Solids only
	Swing Jar	(7.4.11)	Shallow, Composite
	Scoops/Trowel	(7.11.3)	Shallow, Composite, Semi-solid only
	Shovel	(7.11.4)	Shallow, Composite, Semi-solid only
Sediments	Ekman Dredge	(7.3.1)	Bottom Surface, Soft only, Disturbed
	Petersen Dredge	(7.3.2)	Bottom Surface, Rocky or Soft, Disturbed
	Ponar	(7.3.3)	Bottom Surface, Rocky or Soft, Disturbed
	Probe Sampler	(7.5.2)	Bottom Surface or Depth, Undisturbed
	Split Barrel	(7.5.3)	Bottom Surface or Depth, Relatively Undisturbed
	Thin Walled Tube	(7.5.5)	Bottom Surface or Depth, Undisturbed
	Coring Type w/Valve	(7.5.6)	Bottom Surface or Depth, Disturbed
	Hand-Operated Bucket Auger	(7.7.1)	Bottom Surface, Disturbed
	Peat Borer	(7.7.3)	Discrete, Relatively Undisturbed
	Rotating Corer	(7.6.2)	Bottom Surface, Undisturbed if solid
	Scoops, Trowel	(7.11.3)	Exposed Surface only, Disturbed, Selective
	Shovel	(7.11.4)	Exposed Surface only, Disturbed
	Minature Core	(7.5.8)	Exposed Surface only, Undisturbed
	Modified Syringe	(7.5.9)	Exposed Surface only, Undisturbed
	Auto Splr. - Non Vols.	(7.2.1)	25-ft Lift, Discrete or Composite
	Auto Splr. - Vols.	(7.2.1)	25-ft Lift, Discrete
	Peristaltic Pump	(7.2.5)	Shallow(25-ft), Discrete
	Centrifugal Sub. Pump	(7.2.6)	Depth, Discrete

TABLE 3 *Continued*

Media Type	Sampler Type	Section	Sample Type
	Gear Drive Pump	(7.2.7)	Depth, Discrete
Surface Water	Progressing Cavity Pump	(7.2.8)	Depth, Discrete
	Bacon Bomb	(7.4.1)	Depth, Discrete
	Kemmerer	(7.4.2)	Depth, Discrete
	Discrete Level	(7.4.5)	Depth, Discrete
	Plunger Type	(7.8.4)	Shallow (12-ft), Discrete
	Liquids Profiler	(7.8.5)	Shallow, Composite
	Dipper	(7.4.9)	Shallow (10-ft.), Composite
	Liquid Grab	(7.4.10)	Shallow (6-ft), Composite
	Swing Jar	(7.4.11)	Shallow, (10-ft), Composite
	Spoon	(7.11.2)	Shallow (1-in.), Composite
	Air/Gas Displacement	(7.2.2.1)	Depth, Discrete
	Piston Displacement	(7.2.2.2)	Depth, Discrete
	Bladder Pump	(7.2.3)	Depth, Discrete
	Corrugated Bladder Pump	(7.2.4)	Depth, Discrete
	Peristaltic Pump	(7.2.5)	25-ft Lift, Discrete
	Centrifugal Sub. Pump	(7.2.6)	Depth, Discrete
	Gear Drive Pump	(7.2.7)	Depth, Discrete
	Progressing Cavity Pump	(7.2.8)	Depth, Discrete
Ground Water	Inertia Lift Pump	(7.2.9)	Depth Discrete
	Discrete Level	(7.4.5)	Depth, Discrete
	Direct Push Water Sampler	(7.5.1.1)	Depth, Discrete
	Bailer	(7.4.6)	Depth, Composite
	Point Sampling Bailer	(7.4.7)	Depth, Discrete
	Diff. Pressure Bailer	(7.4.8)	Depth, Discrete
	Bag Type Diffusion	(7.9.1)	Depth Discrete
	Chamber Type Diffusion	(7.9.2)	Multiple Depths, Discrete
	Dedicated Multi-Level	(7.10.1)	Multiple Depths, Discrete
	Portable Multi-Level	(7.10.2)	Multiple Depths, Discrete, Pore water
	AutoSplr. -Non Vols.	(7.2.1)	Shallow (25-ft), Discrete or Composite
	Auto Splr. - Vols.	(7.2.1)	Shallow (25-ft), Discrete
	Peristaltic Pump	(7.2.5)	Shallow (25-ft), Discrete
	Centrifugal Sub. Pump	(7.2.6)	Depth, Discrete
	Gear Drive Pump	(7.2.7)	Depth, Discrete
	Progressing Cavity Pump	(7.2.8)	Depth, Discrete
	Bacon Bomb	(7.4.1)	Depth, Discrete
	Kemmerer	(7.4.2)	Depth, Discrete
	HYDRASleeve	(7.4.12)	Depth, Discrete
	Snap Sampler	(7.4.13)	Depth, Discrete
Liquid Effluent	Syringe Sampler	(7.4.3)	Shallow (8-ft), Discrete
	Discrete Level	(7.4.5)	Depth, Discrete
	Reuseable Point	(7.8.1.2)	Shallow (8-ft), Discrete
	Valved Sampler	(7.8.3)	Shallow, Discrete
	Plunger Type	(7.8.4)	Shallow (12-ft), Discrete
	Liquids Profiler	(7.8.5)	Shallow, Composite
	Dipper	(7.4.9)	Shallow (10-ft), Composite
	Liquid Grab	(7.4.10)	Shallow (6-ft), Composite
	Swing Jar	(7.4.11)	Shallow (10-ft), Composite
	Spoon	(7.11.2)	Shallow (1-in.), Composite
	Air Displacement Pump	(7.2.2.1)	Depth, Discrete
	Piston Displacement	(7.2.2.2)	Depth, Discrete
	Bladder Pump	(7.2.3)	Depth, Discrete
	Corrugated Bladder Pump	(7.2.4)	Depth, Discrete
	Peristaltic Pump	(7.2.5)	Shallow (25-ft), Discrete
	Centrifugal Sub. Pump	(7.2.6)	Depth, Discrete
	Gear Drive Pump	(7.2.7)	Depth, Discrete
	Progressing Cavity Pump	(7.2.8)	Depth, Discrete
	Syringe Sampler	(7.4.3)	Shallow (8-ft), Discrete
	Lidded Sludge/Water	(7.4.4)	Shallow (8-ft), Discrete
	Discrete Level	(7.4.5)	Depth, Discrete
Liquid	Direct Push Water Sampler	(7.5.1.1)	Depth, Discrete
	COLIWASA	(7.8.1)	Shallow (4-ft), Composite
	Reuseable Point	(7.8.1.2)	Shallow (8-ft), Discrete
	Plunger Type	(7.8.4)	Shallow, (12-ft), Discrete
	Liquids Profiler	(7.8.5)	Shallow, Composite
	Drum Thief	(7.8.2)	Shallow (3-ft), Composite
	Valved Sampler	(7.8.3)	Shallow (8-ft), Composite
	Bailer	(7.4.6)	Depth, Discrete
	Point Sampling Bailer	(7.4.7)	Depth, Discrete
	Diff. Pressure Bailer	(7.4.8)	Depth, Discrete
	Dipper	(7.4.9)	Shallow (10-ft), Composite
	Liquid Grab	(7.4.10)	Shallow (6-ft), Composite
	Swing Jar	(7.4.11)	Shallow, (10-ft), Composite
	Spoon	(7.11.2)	Shallow (1-in.), Composite
	Scoops & Trowel	(7.11.3)	Shallow, (1-in.), Composite

TABLE 3 *Continued*

Media Type	Sampler Type	Section	Sample Type
	Air Displacement Pump	(7.2.2.1)	Depth, Discrete
	Piston Displacement	(7.2.2.2)	Depth Discrete
	Bladder Pump	(7.2.3)	Depth, Discrete
	Corrugated Bladder Pump	(7.2.4)	Depth, Discrete
	Peristaltic Pump	(7.2.5)	Shallow(25-ft), Discrete
	Centrifugal Sub. Pump	(7.2.6)	Depth, Discrete
	Gear Drive Pump	(7.2.7)	Depth, Discrete
	Progressing Cavity Pump	(7.2.8)	Depth, Discrete
Multi Layer	Syringe Sampler	(7.4.3)	Shallow (8-ft), Discrete
Liquid	Discrete Level	(7.4.5)	Depth, Discrete
	Direct Push Water Sampler	(7.5.1.1)	Depth, Discrete
	COLIWASA	(7.8.1)	Shallow (4-ft), Composite
	Reuseable Point	(7.8.1.2)	Shallow (8-ft), Discrete
	Plunger Type	(7.8.4)	Shallow, (12-ft), Discrete
	Liquids Profiler	(7.8.5)	Shallow, Composite
	Drum Thief	(7.8.2)	Shallow (3-ft), Composite
	Valved Sampler	(7.8.3)	Shallow (8-ft), Composite
	Bailer	(7.4.6)	Depth, Discrete
	Point Sampling Bailer	(7.4.7)	Depth, Discrete
	Diff. Pressure Bailer	(7.4.8)	Depth, Discrete
	Dipper	(7.4.9)	Shallow (10-ft), Composite
	Liquid Grab	(7.4.10)	Shallow (6-ft), Composite
	Swing Jar	(7.4.11)	Shallow (10-ft), Composite

6.5 *Physical Requirements*—Sampling equipment selection should always consider factors such as the size and weight of the equipment, power requirements (battery/110V), and ancillary equipment required (drill rig for split barrel samplers). Most sampling equipment used in the collection of environmental samples is relatively easy to transport and use in the field. The use of equipment with significant physical requirements may impede the progress of a sampling investigation.

6.6 *Ease of Operation*—Much of the equipment used for environmental sampling is rather simple to employ. Samples may be collected easily as long as properly selected equipment is used with adequate consideration of the matrix of interest. Sampling errors may occur as a result of inadequate consideration of matrix effects, and poor collection techniques (**1, 3**). Training requirements should focus on the proper use of equipment in varying environmental matrices.

6.7 *Decontamination and Reuse of Equipment:*

6.7.1 *Decontamination (see Practice D5088)*—Inadequate decontamination of sampling equipment can result in significant errors in analytical results. When choosing sampling equipment, ease of decontamination must be a consideration. Pumps, automatic samplers, Kemmerer samplers and dredges require more effort to decontaminate than does a bailer or split barrel sampler. The investigator should consider decontamination requirements prior to the study to avoid significant delays.

6.7.2 *Reuse*—Due to the expense of materials associated with modern sampling equipment (stainless steel, PTFE), most equipment is reusable following proper decontamination. Some equipment such as bailers may be disposed of after use or dedicated to a sampling point to save time during extensive field investigations. Drum thieves and COLIWASA samplers are typically not reused, particularly when waste samples have been collected.

6.8 *Cost*—Detailed information on the cost of sampling equipment is not contained within this guide. Cost is usually a major consideration in the process of sampling equipment selection. In general, the cost of PTFE and stainless steel equipment will be greater than equipment made of glass, PVC, or other plastics. However, the life expectancy for PTFE or stainless steel equipment is usually longer. In addition, labor costs for decontamination of reusable equipment versus the disposal costs of single use equipment are also relevant considerations. Comments on costs are included in the "Advantages and Limitations" tables, where appropriate.

7. Sampling Equipment

7.1 Presented below are brief descriptions of some sampling equipment used in waste management and in the collection of environmental samples as they relate to waste management activities (**6**). This is by no means an inclusive list of the sampling equipment which is available to investigators. There are many pieces of equipment that have been designed for specific sampling needs. In addition, investigators may design their own pieces of equipment for a specific project. In all these instances, an investigator must keep in mind the criteria for sampling equipment selection which have been discussed previously in this guide.

7.2 *Pumps and Siphons (see Guide D4448)*—Pumps used for the collection of waste and environmental liquid samples for waste management include automatic samplers and displacement, bladder, peristaltic and centrifugal pumps.

7.2.1 *Automatic Samplers (see Guide D6538)*—Automatic samplers may be used when samples are to be collected at frequent intervals (see Figs. 1 and 2). They are frequently used in waste water collection systems and treatment plants, but they can also be used during stream sampling investigations. They may be used to collect time composite or flow proportional samples. In the flow proportional sampling mode, the samplers are activated by a compatible flow meter. Peristaltic and vacuum pumps are commonly employed as the sampling mechanism. Automatic samplers designed specifically for the collection of samples for volatile organic analyses are available. See Table 4 for advantages and limitations.

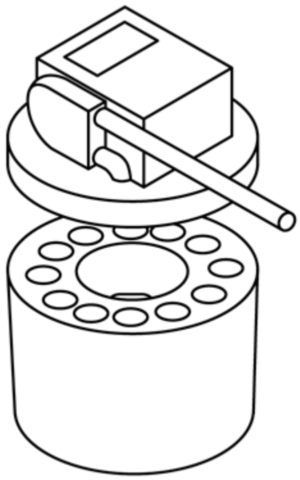


FIG. 1 Automatic Sampler—Non Volatiles

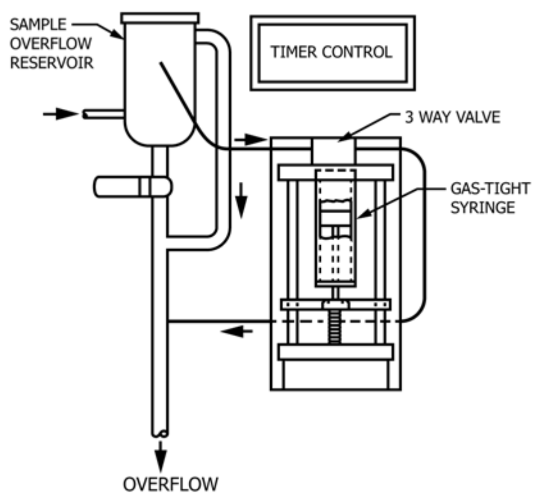


FIG. 2 Automatic Composite Sampler—Volatiles

TABLE 4 Automatic Samplers—Advantages and Limitations

Advantages	Limitations
Can collect either grab samples over time or a composite sample	May be unsuitable for samples requiring volatile organic analysis or samples containing dissolved gases
Will operate unattended	Need power source/battery
Versatile—can be programmed to sample proportional to flow	May be difficult to decontaminate due to design or construction materials, or both
	May be incompatible with liquid streams containing a high percentage of solids

NOTE 2—Flow proportional samples can also be collected using a discrete sampler and a flow recorder and manually compositing the individual aliquots in flow proportional amounts.

7.2.2 *Displacement Pumps (see Guide D4448, Practice D6771)*—Displacement pumps are designed for ground water sampling and mechanically force a discrete column of water to the surface. The air displacement pump uses compressed air. The piston displacement pump uses an actuating rod powered either from the surface or from a separate sealed air or electric actuator. (See Table 5 for advantages and limitations.)

7.2.2.1 The air displacement pump (Fig. 3) operates by applying a positive pressure to the gas line causing the inlet check valve of the sampling device to close and the sample discharge line check valve to open, forcing the contents to the surface. Cyclical removal of gas pressure will cause the flow to stop, the discharge line check valve to close and the inlet check valve of the sampling device to open, allowing the sampling device to fill.

7.2.2.2 The piston displacement pump (Fig. 4) uses a mechanically operated plunger to deliver the sample to the surface at the same time as the chamber fills. It has a flexible flap valve on the piston and an inlet check valve.

7.2.3 *Bladder Pumps*—Bladder pumps are used for sampling ground water, and are constructed with a flexible bladder inside a rigid sample container. There are two types. The squeeze type (Fig. 5) has the bladder connected to the sample discharge line. The chamber between the bladder and the sampler body is connected to the gas line. The expanding type (Fig. 6) has the bladder connected to the gas line with the sample discharge line connected to the chamber surrounding the bladder.

7.2.3.1 The pump operates by applying a positive pressure to the gas line causing either the bladder to expand or be compressed, dependent on the type. The sampler inlet valve closes and the sample discharge valve opens forcing the contents of the sampler up the discharge line. Cyclic removal of the gas pressure causes the flow to stop, the sample valve to close and the sampler inlet valve to open, allowing the sampler to refill. See Table 6 for advantages and limitations.

7.2.4 *Corrugated Bladder Pump*—This variation on the bladder pumps covered in 7.2.3 uses a corrugated fluoropolymer bladder that is alternately compressed and expanded in a vertical axis by mechanical means to pump the sample to the surface (Fig. 7). The inner concentric tube is attached to the corrugated bladder and is used to mechanically open and close the bladder pumping water to the surface through the inner tube. This pump is available in only a 12 mm (0.47 in.) diameter and is used for sampling through small diameter direct push tools and wells. See Table 7 for advantages and limitations.

7.2.5 *Peristaltic Pump* (**4**)—A peristaltic pump is a suction lift pump which is used at the ground surface (see Fig. 8*(a)*). A

TABLE 5 Displacement Pumps—Advantages and Limitations

Advantages	Limitations
Commonly constructed of PVC, or stainless steel, or both, but can be constructed of fluoropolymer to reduce risk of contamination when trace levels of organics are of interest	Potential loss of dissolved gases and VOCs from the pumped sample or contamination from the driving gas
Easy to decontaminate (air displacement)	Compressed gas or mechanical actuation required for operation
Flow rate is adjustable	May be difficult to decontaminate (piston displacement)

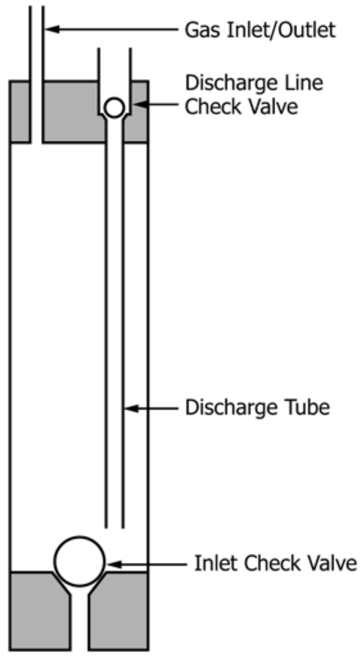


FIG. 3 Air/Gas Displacement Pump

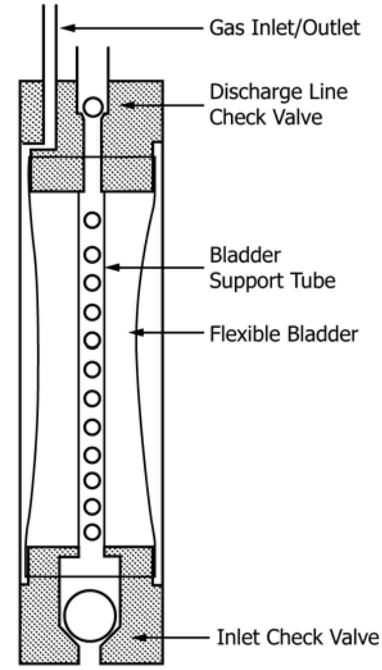


FIG. 5 Bladder Pump—Squeeze Type

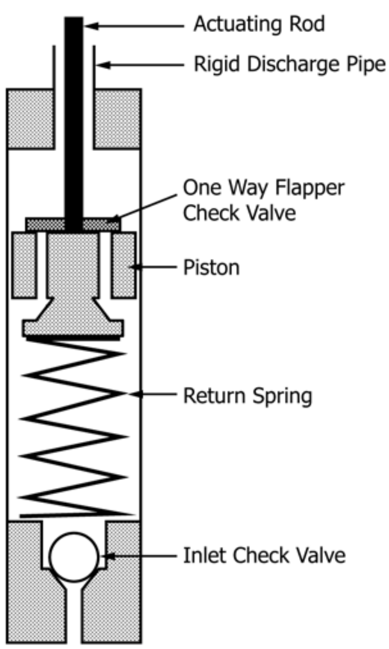


FIG. 4 Piston Displacement Pump

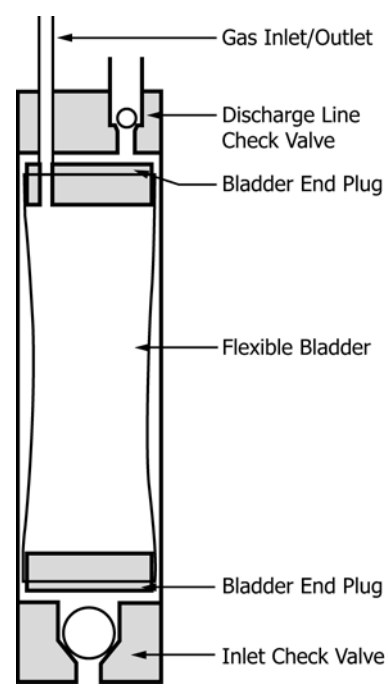


FIG. 6 Bladder Pump—Expanding Type

length of fluoropolymer or other suitable tubing is placed in the liquid and the other end is connected to the piece of flexible tubing which has been threaded around the rotor of the peristaltic pump. A second piece of fluoropolymer or other suitable tubing is connected to the discharge end of the flexible tubing to allow the water to be containerized, (see Fig. 8 *(b)*) sampled etc. If the pump tubing is not compatible with the sample parameters of concern, a modification to the system is necessary.

7.2.5.1 The modification (see Fig. 8*(c)*) consists of a peristaltic pump using fluoropolymer tubing and a fluoropolymer insert to collect samples without the sample coming into contact with the pump tubing. This is accomplished by placing the fluoropolymer insert into the opening of a clean glass container. The fluoropolymer tubing connects the container to the pump and the sample source.

7.2.5.2 The operation of the peristaltic pump results from the rotor compressing the flexible tubing causing a vacuum to be applied to the inlet tubing. The water is drawn up the inlet tubing and into the container, without coming into contact with the pump flexible tubing.

TABLE 6 Bladder Pumps—Advantages and Limitations

Advantages	Limitations
Suitable for sampling liquids containing volatile organic compounds as flow rate is adjustable	Requires compressed air or gas and a controller
Available in a variety of materials, such as fluoropolymer, stainless steel, PVC, etc. and diameters of 11.1 mm (7⁄16 in.) to 88.9 mm (3.5 in.)	Potential contamination from the bladder or housing materials, or both
Have an operational pumping head of up to 305 m (1000 ft)	Decontamination (depending on design) can be difficult

7.2.5.3 Samples for purgeable organic compounds analyses may be collected by attaching the fluoropolymer tubing to the intake side of the peristaltic pump, pumping the tubing full of the liquid, disconnecting the tubing, and allowing the fluoropolymer tube to drain into the sample vials. A peristaltic pump can also be used to mix and sample liquids from drums (see Guide D6063). See Table 8 for advantages and limitations.

7.2.6 *Centrifugal Submersible Pump (see Guide D4448, Practice D6771)* —Centrifugal submersible pumps (Fig. 9) may be used for purging and sampling monitoring wells, waste water impoundments or point discharges. Water contacting parts may be made of fluoropolymer and stainless steel. The motor cavity may be either filled with air, deionized, or distilled water that may be replaced as necessary. The pump may be controlled by either a 12V (DC) or a 110/220V (AC) converter. Flow rates range from 9 gallons per minute down to 100 milliliters per minute. The pump discharge hose may be made of fluoropolymer or other suitable material.

7.2.6.1 Operation of the pump relies upon the rotation of a set of impellers, powered by an electric motor. Water is drawn into the centrifugal pump by slight suction and then pressurized by the impellers working against fixed stator plates. The pressurized water is then driven to the surface through the discharge hose. The speed at which the impellers are driven controls the pressure applied and thence the flow rate. See Table 9 for advantages and limitations.

7.2.7 *Gear Drive Pump (see Guide D6634)*—Gear drive pumps may be used for purging and sampling monitoring wells, impoundments or point discharges. Water contacting parts are usually made from stainless steel and fluoropolymer (Fig. 10). These electric pumps are usually driven by a surface controller and have limited purging capability, but can be used to sample liquids containing VOCs and mobile colloids (**7, 8**).

7.2.7.1 The pump body contains a DC electric motor, usually 12 or 24V DC. This drives two gears within a pump cavity that draw water into the pump and delivers it to the surface through the discharge line. The pump speed controls the pressure and thence the flow. Heat may be generated and cavitation may occur when these pumps are operated for extended periods at high speed. See Table 10 for advantages and limitations.

7.2.8 *Progressing Cavity Pump (see Guide D6634)*—Progressing cavity pumps (Fig. 11) may be used to purge and sample monitoring wells as well as sample impoundments and point discharges. They are also known as helical rotor pumps. The pump design lends itself to use in sampling liquids containing VOCs (**8**), but care should be exercised to limit pump speed to minimize overheating. The output capacity of this pump design is limited.

7.2.8.1 They feature a helical rotor within a stator. In operation a cavity is formed between the rotor and stator that moves upwards as shown in Fig. 11. This carries the trapped water to the discharge and thence to the surface. Usually made from stainless steel and EPDM or Buna-N with PTFE fluorocarbon or PE seals. See Table 11 for advantages and limitations.

7.2.9 *Inertia Lift Pump (see Guide D4448)*—Consists of a rigid or semi-rigid discharge tube with a check valve installed on the lower end (see Fig. 12). They may be used to purge and sample monitoring wells or other bodies of liquid. In use the assembly is lowered into the liquid at the level desired for sampling. Rapid up down motion applied to the upper end of the tube forces the liquid up the tube to the surface. They may be used to sample liquids containing VOCs (**9**), but may cause degassing through excessive mechanical disturbance to the water column.

7.2.9.1 Construction materials may be selected to satisfy the needs of the sampling plan. The tubing selected needs to have sufficient rigidity to allow the reciprocating motion to be applied to the check valve submerged in the liquid being sampled. The operation of the sampler may be facilitated with the use of a mechanical reciprocating device, either electrically or engine driven. Care needs to be taken to limit excessive movement to prevent excessive mixing of liquids; thereby increasing degassing and turbidity in collected samples. See Table 12 for advantages and limitations.

7.3 *Dredges (see Guides D4342, D4343, D4387, E1391, and Practice D4348)*—Dredges are used for the collection of submerged sediments and semi-consolidated sludge.

7.3.1 *Ekman*—The Ekman dredge (Fig. 13) has only limited usefulness in environmental sampling. It performs well where bottom material is unusually soft, as when covered with organic sludge or light mud. It is unsuitable, however, for sandy, rocky, and hard bottoms. It is also too light to use in streams with high flow velocities. It should not be used from a bridge more than a few feet above the water, because the spring mechanism which activates the sampler can be damaged by the messenger if dropped from too great a height.

7.3.2 *Petersen*—The Petersen dredge (Fig. 14) can be used for routine analyses when the bottom is rocky, in very deep water, or when the stream velocity is high. The dredge should be lowered very slowly as it approaches the bottom, because it can displace and miss lighter materials if allowed to drop freely.

7.3.3 *Ponar*—The Ponar dredge (Fig. 15) is a modification of the Petersen dredge and is generally similar in size and weight. Smaller, lighter versions are also available. It has been modified by the addition of side plates and a screen on top of the sample compartment. The screen over the sample compartment permits water to pass through the sampler as it descends thus reducing the “shock wave”. The Ponar dredge is easily operated by one person in the same fashion as the Petersen dredge. The Ponar dredge is one of the most effective samplers

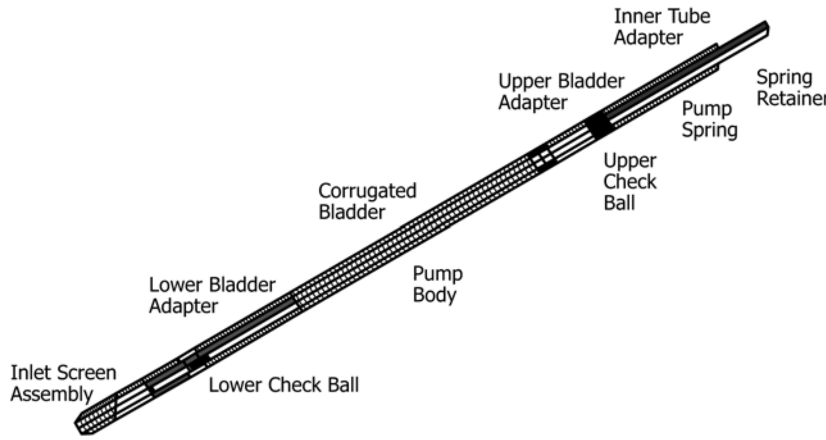


FIG. 7 Corrugated Bladder Pump

TABLE 7 Corrugated Bladder Pump—Advantages and Limitations

Advantages	Limitations
Suitable for sampling liquids containing volatile organic compounds as flow rate is adjustable	When depth to water is more than 23 m (75 ft) flow rate usually <200 mL/min
Available in fluoropolymer and stainless steel in a diameter of 12 mm (0.47 in.)	Potential contamination from the bladder or tubing materials, or both
Manually or 12 V actuator operated	
May be field decontaminated	

for general use on all types of substrates. See Table 13 for advantages and limitations.

7.4 *Discrete Depth Samplers (see Guide D4448 and Practice D6759)* —These samplers are used in lakes, ponds, impoundments, tanks and wells to collect samples at a specific depth or location in the body of liquid. Other types of discrete depth samplers are also available. (For shallow tanks and drums, refer to 7.8).

7.4.1 *Bacon Bomb*—The bacon bomb sampler (Fig. 16), originally designed for sampling oil, can be used for discrete depth sampling in stationary bodies of water, lakes, or waste. The primary advantage of this sampler over other discrete samplers is that it can be constructed of stainless steel and that it remains closed until it is triggered to collect the sample by raising the actuator rod with a second line and allowing the sampler to fill. Once a sample is collected, the device is closed by releasing the second line and the sampler is returned to the surface by raising the primary support line. The sample may then be transferred to a collection container. See Table 14 for advantages and limitations.

7.4.2 *Kemmerer (see Practices D4136 and D6759)*—The Kemmerer (Fig. 17) sampler is a stainless steel or brass cylinder with rubber stoppers that leave the ends open while being lowered in a vertical position to allow free passage of water through the cylinder. The Kemmerer is operated by sending a messenger down a rope when the sampler is at the designated depth, to cause the stoppers to close the cylinder, which is then raised. Water is removed through a valve to fill sample containers. With multiple depth samples, care should be taken not to stir up bottom sediment and thus bias the sample. All fluoropolymer construction is available. See Table 15 for advantages and limitations.

7.4.3 *Syringe Sampler*—A syringe sampler (Fig. 18) is used to sample highly viscous liquids, sludges and tar-like substances. It can also draw samples when only a small amount remains at the bottom of a tank or drum. Syringe samplers are available commercially, they usually include a piston assembly consisting of a T-handle, safety locking nut, control rod (fluoropolymer covered aluminum rod facilitates operation of the piston) piston body assembly, sampling tube assembly, and standard bottom valve or coring bottom. The assembled sampler with the bottom valve opened is positioned at the sampling point. By raising the T-handle, the sample is drawn into the sampler. The bottom valve is closed by pressing down on the sampler against the side or bottom of the container. To empty the sampler, open the bottom valve and extrude the sample into a container by pushing down on the T-handle. See Table 16 for advantages and limitations.

7.4.4 *Lidded Sludge/Water Sampler*—A stainless steel sampling device used to collect sludges or waste fluids in a 1-L glass jar (see Fig. 19). The jar is removed and transported to the laboratory. No transfer of the sample to another container is necessary; this decreases handling and cross contamination. A PTFE insert is placed in the lid and is replaced between collection of samples. Handle extensions with depth markings are available to allow sampling from difficult to access areas.

7.4.4.1 The lidded sludge sampler is lowered into the sludge. When the jar is at the desired depth, the top actuator handle is rotated to upright the jar and close the lid. The jar is removed by lifting it from the holder. For samples containing more than 40% solids, a cutter is added to the jar which cuts the sludge allowing it to fall into the jar. This device can be used in tanks, tank trucks and ponds. See Table 17 for advantages and limitations.

7.4.5 *Discrete Level Sampler*—A sampler that can be used to sample liquids in drums, tanks, surface waters or wells (see Fig. 20). It is fitted with manually operated valve or valves on the ends of the sample collection chamber. Made from fluoropolymer and stainless steel and designed to be reusable. The

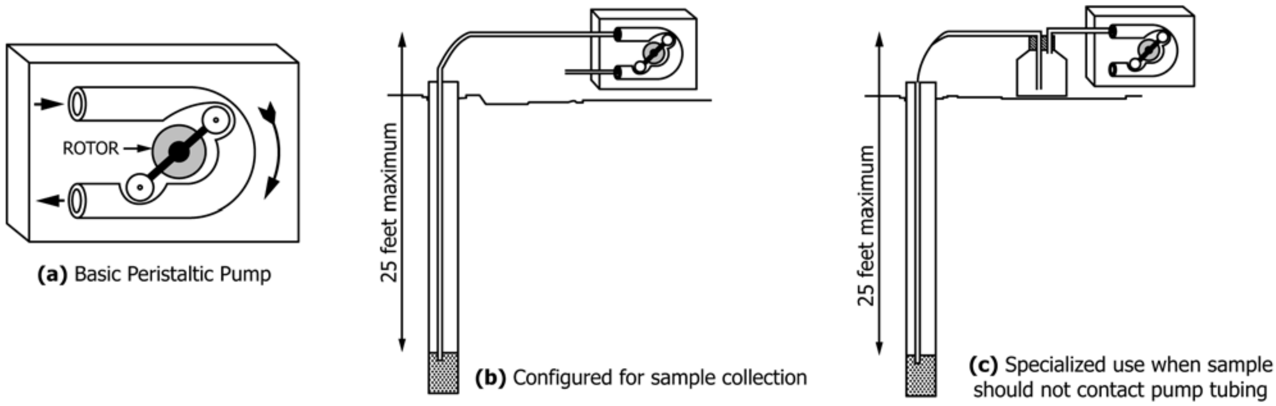


FIG. 8 Peristaltic Pump

TABLE 8 Peristaltic Pumps—Advantages and Limitations

Advantages	Limitations
May be used in small diameter wells	Depth to the liquid surface cannot exceed about 7.6 m (25 ft)
Decontamination of the pump motor is not necessary	May cause a loss of dissolved gases including volatile organic compounds
Easy to replace the pump tubing without decontamination	
Flow rate is adjustable	

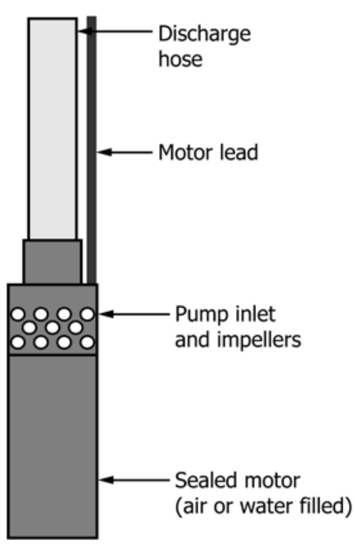


FIG. 9 Centrifugal Submersible Pump

TABLE 9 Centrifugal Submersible Pumps—Advantages and Limitations

Advantages	Limitations
Constructed of materials easily decontaminated, stainless steel and fluoropolymer	Requires an electric power source
May be used to pump liquids up to a 76 m (250 ft) head	May be incompatible with liquids containing a high percentage of solids
Flow rate is adjustable	Portable use may require a winch or reel system
	May not be suitable for collecting samples of liquids containing volatile organic compounds

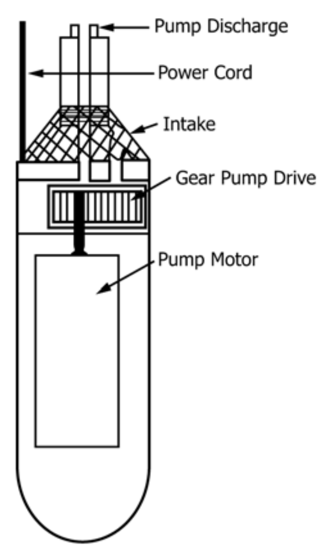


FIG. 10 Gear Drive Pump

sampler is assembled with either a rigid control tube and rod or a flexible tube and inner cable attached to the upper end of the sampler. The proximal ends of the controls are provided with a handle and inner rod or cable actuator. The standard model is provided with an upper manually operated valve for filling and a lower spring retained dump valve for emptying. The dual valve model has manually operated valves at each end.

7.4.5.1 The sampler is lowered into the liquid column to the desired sampling level. The valve or valves are opened manually and the liquid sample collected. The valve or valves are closed before removing the sampler from the liquid column. The collected sample may be taken to the laboratory in the sampler body by replacing the valves with solid fluoropolymer end caps. Alternatively, the standard model may be emptied by pressing the dump valve against the side of the sample collection container. The dual valve model may be emptied by opening the valves manually or with the use of a

TABLE 10 Gear Drive Pump—Advantages and Limitations

Advantages	Limitations
Constructed of materials easily decontaminated, stainless steel and fluoropolymer	Requires an electric power source
May be used to pump liquids up to a 53 m (175 ft) head	May be incompatible with liquids containing a high percentage of solids
Flow rate is adjustable	Low discharge rate (1.4 gpm maximum) may make them unsuitable for purging large volumes of water
Portable and easily disassembled for decontamination	

TABLE 11 Progressing Cavity Pump—Advantages and Limitations

Advantages	Limitations
May be used to pump liquids up to a 55 m (180 ft) head	Requires an electric power source
Flow rate is adjustable	May be incompatible with liquids containing a high percentage of solids
Cavitation free design	Low discharge rate (1.2 gpm maximum) may make them unsuitable for purging large volumes of water
	Difficult to disassemble and decontaminate
	Construction materials may be incompatible with some sample matrices.

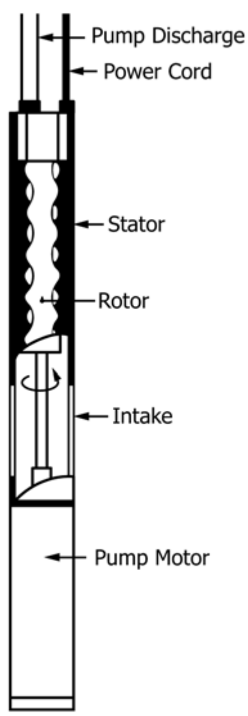


FIG. 11 Progressing Cavity Pump

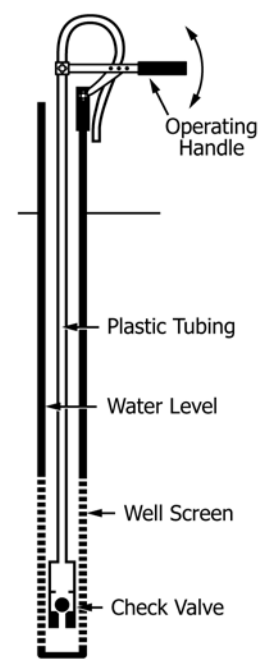


FIG. 12 Inertia Lift Pump

metering device attached to the lower end of the sampler (not shown). See Table 18 for advantages and limitations.

7.4.6 *Bailer (see Guide D4448, Practice D6699)*—A bailer is essentially a length of fluoropolymer, stainless steel or PVC pipe with a check valve on the bottom (see Fig. 21). Preferably, the top should be closed, except for a pouring opening to keep matter on the inside of the well casing from falling into the bailer while sampling. The bottom valve allows the bailer to fill with sample and retain it while being brought to the surface. Bailers are available in numerous sizes to accommodate a wide variety of well sizes as either reusable or single use sampling devices. See Table 19.

7.4.6.1 When using a top-emptying bailer, samples can be recovered with a minimum of aeration if care is taken to gradually lower the bailer until it contacts the water surface and is then allowed to sink as it fills. The bailer should be raised to the surface slowly. When transferring the bailer contents to a sample container, the bailer should be tipped only enough that a slow discharge from the top of the bailer is allowed to flow into the container.

7.4.6.2 Bottom-emptying bailers with controlled flow valves are also available. This type of bailer is particularly good for collecting samples for volatile organic analyses (VOA) since they minimize agitation of the sample and prevent sample aeration as the device is closed during insertion in the lower end of the bailer. Non-valved tubular devices may allow aeration of the bailer contents as they are inserted into the lower end of the bailer.

7.4.7 *Point Sampling Bailer (see Guide D4448, Practice D6699)* —The point-sampling bailer is similar in construction to the bailer described in the prior section. A point source bailer has an additional check valve at the top of the body (see Fig. 22). As the bailer is lowered through the liquid column the

TABLE 12 Inertia Lift Pump—Advantages and Limitations

Advantages	Limitations
May be used to pump liquids up to a 80 m (260 ft) head	May require an electric or engine driven power source for extended use in deep wells
Low cost and simple to use	May cause excessive disturbance to the liquid column
Easily disassembled for decontamination, if required	May dislodge surface materials on well casing above water column
May be used in very small diameter water columns	Tubing and check valve may be externally damaged by the well casing and screen during use through abrasion

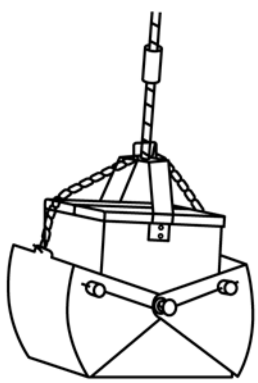


FIG. 13 Ekman Dredge

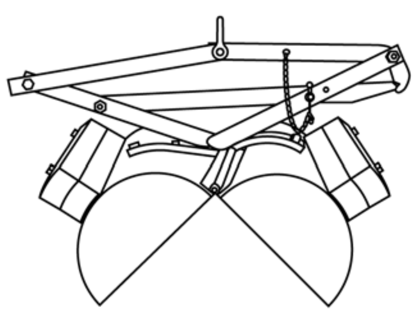


FIG. 14 Petersen Dredge

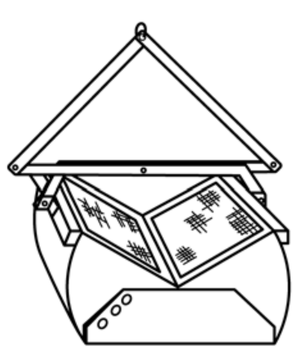


FIG. 15 Ponar Dredge

liquid flows through the bailer. At the sampling point the two check valves will close to contain the sample and prevent

TABLE 13 Dredges—Advantages and Limitations

Advantages	Limitations
Ability to sample most types of stationary sediments from silt to granular material	Are not capable of collecting undisturbed samples
Light weight Ponar dredges are available	Are not capable of collecting a representative lift or repeatedly sampling to the same depth and position
	Petersen and other dredges with extra weights are very heavy
	Care must be taken to minimize disturbance and sample washout as the dredge is retrieved through the liquid column
	May be difficult to decontaminate due to construction or materials
	Not suitable for use in rough waters
	Not useful if the bottom to be sampled is covered with vegetation

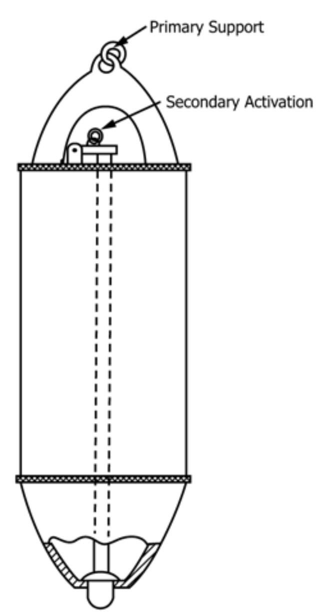


FIG. 16 Bacon Bomb

TABLE 14 Bacon Bomb—Advantages and Limitations

Advantages	Limitations
Sampler is not opened until the desired sample depth is reached	May be difficult to decontaminate due to design or construction materials
Available in 4, 8, 16 and 32-oz sizes	Sampling device construction material may not be compatible with parameters of concern

mixing with the liquids above as the sampler is retrieved. See Table 20 for advantages and limitations.

7.4.8 *Differential Pressure Bailer (see Practice D6699)*—The differential pressure bailer comprises a sealed tubular body with two small diameter tubes built in to the removable top (see

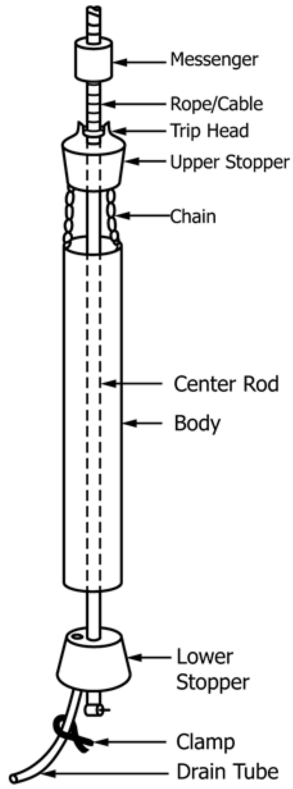


FIG. 17 Kemmerer Sampler

TABLE 15 Kemmerer—Advantages and Limitations

Advantages	Limitations
Able to sample at discrete depths	Sampling container is exposed to medium being sampled while being lowered to sampling point
	May be difficult to decontaminate due to construction or materials

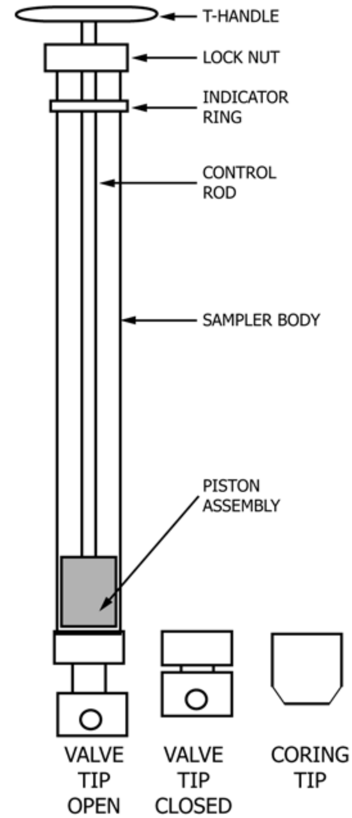


FIG. 18 Syringe Sampler

TABLE 16 Syringe Sampler—Advantages and Limitations

Advantages	Limitations
Simple to use and decontaminate, all sample contacting parts are fluoropolymer	With viscous materials, more materials may end up on the outside of the sampler than inside it
Ability to sample at discrete depths, including the bottom of the container	
May be used to depths of about 1.8 m (6 ft)[A]	

[A] Syringe samplers capable of sampling to depths of several hundred feet may be available.

Fig. 23). It is usually made from stainless steel to provide sufficient weight to allow it to sink quickly to the sampling point. Hydrostatic pressure allows the bailer to fill through the lower tube at the same time as displacing air through the upper tube. See Table 21 for advantages and limitations.

7.4.9 *Dipper (see Practice D5358, D6759)*—This sampling device is used to collect liquid samples at or near the surface of ponds, pits, lagoons, and so forth (see Fig. 24). The sampler can consist of a variety of pieces of equipment assembled in a manner to obtain a sample. One type consists of an adjustable clamp attached to the end of a piece of metal tubing. The tubing forms the handle; the clamp is used to secure a beaker, sample container, etc. Another device is made using a stainless steel scoop clamped to a movable bracket which is attached to a piece of rigid tube. The scoop may face either toward or away from the person collecting the sample, and the angle of the scoop to the pipe is adjustable. See Table 22 for advantages and limitations.

7.4.10 *Liquid Grab Sampler (see D6759)*—The liquid grab sampler is designed to collect liquid or slurry samples at specific depths beneath the liquid surface of ponds, pits and lagoons (see Fig. 25). It is usually made from polypropylene or fluoropolymer with an aluminum or stainless steel handle and stainless steel fittings. The sampling jar, usually glass but plastic is available, is threaded into the sampler head assembly and lowered to the desired sampling position beneath the liquid surface. The valve is opened, by pulling up on the finger ring, to allow the jar to fill and then closed before retrieving the sample. See Table 23 for advantages and limitations.

7.4.11 *Swing Jar Sampler (see D6759)*—The swing jar sampler comprises an extendable aluminum handle attached to a plastic jar holder using a pivot (see Fig. 26). The open top jar is held in the holder with an adjustable clamp. The pivot allows samples to be collected at different angles. It may be used to sample liquids, powders or small solids at distances of up to 3½ m (approximately 12 ft). Normally used with high density polyethylene sample jars. See Table 24 for advantages and limitations.

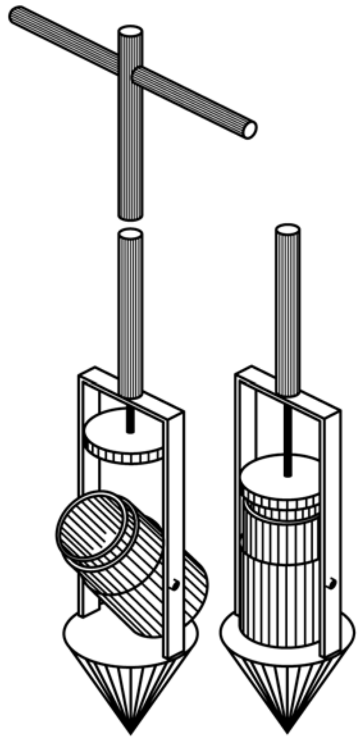


FIG. 19 Lidded Sludge/Water Sampler

TABLE 17 Lidded Sludge/Water Sampler—Advantages and Limitations

Advantages	Limitations
Sampler is not opened until desired depth is reached, allowing collection of samples from discrete depths	Thick sludge is difficult to sample with the device
Sturdy construction, prevents personnel contact with the sample	Equipment is heavy
Bottles and lids are unique to each sample container; decontamination of these is not required	Limited to one bottle size

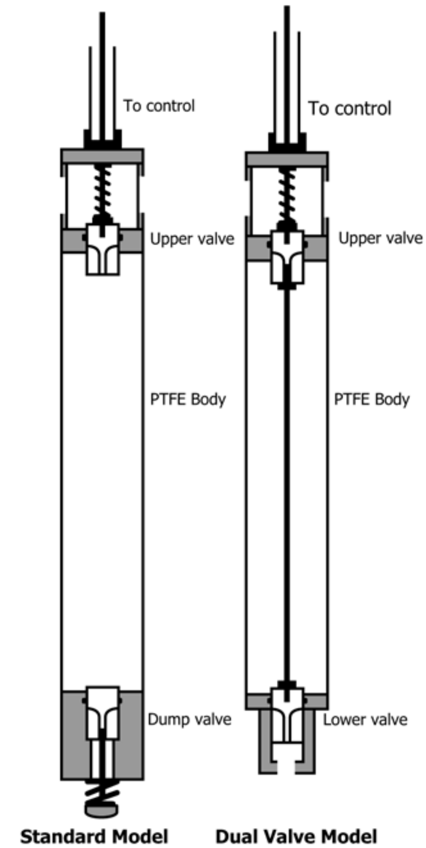


FIG. 20 Discrete Level Sampler

TABLE 18 Discrete Level Sampler—Advantages and Limitations

Advantages	Limitations
May be easily decontaminated	May be unsuitable for sampling liquids containing a high percentage of solids
May be used to sample liquids in most environmental situations	Sample chamber capacities 240 to 475 mL
Sample quality minimally affected by liquids above the sampling point	
Remote operation for hazardous environments.	

7.4.12 *HYDRASleeve Sampler*—The HYDRASleeve sampler is designed as a no purge sampler to collect ground water at discrete depths (see Fig. 27). It is essentially a virgin polyethylene bag with a one-way reed check valve on the upper end of the sampler. The lower end of the sampler is sealed and has a weight/anchor attached. Upon retrieval of the sampler at a pace of 31 cm/sec (1 ft/sec) or greater, the check valve opens a water fills the bag through the sampling interval. Once full, the pressure of the water in the sampler will close the check valve. Multiple discrete depths may be sampled by deploying multiple HYRDASleeve samplers in succession. See Table 25 for advantages and limitations.

7.4.13 *Snap Sampler*—The Snap Sampler is a no purge sampler that is designed to collect ground water at discrete depths (see Fig. 28). The Snap Sampler is a system in which an open sampling bottle is deployed downhole to the desired sampling interval with an attachment/trigger line and left to equilibrate. To collect the sample, the mechanical trigger is released and PFA (Teflon) "Snap Caps" that seal the bottles are pushed into place. The end caps are specially designed to seal the water sample within the bottles with no headspace vapor. Once the closed vial is retrieved from the well, the bottles are prepared with standard septa screw caps and labeled for laboratory submittal. Multiple discrete depths may be sampled by deploying multiple Snap Samplers in succession. See Table for advantages and limitations.

7.5 *Drive/Push Samplers*—Used for sampling contaminated soils and groundwater as well as waste; comprise a wide range of equipment from large transportable rotary, percussive drilling and pushing machines to the more compact direct push equipment now in extensive use for environmental sampling, geotechnical investigation and soil remediation. Most of the

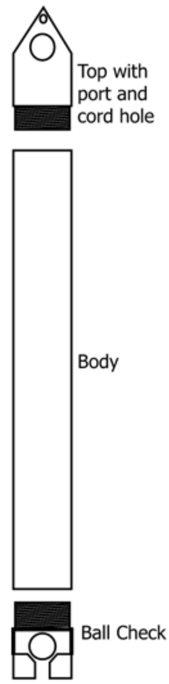


FIG. 21 Bailer

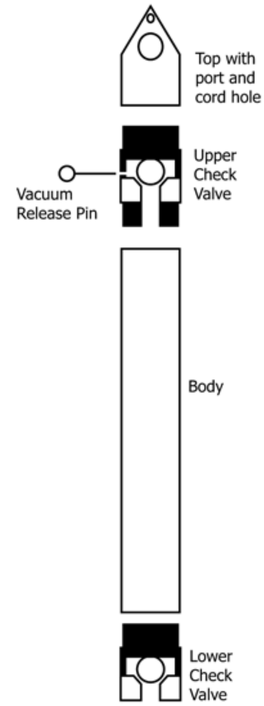


FIG. 22 Point Sampling Bailer

TABLE 19 Bailer—Advantages and Limitations

Advantages	Limitations
Simple to use	Unable to collect samples from specific depths below the liquid surface
External power source not required	Transfer of sample from top-emptying bailer to sample container may aerate sample if not poured carefully
Relatively economical compared to other sampling methods; a separate bailer could be dedicated to each well	May disturb sample in water column if the bailer is lowered too rapidly
Can be made from almost any material that is compatible with the parameters of interest	May be chemically incompatible with certain matrices unless constructed of resistant material

TABLE 20 Point Sampling Bailer—Advantages and Limitations

Advantages	Limitations
Simple to use	Bailer may be compromised as it is lowered through contaminated layers in the liquid column
Allows sample collection at a specific depth in the liquid column	Requires a means to unseat the upper check valve to break the vacuum as the sample is eluted through the lower check valve using a bottom emptying device

forgoing equipment and its applications in geotechnical investigations, geotechnical and well construction and resource exploration are covered in standards developed within ASTM Committee D18, Soil and Rock. Applications within the scope of D34, Waste Management, involve both this machine-driven sampling equipment and hand-operated, smaller devices that have specific uses in the waste management area as well as life sciences. The following ASTM standards, related to soil and rock investigations, were developed primarily within ASTM Committee D18. They should be referred to for specific information on this equipment: Practices D1452, D1587, D3550, D5079, D6151, D6640, Test Method D1586, Guides D4696, D4700, D5314, D5730, D5778, D5781, D5782, D5783, D5784, D5875, D5876, D6001, D6169, D6282, and D6286.

7.5.1 *Direct Push Devices:*

7.5.1.1 *Direct Push Water Sampler*—This sampler is a specialized device pushed hydraulically into a water-bearing zone at a selected depth for discrete ground water sampling (see Fig. 29). This device may be used in conjunction with a hollow-stem auger where the center plug is removed and then the device is inserted into the auger and pushed or driven to the required location in the aquifer. The device is then opened to allow entry of water and subsequently closed and retrieved for decontamination and reuse. The device can also be used as a temporary well. Use of this device reduces the volume of soil cuttings which may have to be handled as an investigative derived waste. See Table 27 for advantages and limitations.

7.5.2 *Probe Samplers*—Probe samplers can be used for sampling soil vapor, soil and ground water (see Figs. 30 and 31. These samplers range in construction from a simple small diameter tube (usually less than 25 mm (1 in.) diameter) with a hard detachable point that is hand or manually hammer driven to more complex and larger devices that are rig driven and can be opened after penetrating the ground surface.

7.5.2.1 The rig driven probe samplers generally consist of a single or dual tube system, 50 mm (2 in.) or more in diameter

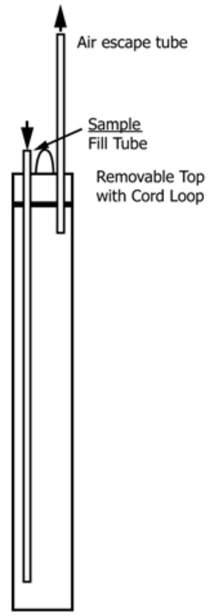


FIG. 23 Differential Pressure Bailer

TABLE 21 Differential Pressure Bailer—Advantages and Limitations

Advantages	Limitations
Simple to use	Decontamination requires care to ensure that all parts of the device, including the air escape and sample entry tubes, are clean
Allows sample collection at a specific depth in the liquid column, without risk of contaminants in upper layers compromising the sample	

FIG. 24 Dipper

TABLE 22 Dipper—Advantages and Limitations

Advantages	Limitations
Inexpensive	When liquids are stratified, it cannot be used to obtain a sample containing the same proportions of the strata as the location being sampled
When attached to a rigid tube, can reach easily 3 to 4 m (10 to 13 ft) away from the person collecting samples	Can be used only to obtain surface samples

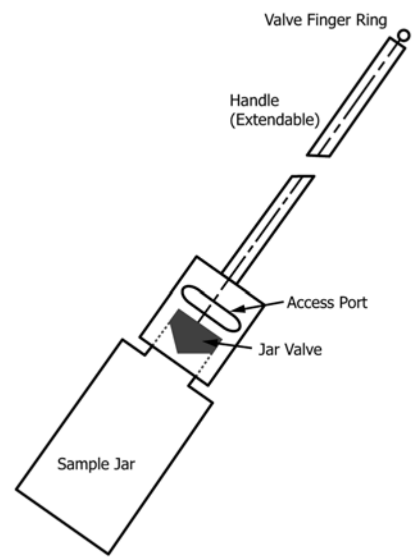


FIG. 25 Liquid Grab Sampler

TABLE 23 Liquid Grab Sampler—Advantages and Limitations

Advantages	Limitations
Simple and easy to use	Care in use is required to prevent breakage of the glass sample jar
May be used to sample ponds, impoundments, tanks, drums and through manholes	Construction materials should be compatible with the media being sampled
The closed sampler prevents contaminants in upper layers compromising the collected sample	
The filled sampling container may be capped, stored, and shipped	

with detachable hard steel tips and are pushed or hydraulically driven into the subsurface materials.

7.5.2.2 Single tube piston samplers are used for discrete interval sampling. Dual tube piston samplers permit sampling of soils in saturated conditions—flowing heaving sands, expanding clays and soils below the water table.

7.5.2.3 Continuous coring is often conducted with dual tube soil sampling systems which provide increased sample integrity because the borehole is cased (see Guide D6282). Some probe samplers are equipped with adjustable screens or retractable inner rods to allow for sampling of soil vapor or ground water. Ground water can be retrieved using a peristaltic pump (see 7.2.5), miniature bladder pump (see 7.2.3 and 7.2.4) or miniature bailer (see 7.4.6). Soil samples can be collected at discrete intervals using specialized attachments.

7.5.2.4 Samples can be prepared for on-site analysis in a field laboratory or off site depending upon volumes obtained (see Practice D6640) and the use of the data as determined by the data quality objectives process. See Table 28 for advantages and limitations.

7.5.3 *Split-Barrel (see Test Method D1586 and Practice D3550)*—A split-barrel sampler is used to collect soil samples at depth. The sampler consists of a length of steel tubing split longitudinally and equipped with a drive shoe and a drive head

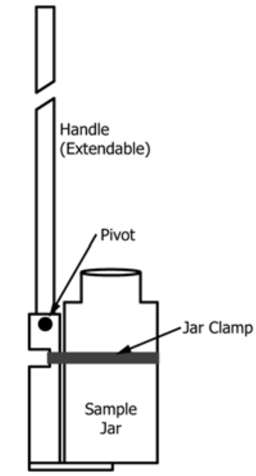


FIG. 26 Swing Jar Sampler

TABLE 24 Swing Jar Sampler—Advantages and Limitations

Advantages	Limitations
Simple and easy to use	Cannot collect discrete samples
Easily adaptable to sample jars of different sizes and materials	Construction materials should be compatible with the media being sampled
The filled sampling container may be capped, stored and shipped	Care required to prevent breakage when using a glass sample jar

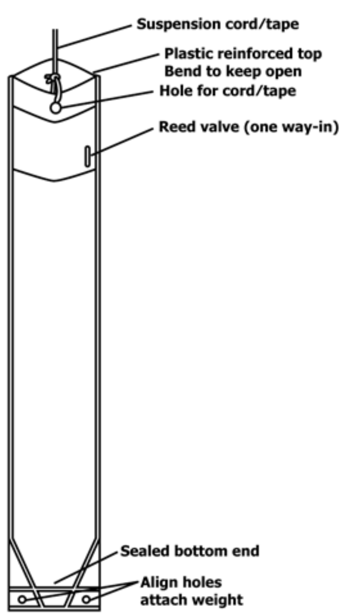


FIG. 27 HYDRASleeve Sampler

TABLE 25 HYDRASleeve Sampler—Advantages and Limitations

Advantages	Limitations
Simple and easy to use	May be chemically incompatible with certain matrices and contaminants
Disposable	Cannot collect samples from bottom of well to the top of the sampler
Inexpensive	Practical sample size limited by weight of sample at about 3 L
Can be designed to fit well size and sampling need/volume	

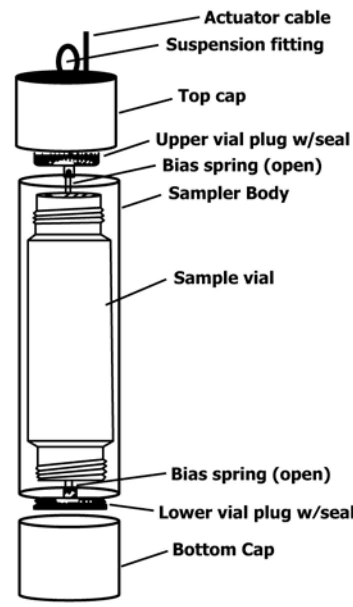


FIG. 28 Snap Sampler

Advantages	Limitations
Simple and easy to use	May be chemically incompatible with certain matrices and contaminants
Sample sealed *in situ*	Samples sizes limited to 40 m, 125 m, and 350 mL
Inexpensive	Special Snap Caps and bottles are necessarily for proper sampling

(see Fig. 32 and Fig. 33). They are available in a variety of diameters and lengths.

7.5.3.1 The sampler can be driven manually with a slide hammer or mechanically with a rig drive weight assembly or pushed using rig hydraulics.

7.5.3.2 Drill and direct push rigs offer the capability of collecting soil samples from greater depths. For all practical purposes, the depth of investigation achievable by this method is controlled only by the depth of soil overlying bedrock, which may be in excess of 31 m (100 ft) (see Guide D6286).

7.5.3.3 When used in conjunction with drilling, split-barrel samplers are usually driven either inside a hollow-stem auger or inside an open borehole after rotary drilling equipment has been temporarily removed. The barrel is driven with a 140-lb drop hammer through a distance of up to 24 in. and removed. If geotechnical data is also required, the number of blows with the hammer for each 6 in. driven interval is also recorded (see Test Method D1586).

7.5.3.4 Split-barrel samplers are sometimes used with liners. The advantage of a liner is that the sample can be removed from the sampler with a minimum amount of disturbance; and, if used correctly, they can minimize contamination of the samples. Liners are often used in situations where volatile

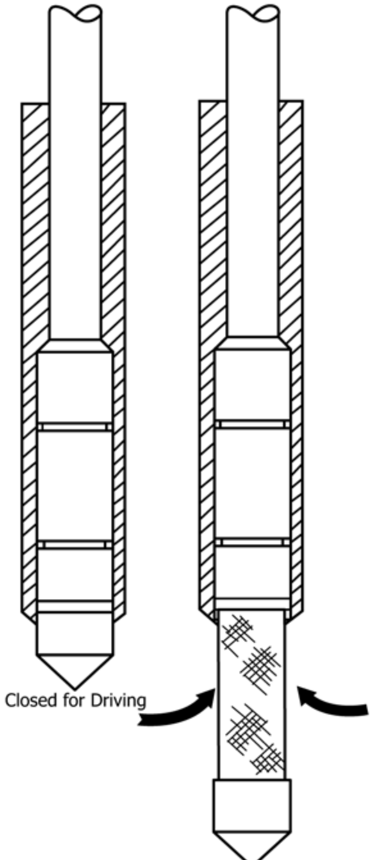


FIG. 29 Direct Push Water Sampler

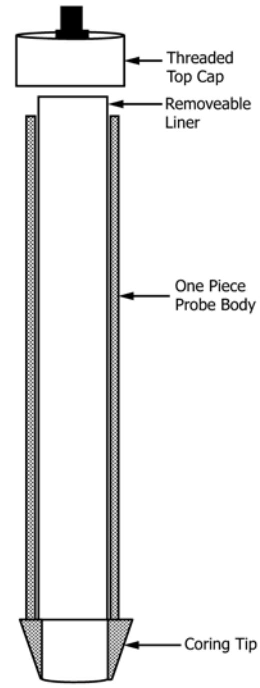


FIG. 30 Probe Sampler, Hand Use

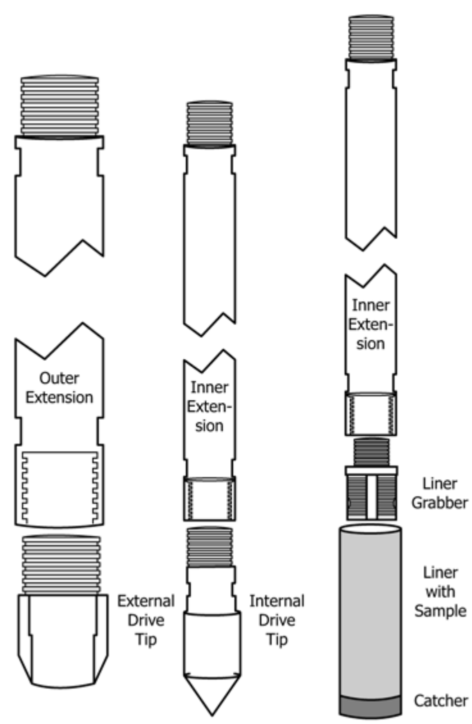


FIG. 31 Probe Sampler, Rig Use

TABLE 27 Direct Push Water Sampler—Advantages and Limitations

Advantages	Limitations
Provides discrete depth ground water samples without the installation of a monitoring wall	Volume of sample may be limited which may influence the type of analysis possible
Can aid in more appropriate placement of permanent monitoring wells when used with onsite analytical methods	Requires the use of a drill or direct push rig and some specialized training for use
Can be used to rapidly and inexpensively collect samples for expedited site characterization	May be physically incompatible with matrices that result in refusal of the direct push device (e.g. consolidated rock, thick caliche, cobbles)
Can be used in depths reached by appropriate drilling equipment	
Reduces investigative derived waste	
Some samplers effective for vertical water quality profiling	

organic compounds are constituents of concern or where there is an interest in trace elements or compounds. It is important that the investigator chooses liners composed of materials that are chemically compatible with the matrix and constituents of concern. For sub-sampling see Practice D6640.

7.5.3.5 Split-barrel samplers may be fitted with a core catcher immediately behind the drive tip. This will allow the sampler to collect samples of wet or cohesionless soils. See Table 29 for advantages and limitations.

7.5.4 *Continuous Core Sampler (see Guide D5784)*—These samplers are similar in design to those described in the previous section (see 7.5.3 and Fig. 33). They are usually

TABLE 28 Probe Sampler—Advantages and Limitations

Advantages	Limitations
Can be used to rapidly collect samples for expedited site characterization	Limited sample volume (Hand-use model)
Versatile, generally 15–20 locations a day can be sampled for soil vapor, ground water, soil, or any combination using hydraulically powered equipment	Penetration can be limited by composition of subsurface materials
When combined with field analysis these samplers can reduce the use of more expensive off-site fixed laboratory analytical work	Use can be limited by depth to target media such as deeper ground water or accessibility of placement unit
Reduces investigative derived wastes	May be physically incompatible with matrices that result in refusal of the direct push device
Provides a relatively undisturbed sample, providing the sample particle size is significantly smaller than the sampler inside diameter	

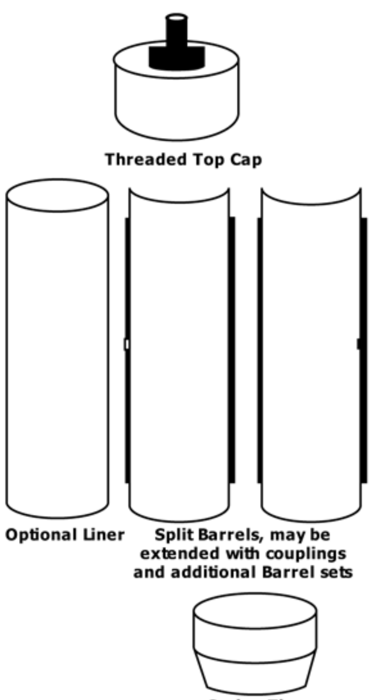


FIG. 32 Split-Barrel (also known as) Split Core Sampler for Hand Use

longer than those previously described as they may be used to obtain 1.52 m (5 ft) long, continuous samples approximately 7.6 to 12.7 cm (3 to 5 in.) diameter.

7.5.4.1 These devices are designed for use with a hollow stem auger type drill rig. The sampler is usually placed inside a 5-ft long hollow stem auger section and advanced with the auger during drilling. As the auger advances, the central core of soil moves into the sampler where it is retained until retrieved.

7.5.4.2 Continuous samplers used within a hollow stem auger allow the collection of a core as the system is advanced. The continuous sampler needs to be retrieved every time it is driven its length and replaced with a clean sampler (see Guide D5784).

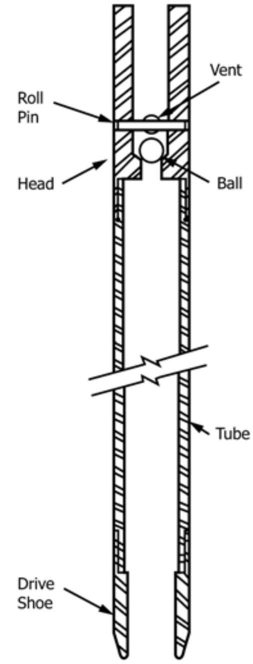


FIG. 33 Split-Barrel Sampler for Rig Use

TABLE 29 Split-Barrel Samplers—Advantages and Limitations

Advantages	Limitations
Provides a relatively undisturbed sample, providing the sample particle size is significantly smaller than the sampler inside diameter	Usually requires a drill or direct push rig for deep samples up to 30 m (100 ft) below the soil surface
Since the sample is not extruded, fewer volatile organic compounds may be lost	The sample is exposed to the atmosphere, potentially allowing loss of volatile organic compounds, unless subsampling is immediately performed
Samples collected in capped liners can be stored for limited times before subsampling	Sampling in a water-filled open borehole may not allow collection of good samples

7.5.4.3 Advantages and limitations for this device are as shown in Table 29.

7.5.5 *Thin-Walled Tube (see Practice D1587)*—This is generally constructed of stainless steel and has a beveled leading edge, which is pushed directly into the soil. This type of sampling device is particularly useful if a relatively undisturbed sample is required (see Fig. 34). The sampling device is removed from the push head, then the sample is extruded from the tube into a pan or sample container with a spoon or special extruder. Even though the push head is equipped with a check valve to help retain samples, the thin-wall tube will generally not retain all soils. Thin-walled tubes come in a variety of sizes and may be used in conjunction with drills, from hand-held to full sized drill rigs. See Table 30 for advantages and limitations.

7.5.6 *Coring Type Sampler with Valve (see Guide D4823)*—This is designed for sampling sediments, sludges and free

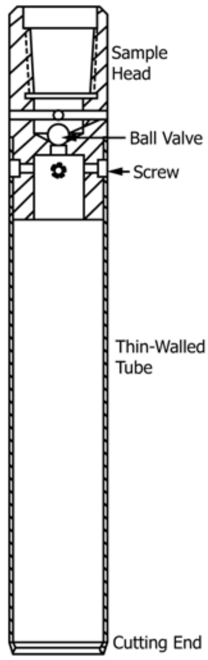


FIG. 34 Thin-Walled Tube

TABLE 30 Thin-Walled Tube Sampler—Advantages and Limitations

Advantages	Limitations
Provides a core sample	Cannot be used in gravel or rocky soils
Collects a structurally undisturbed sample which minimizes loss of volatiles	Loss of volatile organic compounds possible if the sample is extruded and/or sub-sampling is delayed
Can be deployed down a bore hole to collect deep samples	Samples containing VOCs cannot be stored in the liner
Inexpensive and easily decontaminated	Not effective in cohesionless soils

flowing powders (see Fig. 35). It is a stainless steel cylindrical sampler with a non-return valve at the lower end behind a coring or augering tip. The sample will normally be collected in an optional liner. It is operated by attaching a handle or an extension with a handle to the top of the coring device. The corer is lowered to the sampling point, pushed into the material being sampled and then removed. To recover the sample, the top cap is removed and the contents emptied into a sample container. Alternatively, the liner can be removed and capped on both ends for subsequent shipment to a laboratory. See Table 31 for advantages and limitations.

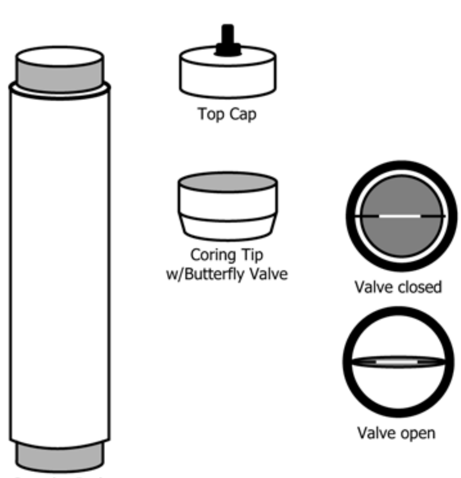


FIG. 35 Coring Sampler with Butterfly Valve (Hand Use)

7.5.7 *Concentric Tube Thief and Trier (see Practices D5451 and E300)* —These hand-held devices can be used for sampling powdered or granular materials or wastes in piles or in bags, drums or similar containers.

7.5.7.1 The concentric tube thief (Fig. 36) consists of two slotted telescoping tubes, constructed of stainless steel, brass or other material. The outer tube has a conical, pointed tip on one end that allows the thief to penetrate the material being sampled. The thief is opened and closed by rotating the inner tube.

7.5.7.2 The trier (Fig. 37) is essentially a tube with a slot that extends along most of its length. The tip and edges of the tube slot are sharpened to allow the trier to cut a core of the material to be sampled when rotated after insertion into the material. Commercially available triers are usually constructed from stainless steel. See Table 32 for advantages and limitations.

7.5.8 *Miniature Core Sampler (see Practice D6418)*—The device is designed to collect and store small volume soil samples and allow transportation to a laboratory for subsequent chemical analysis of VOCs. Constructed from an inert composite polymer, the device consists of a coring body, a plunger and an end cap (Fig. 38). Stainless steel handles are available to assist in collecting and subsequently extruding the sample. The sampler is available in sizes to allow collection of volumetric samples of approximately 5 and 25 g. Air-tight sealing is achieved with Viton® O-rings placed on the plunger and in the cap. The device may be used to retrieve samples of soil from the ground surface or trench walls. It is also frequently used to collect sub-samples from soil cores. See Table 33 for advantages and limitations.

7.5.9 *Modified Syringe Sampler (see Guide D4547)*—The sampler is used for collecting a small volume sample from a material surface or more usually to subsample a core for subsequent VOC analysis. The sample then is transferred

TABLE 31 Coring Type Sampler with Valve—Advantages and Limitations

Advantages	Limitations
Provides a core sample of semi-liquid materials	Cannot be used in gravel or large particle sediments or sludges
Easily decontaminated	Samples containing VOCs cannot be stored and transported in the liner–sub-sample promptly
May be used in drums and small containers as well as tanks, lagoons, and waste impoundments	For sampling surface materials only
Usually hand operated	

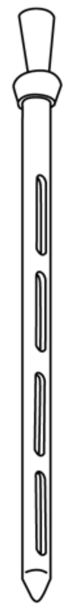


FIG. 36 Concentric Tube Thief (Hand Use)

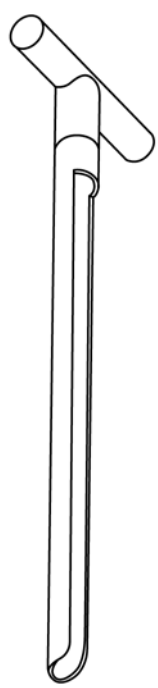


FIG. 37 Trier (Hand Use)

immediately to a vial for transportation and analysis. The device is available commercially or made by modifying a plastic, disposable syringe. The lower end with the attachment for a needle and plunger cap is removed (see Fig. 39). The plunger is pushed in until it is flush with the cut end. The syringe sampler is then pushed into the soil core to collect the sample which should then be placed in a prepared, air-tight glass vial for transport to a laboratory until analyzed. The vial mouth should have a diameter larger than the syringe barrel. See Table 34 for advantages and limitations.

TABLE 32 Tube Thief and Trier—Advantages and Limitations

Advantages	Limitations
Concentric tube thief is best used in dry, unconsolidated materials	Does not collect samples containing all particle sizes if the diameter of the largest solid particle is greater than one third of the slot width
The trier is best for moist or sticky materials	Samples may not be representative

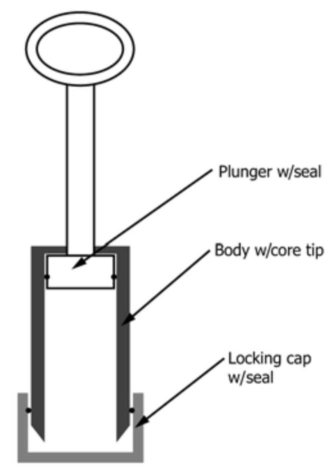


FIG. 38 Miniature Core Sampler

TABLE 33 Miniature Core Sampler—Advantages and Limitations

Advantages	Limitations
Provides a core sample from a soil surface or trench wall	Difficult to use in dry sandy materials
Collects a relatively undisturbed sample	Care required to ensure that soil does not compromise the end cap seals
Sampler is designed as a single use device for collection, storage and transportation of samples containing VOCs.	Cost may be a consideration for this single use device
Collects a sample of suitable size for analysis. Laboratory or field subsampling is not required	
Sliding plunger prevents air entrapment and allows sample extrusion	

7.6 *Rotating Coring Devices*—Includes a screw auger that collects cuttings of consolidated materials and rocks, a rotating corer that collects cores of consolidated materials and a captive screw auger that is used to collect samples of semi-consolidated materials.

7.6.1 *Screw Augers*—For sampling consolidated solids such as construction materials, soft rock and wood. These augers are similar to drill bits and can be operated by hand (brace and bit) or powered by a portable electric drill (see Fig. 40). As the auger advances into the material being sampled, the cuttings move up the auger stem to the surface where they are collected for the sample. See Table 35 for advantages and limitations.

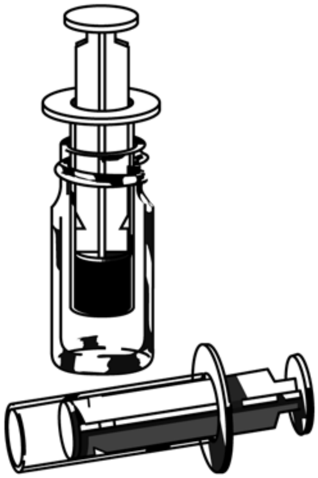


FIG. 39 Modified Syringe Sampler

TABLE 34 Modified Syringe Sampler—Advantages and Limitations

Advantages	Limitations
Provides a core sample if sampled from a soil surface or trench wall	Difficult to use in dry sandy materials
Collects a relatively undisturbed sample	Care required to ensure device is clean before use
Sampler is a low cost single use device	
Collects a sample suitable for VOC analysis, laboratory, or field subsampling is not required	
Sliding plunger prevents air entrapment and allows sample extrusion	

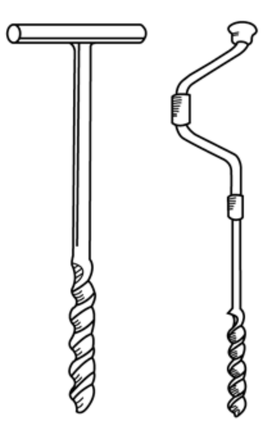


FIG. 40 Screw Augers

7.6.2 *Rotating Coring Device*—This device is used to obtain a core of consolidated solid (see Fig. 41). It consists of a diamond or carbide tipped open steel cylinder attached to an electric drill. The drill may be hand held or mounted on a stand placed on the ground surface. Water is usually used to cool and lubricate the cutting edge. The core barrel diameter ranges from 5 to 15 cm (2 to 6 in.). The described device is used to obtain a sample from the surface to depths of 30 cm (12 in.). See Table 36 for advantages and limitations.

TABLE 35 Screw Augers—Advantages and Limitations

Advantages	Limitations
Allows collection of a sample from a solid material	Destroys layers and soil horizons and cannot obtain an undisturbed sample
	Loss of volatile organics likely

FIG. 41 Rotating Corer

7.6.3 *Captive Screw Auger (see Practice D5680)*—The captive screw auger (see Fig. 42) may be used to sample semi-consolidated materials in piles or drums. The stainless steel chisel tipped flighted (screw) auger is contained within an 1¼ in. (3.2 cm) diameter by up to 42 in. (107 cm) long stainless steel tube. It may be driven with either an electric, hydraulic or air powered motor. The device may be inserted into the drum through the bung hole. When operated, the chisel tipped flighted auger cuts into the sample and carries the recovered portion up the flights to the collection container at the top of the sampler. This may be emptied by pouring from the port into a sample container. The sampler cuts a core through the material being sampled, allowing collection of a disturbed, composite sample. See Table 37 for advantages and limitations.

7.7 *Augers (see Practices D1452, D6907, and Guide D4700)* —Augers are used primarily to collect soil samples and fine sediments. They work by rotating and pushing the auger into the material to be sampled. Many different types and designs are available, ranging from the hand-held to portable power-driven to pick-up or van mounted to full-scale drill rigs.

NOTE 3—Large diameter, for example, 36-in. (91-cm), bucket augers are used to collect samples of municipal solid waste (MSW) for analysis and testing.

TABLE 36 Rotating Corer—Advantages and Limitations

Advantages	Limitations
Can obtain a solid core	Need power and water source
	Difficult to operate
	May affect integrity of the matrix

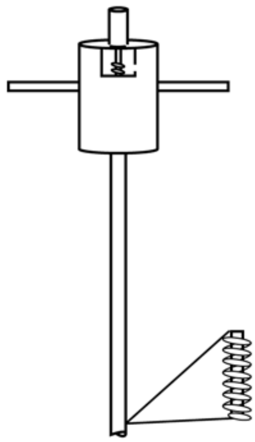


FIG. 42 Captive Screw Auger

TABLE 37 Captive Screw Auger—Advantages and Limitations

Advantages	Limitations
Allows sampling of semi-solid, consolidated samples in both drums and pile	Requires an external power source (air/gas/hydraulic/electric)
All stainless steel construction	Collects only disturbed samples
May be used in hazardous environments	Care needed when sampling materials containing volatile organic compounds

7.7.1 *Hand-Operated Bucket Augers*—Typically, hand-operated bucket augers (Fig. 43) with cutting heads are pushed and twisted into the media and removed as the buckets are filled. The auger holes are advanced one bucket at a time. The practical depth of investigation using a hand auger is related to the material being sampled. In sands, augering is usually easily accomplished, but the depth of investigation is controlled by the depth at which sands begin to cave. At this point, auger holes usually begin to collapse and cannot practically be advanced to lower depths, and further samples, if required, must be collected using some type of pushed or driven device. Hand augering may also become difficult in tight clays or cemented sands. At depths approaching 20 ft (6 m), torquing of hand auger extensions becomes so severe that in resistant materials, powered methods must be used if deeper samples are required.

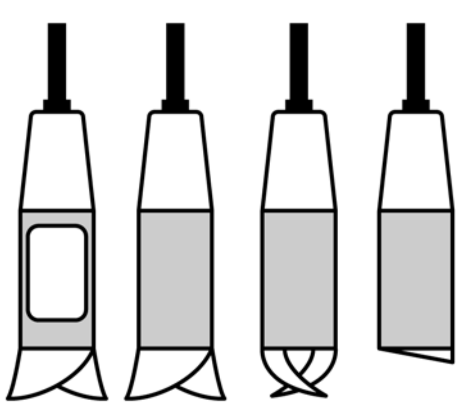


FIG. 43 Hand-Operated Bucket Augers

7.7.1.1 When a vertical sampling interval has been established, one bucket auger is used to advance the auger hole to the first desired sampling depth. If the sample at this location is to be a vertical composite of all intervals, the same bucket may be used to advance the hole, as well as collect subsequent samples in the same hole. However, if discrete samples are to be collected to characterize each depth, a clean bucket auger must be used to collect the next sample. The top several inches of material should be removed from the bucket to minimize chances of cross-contamination of the sample from fall-in of material from the upper portions of the hole.

7.7.1.2 The Planer type bucket auger may be used to remove loose material from the bottom of an augered hole, prior to core sampling. It may also be used to collect samples of solid materials from the bottom of drums and tanks. See Table 38 for advantages and limitations.

7.7.2 *Flighted Augers (see Practice D1452, Practice D6151, Guide D5784, Guide D6286)*—Flighted augers are most often used for accessing sampling points below the ground surface and may be used directly for collecting disturbed samples, usually for on-site evaluation (see Fig. 44). Flighted augers are always driven with an external power source. They are available in sizes from 2 in. (5.1 cm) to over 24 in. (61 cm) in diameter with either a solid or hollow stem to which the flights are attached. Auger sections are made in lengths from 2 ft (61 cm) to 6 ft (1.83 m) long with couplings on each end to allow attachment of additional sections during the drilling process.

7.7.2.1 Solid stem flighted augers are provided with a cutting tip on the lower end of the first flight. During use the soil travels up the flights to the surface as the auger turns. This soil may be examined for classification and evidence of gross contamination but would usually not be used for chemical analysis as it may not be totally representative owing to mixing and sloughing that may occur as it travels to the surface.

7.7.2.2 Hollow stem flighted augers are a commonly used method for both soil and water sampling as well as the installation of ground water monitoring wells and devices. This auger's tubular center allows sampling devices to pass through while maintaining a cased hole. Hollow stem models are provided with a plug or removable drive tip to prevent soil from entering the stem during drilling.

7.7.2.3 Samples for chemical analysis would usually be collected from a hollow stem auger by using a core sampler (Test Method D1586, Practice D1587, D3550, D4700). The sampler would be deployed through the central cavity of the auger, after removing the rods with end plug. Sampler types include split barrel, core barrel and piston types that may be

TABLE 38 Hand-Operated Bucket Augers—Advantages and Limitations

Advantages	Limitations
Easy and quick for shallow subsurface samples	Collects only disturbed samples
	May be inappropriate for sampling soils for volatile organic compounds destined for chemical analysis

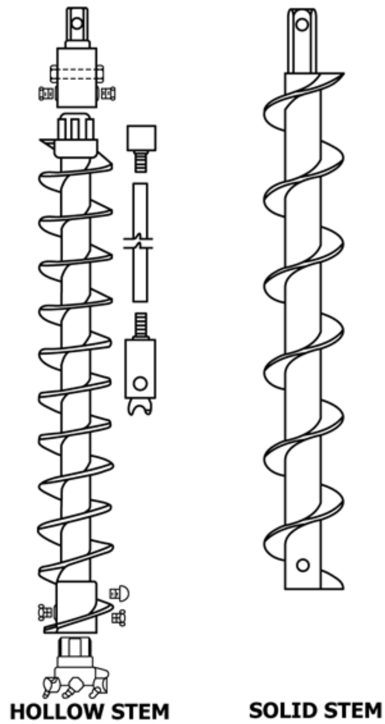


FIG. 44 Flighted Augers

driven ahead of the lower end of the auger or, using a continuous core sampler the length of the auger section as it is rotated its length into the ground. Using these sampler types with thin walls and liners allows the collection of relatively undisturbed samples. See Table 39 for advantages and limitations.

7.7.2.4 Sample collection from a solid stem auger would be accomplished by inserting a core sampler into the open hole created by the auger. See Table 40 for advantages and limitations.

7.7.3 *Peat Borer* (**7**)—This device was originally designed to sample bog and salt marsh sediments for paleoecological analysis and to collect uncompressed cores in poorly decomposed woody peat. It may also be used to sample soft sediments in shallow water conditions (Fig. 45). Recent applications (**7**) demonstrated its usefulness in sampling contaminated sediments below water to depths of 25 ft (6.4 m).

TABLE 39 Hollow Stem Flighted Augers—Advantages and Limitations

Advantages	Limitations
Can be used to access a sampling point from immediately below the ground surface to considerable depths	Requires an external power source to drive the auger and usually heavy truck mounted equipment to transport, deploy and operate
May be used to sample soils for VOC analysis, with the use of appropriate samplers	
May be used to access sampling points beneath the water table as it provides a cased hole	

TABLE 40 Solid Stem Flighted Augers—Advantages and Limitations

Advantages	Limitations
Can collect disturbed samples from immediately below the ground surface to considerable depths	Requires an external power source to drive the auger and usually heavy truck-mounted equipment to transport, deploy and operate
Primarily used to access a sampling point	Inappropriate for directly sampling soils for volatile organic compounds

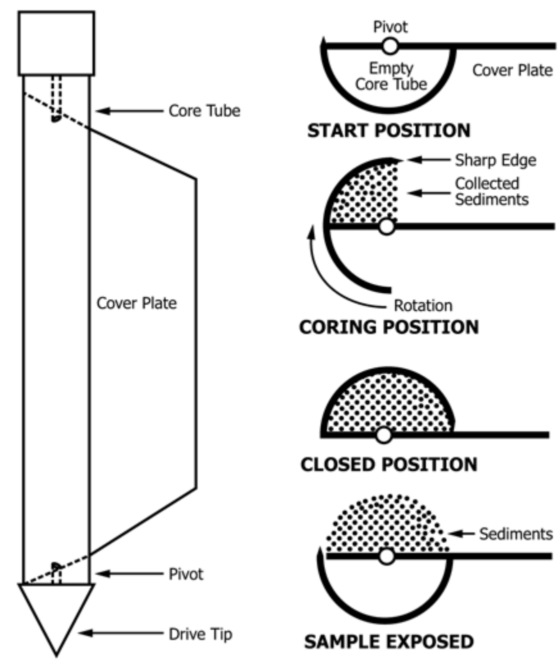


FIG. 45 Peat Borer

7.7.3.1 The sampler consists of a stainless steel coring tube with one longitudinal wall sharpened and a stainless steel cover plate pivoted at the center of the core tube cavity. The sampler has Delrin lower and upper ends designed to both facilitate insertion into the material to be sampled and allow attachment of deployment extensions on the upper end. The sampler collects a 19.6 in. (50 cm) long core by 2.2 in. (5.4 cm) diameter with a half circle cross-section.

7.7.3.2 The sampler is assembled with the cover plate enclosing the core tube to prevent entry of material as it is pushed to the sampling point. The sample is then collected by rotating the sampler in a clockwise direction until the sharp edge of the coring tube is in contact with the cover plate. The sampler is then withdrawn and the sample exposed by rotating the cover plate in a counterclockwise direction. See Table 41 for advantages and limitations.

7.8 *Liquid Profile Devices:*

7.8.1 *COLIWASA (see Practices D5495 and D5743)*—The COLIWASA (Composite Liquid Waste Sampler) sampler is used to obtain a vertical column of liquid of the sampled material (see Figs. 46 and 47). Its most common use is for sampling containerized liquids, such as tanks, barrels, and drums. It may also be used for pools and other open bodies of

TABLE 41 Peat Borer—Advantages and Limitations

Advantages	Limitations
Portable and operable by one person	Materials of construction, Delrin, aluminum and stainless steel may pose concerns in highly contaminated media
Capable of collecting a discrete, relatively undisturbed sample	Unsuitable for deployment in compacted media
Generates virtually no IDW	

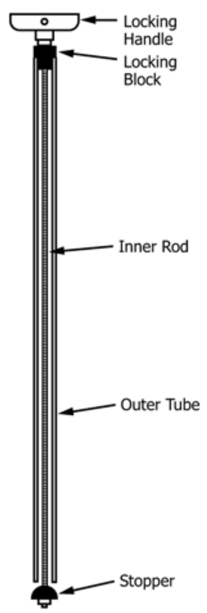


FIG. 46 Original COLIWASA

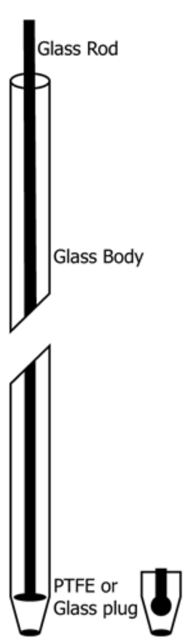


FIG. 47 Single Use COLIWASA

stagnant liquids. It may be constructed of any material compatible with the samples being collected.

7.8.1.1 COLIWASA's are available commercially with different types of stoppers and locking mechanisms, but all operate using the same principle. In use, the device is lowered into the liquid, tapered end first. The COLIWASA should be open at both ends so that the material flows through it as it is lowered to the desired sampling depth. This must be done slowly because the container may contain solid material which might break the tube and injure the sampler, and slowly lowering the tube allows the liquid phases to stay in equilibrium with the COLIWASA sampler.

7.8.1.2 The reusable point sampler (Fig. 48) is used in the same way as the COLIWASA. In addition it may be used to sample at a specific point in the liquid column. This sampler is usually made of fluoropolymer.

7.8.1.3 Once the COLIWASA has filled, the stopper mechanism is seated and both tubes are withdrawn from the material together. By manipulating the inner tube, the sampler can control the rate of flow of sampled liquid into the sample container. See Table 42 for advantages and limitations.

7.8.2 *Drum Thief (see Guide D5743)*—A drum thief is a 1.3 m (4 ft) long tube used to sample liquids in drums and similar containers. It is usually made of glass, but can be constructed of other materials (see Fig. 49). In most instances, glass tubes with a 1 centimeter (½ in. or less) inside diameter work best. The tube is inserted into the opening of the drum or barrel as far as possible. The open end is then sealed either with the thumb or a rubber stopper to hold the sample in the tube while removing the tube from the container. The sample is then placed in an appropriate container, and the procedure repeated until an adequate amount of sample is collected. See Table 43 for advantages and limitations.

7.8.3 *Valved Sampler*—This device allows collection of a vertical column of liquid from a drum or tank (see Fig. 50). It may be constructed from fluoropolymer for reuse or polypropylene for single use. The device is operated by first opening the top plug and the bottom valve and then lowering it

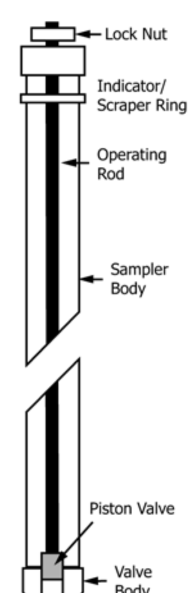


FIG. 48 Reuseable Point Sampler

TABLE 42 COLIWASA—Advantages and Limitations

Advantages	Limitations
Simple to use	Depth to sample limited to length of sampler
Reuseable and single use models available	Stopper mechanism may not allow collection of approximately the bottom inch of material
Inexpensive	High viscosity fluids difficult to sample
	May break if made of glass and used in consolidated matrices
	If constructed of glass and reused, decontamination may be difficult

FIG. 49 Drum Thief

TABLE 43 Drum Thief—Advantages and Limitations

Advantages	Limitations
Simple to use	Depth to sample limited to length of sampler
Usually single use	High viscosity fluids difficult to sample
Inexpensive	Drum size tubes have a small volume capability, possibly requiring repeated use to obtain a sample. Larger sizes are available, however, two or more people may be required
	May be difficult to hold sample in the tube
	May break if used in consolidated matrices
	If made of glass and reused, decontamination may be difficult

vertically and slowly into the liquid to allow levels inside and outside to equalize. The top plug is closed manually and the bottom valve is pressed against the side or bottom of the container to close it. To empty the sampler, the contents are poured from the top into a suitable container. See Table 44 for advantages and limitations.

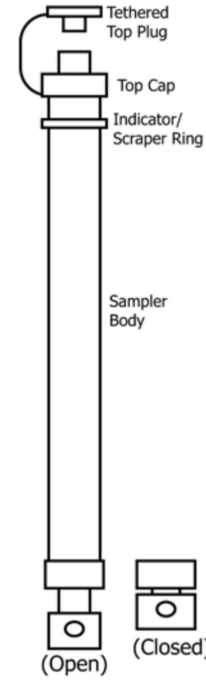


FIG. 50 Valved Sampler

7.8.4 *Plunger-Type Sampler (see Practice D5743)*—The plunger type sampler is used to obtain a vertical column of liquid or slurries from drums, tanks or similar containers. It is made from high density polyethylene or fluoropolymer with an optional glass sampling tube (see Fig. 51). It has an open lower end and a fixture at the upper end to hold a sampling bottle. The device is lowered into the liquid to be sampled, the plunger is engaged to secure the sample aliquot and the cord or rod is raised to transfer the sample directly into the sampling bottle or jar. The plunger can be pushed back down the sampling tube to reset the sampler. They are available in lengths suitable for sampling drums, road tankers and rail cars. See Table 45 for advantages and limitations.

7.8.5 *Liquids Profiler*—The sampler is made from clear PVC and is provided with 1-ft depth markings on the 5-ft sampler body sections, a check valve on the lower section and a cord on the upper section (see Fig. 52). Its primary use is to allow measurement and sampling of settleable solids as would be found in sewage treatment plants, waste settling ponds, and impoundments containing waste materials. In use, it is

TABLE 44 Valved Sampler—Advantages and Limitations

Advantages	Limitations
Simple to use	Bottom valve prevents collection of the bottom 1.25 cm (½ in.)
Reusable if made from fluoropolymer; single use if made from polypropylene	High viscosity liquids may be difficult to sample
Unbreakable and can sample to depths of about 6.5 m (21 ft), using body extensions	

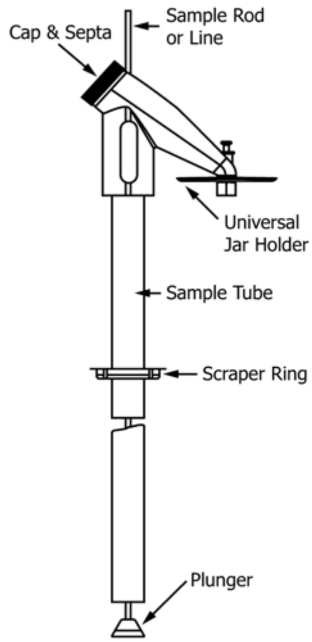


FIG. 51 Plunger Type Sampler

TABLE 45 Plunger Type Sampler—Advantages and Limitations

Advantages	Limitations
Simple to use	Care needed when using a glass sampling tube
Provides a sealed collection system	Heavy contamination may be difficult to remove, particularly when a glass sampling tube is used
May be used as either a reusable or single use device	
Relatively inexpensive and available in various lengths	

assembled, using threaded connections to the length needed and lowered into the liquid to allow it to fill. A slight tug on the cord will set the check valve and allow it to be removed. The levels of settleable solids can be measured using the markings. It may be emptied by pressing the protruding pin on the lower end against a hard surface, or it may be pushed in and held manually. See Table 46 for advantages and limitations.

7.9 *Passive Water Sampling Devices*—Comprise a group of samplers used to sample ground water, usually monitoring wells (see Figs. 53 and 54). They rely upon the diffusion of chemical ions and compounds across a semipermeable membrane. The device consists of a sealed chamber with a semipermeable window or a bag made from a semipermeable material. The container is filled with deionized water and then deployed in the media to be sampled. Over time, an equilibrium will be established between the ion and compound concentrations in the media being sampled and the sampler. The sampler is then removed from the media and the sealed chamber immediately opened or directly subsampled for on-site analysis. Alternatively, a sample may be placed into a container suitable for shipment to a laboratory for analysis.

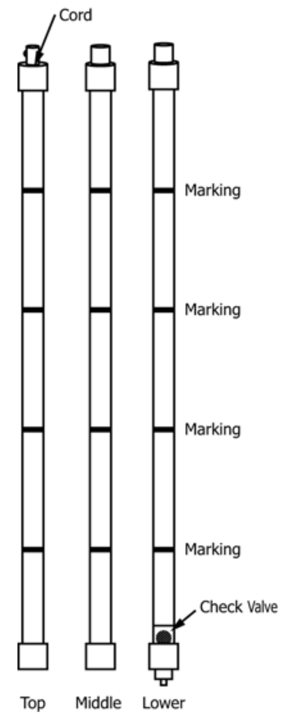


FIG. 52 Liquids Profiler

TABLE 46 Liquids Profiler—Advantages and Limitations

Advantages	Limitations
Allows length measurement of liquid/settleable solids columns of any length	Suitable for sampling non-caustic liquids
Easily assembled and used	High viscosity materials may be difficult to sample
Unbreakable in normal use and reusable	

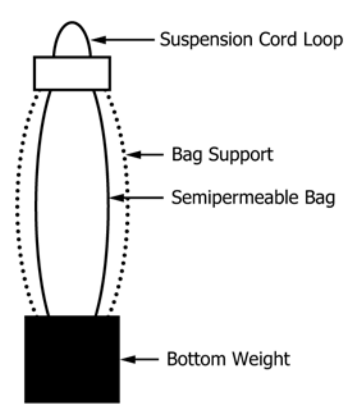


FIG. 53 Bag-Type Passive Sampler

7.9.1 *Bag-Type Passive Sampler*—Comprises a sealed bag made from a semipermeable plastic with a means to allow filling and removal of any trapped air. A support frame of inert material prevents the filled bag from failure when exposed to the atmosphere. A weight to allow the device to sink to the sampling point and a means to allow lowering and retrieval from the media being sampled. All components of this sampler

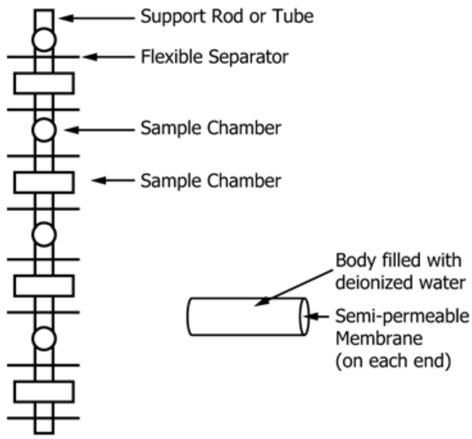


FIG. 54 Chamber-Type Passive Sampler

may be cleaned and reused, except for the sealed bag which is considered a single use item. See Table 47 for advantages and limitations.

7.9.2 *Chamber-Type Passive Sampler*—Comprises a central support rod or tube with horizontal holes along its length to allow placement of short tubular sampling containers. Certain models also have a flexible disc placed between each successive chamber to allow for isolation and allow for zone sampling. Each sealed chamber is provided with a semipermeable membrane on one or both ends. The assembly would be carefully lowered into the well and left to allow for ion equilibrium to be established. On removal, the sealed chambers can be capped and sent to a chemical analysis facility. See Table 48 for advantages and limitations.

7.10 *Multi-Level Sampling Devices* are inserted into a hole in the ground for the purpose of either identifying contaminants or collecting samples of soil gas or ground water, or both, at specific locations in the hole (see Figs. 55-57). Those designed for multi-level sampling in saturated soils are normally dedicated and therefore left permanently in the ground. Types designed for in situ identification of contaminants as well as sampling are usually recoverable as they are made from an inflatable, flexible, closed end tube.

7.10.1 *Dedicated Multi-Level Samplers*—Comprise a series of sampling ports placed in a casing and separated by inflatable packers or bentonite contained in annular sacks (see Figs. 55 and 56). The sampling ports in each monitoring zone are either fitted with a sampling pump connected directly to the surface

TABLE 47 Bag-Type Passive Sampler—Advantages and Limitations

Advantages	Limitations
Simple, low cost construction	Requires time for diffusion to occur(days-weeks)
Easily assembled and used in wells of any diameter	Sample volume limited to size of sampling container
As no water is removed from the formation, may be used to sample wells with very low recovery potential	Membranes affected by excessive heat and high concentrations of some solvents

TABLE 48 Chamber-Type Passive Sampler—Advantages and Limitations

Advantages	Limitations
Allows several zones to be sampled when used with separators	Requires time for diffusion to occur(days-weeks)
As no water is removed from the formation, may be used to sample wells with very low recovery potential	Requires care in assembly, installation and recovery to prevent damage and hang-up
	Usually requires wells or boreholes to be of 2 or 4-in. diameter

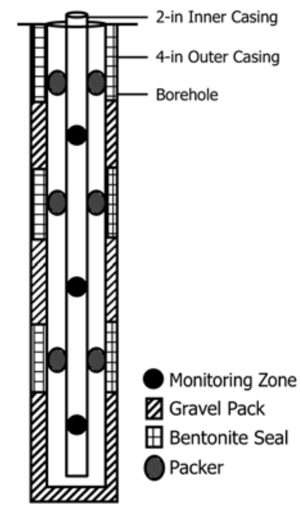


FIG. 55 Dedicated Multi-Level Type 1, Ground Water Monitoring System

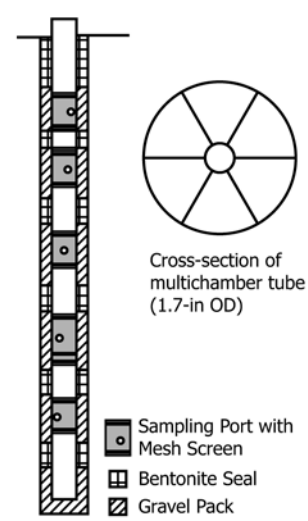


FIG. 56 Dedicated Multi-Level Type 2, Ground Water Monitoring System

or are provided with a valued sampling port that may be accessed by a sampling mechanism, lowered into the inner well casing. A second type employs a multi-cavity tube. Each cavity is ported at a specific depth to allow sampling and each cavity

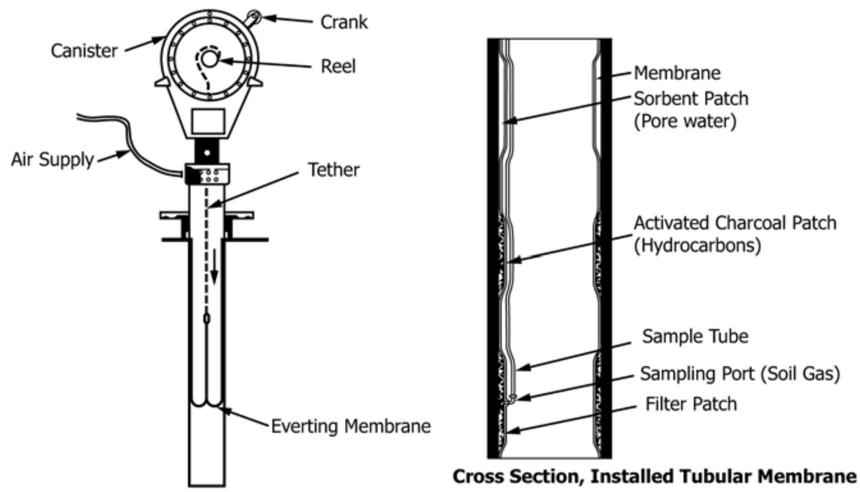


FIG. 57 Portable Multi-Level, Below Ground Monitoring System

is sealed below the sampling point. Systems employing inflatable packers and not bentonite sacks are usually removable and therefore reusable. See Table 49 for advantages and limitations of these devices

7.10.2 *Portable (Reusable) Multi-Level Sampler*—Comprises a strong but flexible tubular membrane with an internal tether attached to the sealed distal end (see Fig. 57). The proximal end of the tubular membrane is attached to an enclosed canister with reel. The system is deployed by pressurizing the canister interior and unwinding the tether and attached tubular membrane. It automatically deploys itself into the borehole. A series of sampling ports, sensor strips or absorbent patches may be attached to or through the external wall of the membrane to allow sampling of the borehole wall at predetermined depths. Systems may be used for dedicated or portable sampling. Depending on field conditions, the interior of the membrane may be filled with air, water or dry sand for portable use. Permanent installations may use bentonite grout as a fill material. In situations where there is concern about hole collapse, a dual tubular membrane system may be deployed to prevent this when the sampling tubular membrane is removed. Removal of an installed tubular membrane is accomplished by releasing the air pressure or removing other fill materials and winding in the tether and membrane onto the reel in the canister. See Table 50 for advantages and limitations.

TABLE 49 Dedicated Multi-Level Ground Water Monitoring Systems—Advantages and Limitations

Advantages	Limitations
Allows several zones to be sampled or monitored consecutively or simultaneously	Requires expertise beyond that needed for conventional monitoring well installation and subsequent use
Significantly lower installation costs, compared to conventional cluster wells	System material costs may be a consideration, Type 1
Low material and installation costs, Type 2	

TABLE 50 Portable Multi-Level Below Ground Monitoring System—Advantages and Limitations

Advantages	Limitations
Allows sampling and physical parameter measurement directly from the borehole wall	Requires expertise beyond that needed for conventional monitoring well installation and subsequent use
Each system is custom configured for a specific borehole	May be difficult to install in boreholes subject to collapse, unless special techniques are employed
Low material and installation costs and reusable	

7.11 *Surface Sampling Devices (See Practice D5679):*

7.11.1 *Impact Devices*—These devices are used for sampling consolidated solids (see Fig. 58). The most common "device" is a hammer and hand chisel. Another device is the pneumatic chisel where compressed air takes the place of the hammer. See Table 51 for advantages and limitations. .

7.11.2 *Spoon*—A spoon may be used to sample particulate materials on the ground surface or from an open container or waste pile (see Fig. 59). Small samples of liquid may also be collected with this device, although it is not the preferred method. Made from stainless steel or fluoropolymer they can be easily cleaned for reuse. Plastic spoons may be used as they are inexpensive and can be considered a single use item. See Table 52 for advantages and limitations.

7.11.3 *Scoops and Trowels (see Practice D5633)*—These have limited application for collecting surface soil samples but may be used for solid waste sampling. These devices come in

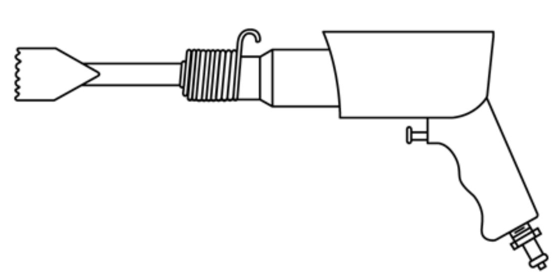


FIG. 58 Impact Device

TABLE 51 Impact Devices—Advantages and Limitations

Advantages	Limitations
Can obtain a sample of a solid material by chipping or flaking at the surface of the material	Pneumatic system needs an air source
	May not collect all layers of a heterogeneous solid

FIG. 59 Spoon

TABLE 52 Spoon—Advantages and Limitations

Advantages	Limitations
Inexpensive	Small sample volume
Easy to use and clean	Will exacerbate the loss of volatile organic compounds by disturbance
	A single sample may not be representative

different sizes and materials (see Fig. 60). Unpainted stainless steel is preferred. Scoops are available from laboratory and field equipment supply houses; trowels can be obtained from hardware stores. See Table 53 for advantages and limitations.

7.11.4 *Shovels*—Shovels used for environmental sample retrieval are usually made from stainless steel or suitable plastic materials (see Fig. 61). Their primary use is collection of surface materials or large samples from waste piles. Their other use is the mixing of large sample volumes as may be required for the collection and mixing of composite samples. See Table 54 for advantages and limitations.

7.12 *Vadose Zone Pore Sampling*—The vadose zone is the hydrogeological region extending from the ground surface to the top of the principle water table. It may contain locally

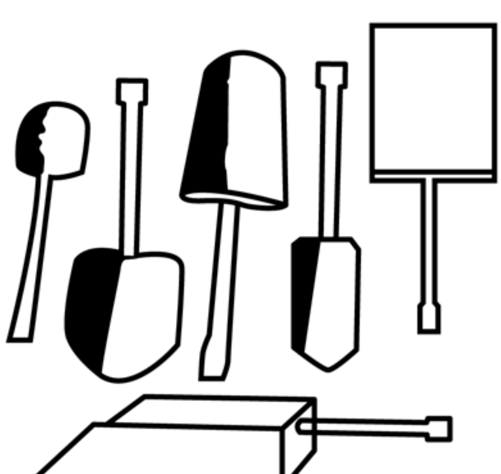


FIG. 60 Stainless Steel Scoops

TABLE 53 Scoops and Trowels—Advantages and Limitations

Advantages	Limitations
Easy to use and clean	May affect the matrix during sample collection by selecting certain particle sizes
Inexpensive	May not be constructed in a shape that is compatible with the dimensions of the matrix
	Will exacerbate the loss of volatile organic compounds by disturbance

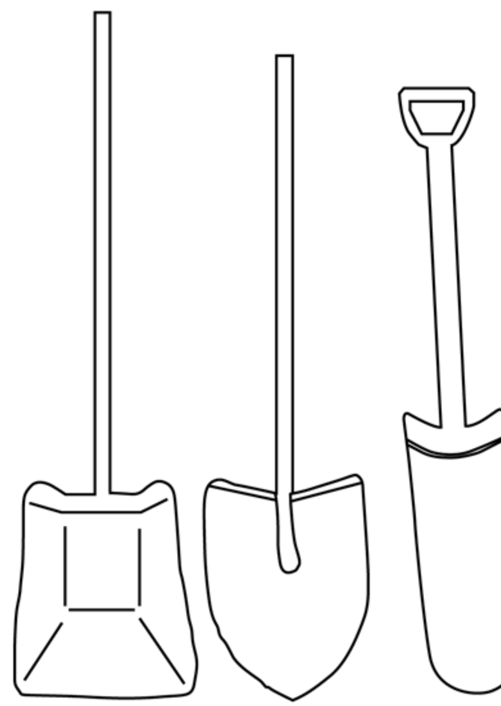


FIG. 61 Stainless Steel Shovels

TABLE 54 Shovels—Advantages and Limitations

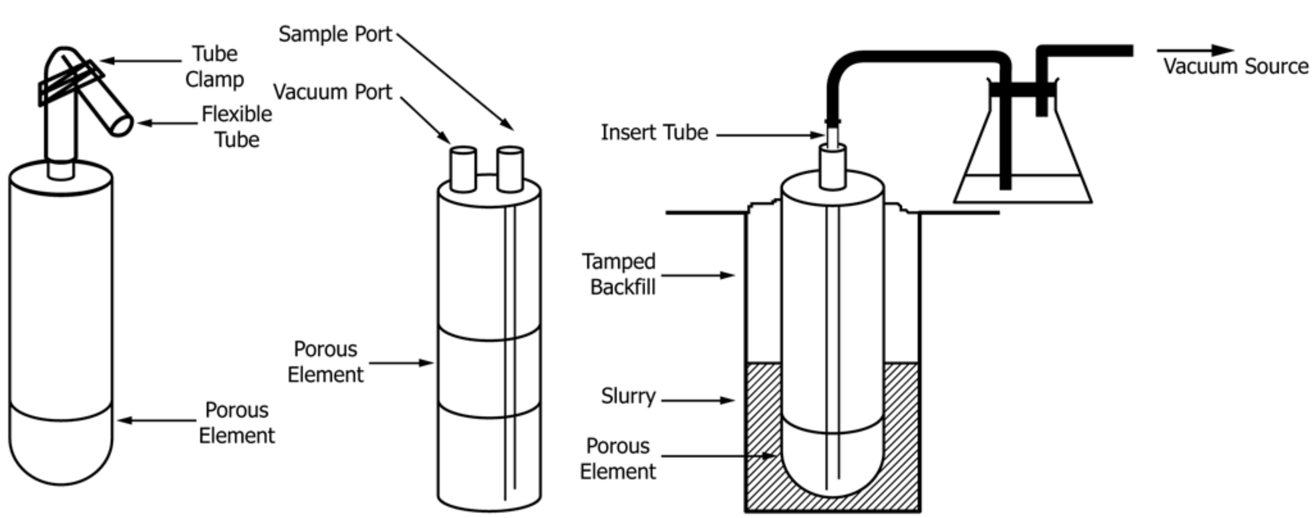
Advantages	Limitations
Easy to use and clean	For surface use only
Rugged for use with hard materials	Cannot be easily used to fill sample containers
	Will exacerbate the loss of volatile organic compounds by disturbance

saturated areas, for example, perched water zones. Collection of liquid samples requires that the porous sampler be in intimate contact with the soil or slurry pack. Under partial vacuum, liquids are drawn into the sampler. Pore sampling from this region involves collection of interstitial liquids or gases from the spaces between soil particles. The majority of liquid samplers used are suitable for the collection of aqueous-based samples and may not be capable of collecting samples of non-aqueous based fluid contaminants, for example hydrocarbons. Vadose zone liquid samplers are installed for usually extended periods and operated intermittently to collect samples. Vadose zone gas samplers are usually installed for a predetermined time to allow for passive adsorption of the soil gases. They are then recovered for desorption of the sample into an analytical device. Environmental applications for pore liquid samplers include monitoring leachates beneath landfills and waste piles, spray fields and sites where wastewater is used for irrigation. Passive soil gas samplers are used to detect or monitor below-surface contaminants and contaminant movement.

7.12.1 *Vacuum Lysimeters (see Guide D4696)*—The vacuum or suction lysimeter is designed for installation at depths of 20 ft or less from the ground surface and are used to collect samples of aqueous pore liquids. The Vacuum Lysimeter is constructed from a sealed chamber with a porous end or midsection (see Fig. 62). One or two access ports are included in the upper end with an optional fitting for attachment to a casing string. The porous element is available in various ceramics and stainless steel. Such porous elements must be constructed from hydrophilic materials such as naturally wetting ceramics, steels or other materials of uniform pore size, capable of sustaining a 14.7 psi pressure differential when wetted. The pore size, pore consistency and pore volume of this element determines its ability to extract liquid samples from the soil formation when a vacuum is applied to the interior surface of the element. Intimate contact between the porous element and the surrounding soil is essential. Usually, the installation will involve the placement of either a sieved soil slurry or 200 mesh silica slurry around the porous element. The upper body and/or casing are sealed from the surface with either tamped soil or a bentonite seal followed by tamped soil. A vacuum is applied to the lysimeter and it is then sealed. The applied suction will allow pore liquids to pass from the surrounding soils through the slurry pack and porous element to the interior of the lysimeter. Samples may be collected after several hours or days, depending on the soil conditions by releasing the vacuum and inserting a small diameter tube to the bottom of the body of the single tube model, connecting it to a collection vessel and applying a vacuum to deliver the sample to the surface. The two tube models may be sampled similarly or a gentle pressure applied to the vacuum port to deliver the sample to the surface. See Table 55 for advantages and limitations.

7.12.2 *Vacuum/Pressure Lysimeters (see Guide D4696)*—Vacuum/pressure lysimeters are a modification of the vacuum lysimeters described in 7.12.1. They are designed for use at considerable depths below ground surface or where the installation is lateral. The modifications include a check valve in the sample delivery line to prevent back-flow. A separate sample collection chamber is also installed within the body of the lysimeter. This collection chamber is connected to the porous element using a tube and check valve (see Fig. 63). This check valve prevents pressure being applied to the porous element during sample recovery when pressure is used to deliver the sample to the surface. These models are always installed on the end of a casing string to allow careful placement and to prevent compression or damage to the tubing connecting the lysimeter to the surface. To operate the sampler, close the sample collection port and apply a vacuum to the vacuum/pressure port and then close it. Pore water will flow from the surrounding soil through the slurry pack (usually 200 mesh silica flour) and through the porous element into the lower chamber. As this fills over the lower check valve tube the liquid will be drawn into the (upper), sample collection chamber. After sufficient time has elapsed the sample will be collected. Open and connect the sample port to a collection vessel. Open and connect the vacuum/pressure port to a supply of compressed air or gas. The sample will be delivered to the sample container. For deep installations it is usually necessary to use small diameter tubing of suitable pressure rating to ensure that small samples are delivered to the surface. See Table 56 for advantages and limitations.

7.12.3 *Gas Adsorbers (see Guide D5314)*—Soil gas sampling using passive adsorbers are used primarily for screening purposes and are an alternative to the active sampling of soil gas described earlier in this standard (7.5.1 and 7.5.2). It should also be noted that the lysimeters described in this section



NOTE 1—Left: Cup and Tube Type Vacuum Lysimeters
Right: Vacuum Lysimeter Installation showing sample collection

FIG. 62 Vacuum Lysimeters

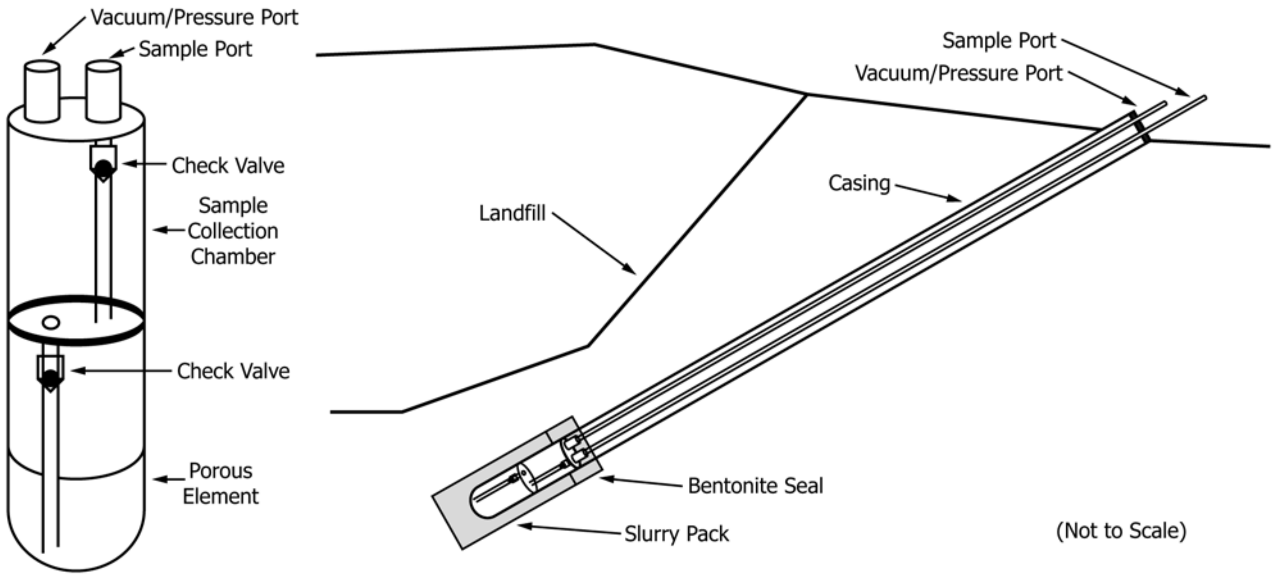
TABLE 55 Vacuum Lysimeters—Advantages and Limitations

Advantages	Limitations
Allows periodic multiple sample collection over time	For use at depths to about 20 ft below ground surface
Samples are minimally disturbed	Careful handling and technique required for installation
Available in several materials to allow use in collecting samples containing low levels of contaminants	Porous elements can become blocked or nonfunctional if the device is improperly manufactured, installed or maintained in conditions of very fine particles or certain contaminants
Relatively inexpensive	Not suitable for collection of non-aqueous liquids
	Sample collection requires several hours to days per event
	Not suitable for sampling constituents of interest with moderate to high vapor pressures

(7.12.1 and 7.12.2) may also actively collect soil gas samples in loose, coarse-grained formations. Gas adsorber samplers are comprised of an adsorbent material contained within a protective shield that will allow soil gas to enter the adsorbent but prevent ingress of soil particles and water. These devices are used to sample volatile organic compounds-VOCs and may also sample semi-volatile organic compounds-SVOCs, depending upon the adsorbent material selected and the diffusion membrane used. Over time, days to weeks, passive adsorbent samplers allow for an equilibrium to be developed between the soil gases and the adsorbent material. This long-term exposure may enhance the contaminant detection sensitivity through concentration of the mass of VOCs and SVOCs adsorbed by the samplers. Construction of these devices varies, one form is a hydrophobic, micro-porous fluoropolymer membrane sock with the adsorbent materials contained in pockets in the lower end. Another has the adsorbent material sealed within a mesh screen and suspended in a glass vial with a mesh-covered opening in the screw cap installed on the bottom of the sampler. (See Fig. 64; (**8, 9**)). These samplers are designed for placement between a few inches and 3 ft below ground surface using hand tools to create a hole. After placement, the hole is sealed at the surface and the sampler left undisturbed for 3 days (Vial Type) or 2 to 3 weeks (Membrane Type). The samplers are then recovered, suitably packaged and sent to a laboratory for analysis. See Table 57 for advantages and limitations.

8. Keywords

8.1 environmental; liquid; monitoring; sampling; sampling equipment; sediment; soil; waste management; water

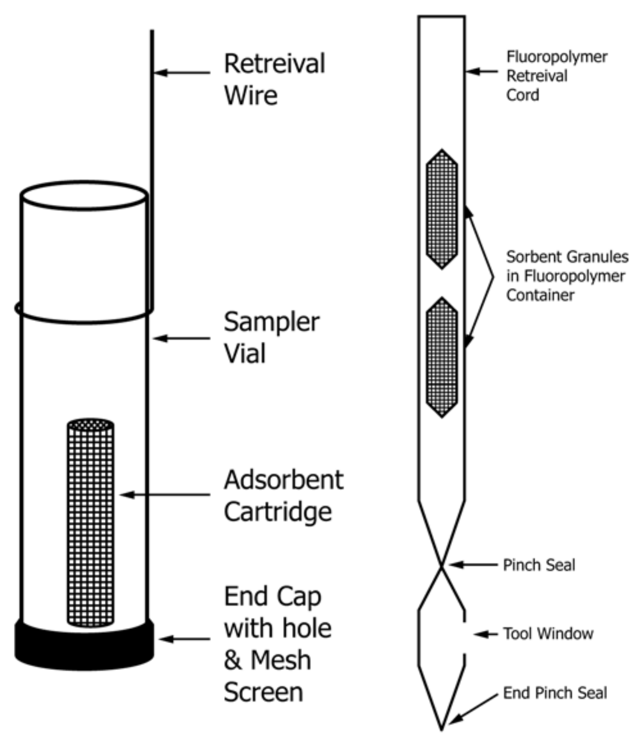


NOTE 1—Left: Vacuum/Pressure Cup Type Lysimeter
Right: Vacuum/Pressure Lysimeter-Landfill Installation

FIG. 63 Vacuum/Pressure Lysimeters

TABLE 56 Vacuum/Pressure Lysimeters—Advantages and Limitations

Advantages	Limitations
May be used to monitor leakage or leachate beneath landfills, waste piles and underground storage tanks	Requires drilling or direct push equipment to prepare a hole for installation
The sampling point may be up to 300 ft from the installed vacuum/pressure lysimeter	Careful handling and technique required for installation
Allows periodic multiple sample collection over time	Porous elements can become blocked or nonfunctional if the device is improperly manufactured, installed or maintained in conditions of very fine particles or certain contaminants
Samples are minimally disturbed	Not suitable for collection of non-aqueous liquids
Available in several materials to allow use in collecting samples containing low levels of contaminants	Sample collection requires several hours to days per event
	Not suitable for sampling constituents of interest with moderate to high vapor pressures



NOTE 1—Left: Gas Adsorber-Vial Type
Right: Gas Adsorber-Membrane Type

FIG. 64 Gas Adsorbers

TABLE 57 Gas Adsorbers—Advantages and Limitations

Advantages	Limitations
Easy and quick to install and recover	Analysis normally performed in the manufacturer's laboratory
One product incorporates modeling software used to predict optimal sampling times	Cost for deployment and analysis of these passive samplers may be higher than that for active soil gas sampling
Capable of detecting SVOCs as well as VOCs	Sampling time from 3 days to 2 weeks needed, depending on sampler type
Adsorbants may be selected for specific contaminants	Analysis and reporting may add 2 to 3 weeks before results are available
Although generally used at shallow depths, they can be used in deeper locations, up to 200 ft	Generally these devices show only the presence and relevant abundance of contaminants present

APPENDIX

(Nonmandatory Information)

X1. ADDITIONAL RELATED PUBLICATIONS

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