Standard Practice for Active Soil Gas Sampling for Direct Push or Manual-Driven Hand-Sampling Equipment[1]

This standard is issued under the fixed designation D7648; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 This practice details the collection of active soil gas samples using a variety of sample collection techniques with tooling associated with direct push drilling technology (DPT) or manual-driven hand-sampling equipment, for the express purpose of conducting soil gas surveys.

1.2 This practice proceeds on the premise that soil gas surveys are primarily used for two (2) purposes, 1) as a preliminary site investigative tool and 2) for the monitoring of ongoing remediation activities.

1.3 The practicality of field use demands that soil gas surveys are relatively accurate, as well as being simple, quick, and inexpensive. This guide suggests that the objective of soil gas surveys is linked to three factors:

1.3.1 VOC detection and quantitation, including determination of depth of VOC contamination.

1.3.2 Sample retrieval ease and time.

1.3.3 Cost.

1.4 This practice will likely increase the awareness of a fundamental difference between soil gas sampling for the purpose of soil gas surveys versus sub-slab or vapor intrusion investigations or both. Specifically, the purpose of a soil gas survey is to provide quick and inexpensive data to the investigator that will allow the investigator to 1) develop a site investigation plan that is strategic in its efforts, 2) determine success or progress of on-going remedial activities, or 3) select the most suitable subsequent investigation equipment, or combinations thereof. On the other hand, the objective of soil gas sampling for sub-slab and vapor intrusion investigations (**1**, **2**, **3**,[2] etc.) is not preliminary, but rather the end result of the site investigation or long-term precise monitoring. As such, stringent sampling methods and protocol are necessary for precise samples and data collection.

1.5 Details included in this practice include a broad spectrum of practices and applications of soil gas surveys, including:

1.5.1 Sample recovery and handling,

1.5.2 Sample analysis,

1.5.3 Data interpretation, and

1.5.4 Data reporting.

1.6 This practice suggests a variety of approaches useful to conducting successful soil gas surveys but cannot replace education or experience and should be used in conjunction with professional judgment. Not all aspects of this practice may be applicable in all circumstances. This ASTM standard is not intended to represent or replace the standard of care by which the adequacy of a given professional service must be judged, nor should this document be applied without consideration of a project's many unique aspects.

1.7 This practice offers an organized collection of information or a series of options and does not recommend a specific course of action. The success of any one soil gas survey methodology is strongly dependent upon the environment in which it is applied.

1.8 This practice is not to be used for long term monitoring of contaminated sites or for site closure conformation.

1.9 This practice is not to be used for passive determination of flow patterns at contaminated sites.

1.10 *This practice 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 practice to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

1.11 This practice does not purport to set standard levels of acceptable risk. Use of this practice for purposes of risk assessment is wholly the responsibility of the user.

1.12 Concerns of practitioner liability or protection from or release from such liability, or both, are not addressed by this practice.

[1] This practice is under the jurisdiction of ASTM Committee D18 on Soil and Rock and is the direct responsibility of Subcommittee D18.21 on Groundwater and Vadose Zone Investigations.

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

2. Referenced Documents

2.1 *ASTM Standards:*[3]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D1356 Terminology Relating to Sampling and Analysis of Atmospheres

D1357 Practice for Planning the Sampling of the Ambient Atmosphere

D1452 Practice for Soil Exploration and Sampling by Auger Borings

D3249 Practice for General Ambient Air Analyzer Procedures

D3614 Guide for Laboratories Engaged in Sampling and Analysis of Atmospheres and Emissions

D5314 Guide for Soil Gas Monitoring in the Vadose Zone

D6196 Practice for Selection of Sorbents, Sampling, and Thermal Desorption Analysis Procedures for Volatile Organic Compounds in Air

2.2 *EPA Standards:*[4]

EPA Method TO-15 Determination Of Volatile Organic Compounds (VOCs) In Air Collected In Specially-Prepared Canisters And Analyzed By Gas Chromatography/ Mass Spectrometry (GC/MS)

EPA Method TO-17 Determination of Volatile Organic Compounds in Ambient Air Using Active Sampling Onto Sorbent Tubes

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *active sampling, n*—a means of collecting an airborne or emission substance that employs a mechanical device such as a pump or vacuum assisted critical orifice to draw air or emissions onto or through the sampling device.

3.1.2 *capillary fringe, n*—the basal region of the vadose zone comprising sediments that are saturated, or nearly saturated, near the water table, gradually decreasing in water content with increasing elevation above the water table. Also see Terminology D653.

3.1.3 *contaminant, n*—a material added by human or natural activities which may, in sufficient concentrations, render the atmosphere unacceptable.

3.1.4 *emplacement, n*—the establishment of contaminant residence in the vadose zone in a particular phase.

3.1.5 *free product, n*—liquid phase contaminants released into the environment.

3.1.6 *free vapor phase, n*—a condition of contaminant residence in which volatilized contaminants occur in porosity that is effective to free and open gaseous flow and exchange, such porosity generally being macroporosity.

3.1.7 *hot spot, n*—areas where contaminants exceed cleanup standards or the highest level at a contaminated site.

3.1.8 *liquid phase, n*—contaminant residing as a liquid in vadose zone pore space, often referred to as "free product."

3.1.9 *partitioning, n*—the act of movement of contaminants from one soil residence phase to another.

3.1.10 *semivolatile organic compound (SVOC), n*—an organic compound with a saturated vapor pressure between 10-2kPa and 10-8 kPa at 26 °C.

3.1.11 *soil gas, n*—vadose zone atmosphere.

3.1.12 *solute phase, n*—a condition of contaminant residence in which contaminants are dissolved in ground water in either the saturated or the vadose zone.

3.1.13 *sorbed phase, n*—a condition of contaminant residence in which contaminants are adsorbed onto the surface of soil particles or absorbed by soil organic matter.

3.1.14 *sorbent, n*—a solid or liquid medium in or upon which materials are collected by absorption, adsorption, or chemisorption.

3.1.15 *sorption, n*—a process by which one material (the sorbent) takes up and retains another material (the sorbate) by processes of absorption, adsorption, or chemisorption.

3.1.16 *vadose zone, n*—the hydrogeological region extending from the soil surface to the top of the principal water table.

3.1.17 *volatile organic compound (VOC), n*—an organic compound with a saturation vapor pressure greater than 10-2kPa at 26 °C.

4. Summary of Guide

4.1 Sampling of soil gases (volatile contaminants such as methane and carbon dioxide, which are indicators of increased microbial activity resulting from organic contaminants) in the vadose zone is an industry-accepted method used to directly measure characteristics of the soil atmosphere. Characteristics determined from soil gas sampling are frequently used as indirect indicators of processes occurring in and below a sampling horizon, including the presence, composition, origin and distribution of contaminants in and below the vadose zone.

4.2 Previously, soil gas sampling was used more as a tool for laying the groundwork for further soil exploration. The ability to quickly, accurately, and inexpensively determine VOCs, presence, levels, and depths allowed this method to become a standard practice for preliminary site investigation as well as for monitoring the success of on-going site remediation efforts. Currently soil gas sampling has been gaining acceptance as a reasonable method for the determination of risk assessment of contaminated sites, known as soil gas investigations. This new direction in soil gas sampling is playing a major role in the development of new methodologies with a current trend towards more stringent soil gas sampling methods and protocols.

4.3 However, the practicality of field use demands that there is a soil gas sampling method that is accurate as well as simple, quick, and inexpensive, for the purposes of preliminary site

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

[4] Available from United States Environmental Protection Agency (EPA), Ariel Rios Bldg., 1200 Pennsylvania Ave., NW, Washington, DC 20004, http://www.epa.gov.

investigation and the monitoring of on-going remediation efforts. This guide refers to this method as soil gas survey.

4.4 The objective of a soil gas survey is to determine, through relative data, the highest level of contamination at a site (hot spot). Data collected from soil gas surveys provides information useful for the development of strategic and cost effective site investigation plans.

4.5 The leading principle behind this guide is that there is a difference between soil gas surveys and soil gas investigations (**1**, **2**, 3).

4.6 While the need for stringent methodology is strongly supported for soil gas investigations, (sub-slab and vapor intrusion investigations) those same stringent methods and protocols, when used for the purpose of soil gas surveying, are not cost effective nor time efficient.

4.7 Soil gas surveys need to be more quick, time efficient, and cost effective than soil gas investigation methods. The economic limits coupled with the objective of a soil gas survey must be the leading factor behind the development of soil gas survey methodology and protocol. If it takes as much time or much money to survey as to investigate, then investigators will not utilize this tool/practice.

4.8 Vadose zone sampling methods have a set of procedures, both general and specific, that must be consistently followed in order to provide maximum data quality and usefulness. Soil gas surveys are no exception, with the primary procedures common to all soil gas sampling techniques. The procedures include:

(1) Planning and preparation,

(2) The act of sampling soil gas in the field,

(3) Handling and transporting the sample, and

(4) This method does not recommend a sample analysis, interpretation of the results of analysis, nor specific format for the preparation of a report of findings. Instead it indicates minimum information to be included in a report of findings.

4.8.1 The planning and preparation step begins with the formulation of project objectives, including purpose of the survey, appropriate application of the data to be collected and data quality objectives.

4.8.2 Actual field work consists of recovery of soil gas samples. The method selected should be based upon site specific factors and dictated by the project objectives.

4.8.3 As samples are being recovered or collected, they must be handled, field screened, or transported, or combinations thereof, in such a way as to assure preservation prior to analysis.

5. Significance and Use

5.1 Soil gas is simply the gas phase (air) that exists in the open spaces between soil particles in the unsaturated portion of the vadose zone. Normally comprised of nitrogen and oxygen, soil gas becomes contaminated when volatile organic compounds (VOCs) are released in the subsurface due to spills or leaks, and they begin to evaporate from a fluid phase and become part of the soil gas. Over time, VOCs can potentially migrate through the soil or groundwater or both and present a problem to the environment and human health.

5.2 *Application of Soil Gas Surveys*—Soil gas surveying offers an effective, quick and cost-effective method of detecting volatile contaminants in the vadose zone. Soil gas surveying has been demonstrated to be effective for selection of suitable and representative samples for other more costly and definitive investigative methods. This method is highly useful at the initiation of an investigation into the preliminary site investigation of determining the existence and extent of volatile or semivolatile organic contamination, and determination of location of highest concetrations, as well as, monitoring the effectiveness of on-going remedial activities.

5.3 Samples are collected by inserting a sampling device into a borehole with hydraulically-driven direct push drilling technology or manually-driven driven hand sampling equipment.

5.4 Soil gas surveys can be performed over a wide range of spatial designs. Spatial designs include soil gas sampling in profiles or grid patterns at a single depth or multiple depths. Multiple depth sampling is particularly useful for contaminant determinations in cases with complex soil type distribution and multiple sources. Depth profiling can also be useful in the determination of the most appropriate depth(s) at which to monitor soil gas, as well as the demonstration of migration and degradation processes in the vadose zone.

5.5 Soil gas surveys are used extensively in preliminary site investigations and monitoring of effectiveness of on-going site remediation efforts. Project objectives must be known and the limitation of this method considered. Limitations include:

5.5.1 Data generated from soil gas surveying is relative and not of the quality necessary for a single data set; and

5.5.2 Soil gas surveys need to be done quickly, so this method is for active soil-gas sampling devices only.

6. Apparatus

6.1 Soil gas samples are collected by inserting a sampling device into an open borehole or telescopically pushed into native lithology, through other subsurface conduits, with hydraulically driven direct push drilling technology or manual driven hand sampling equipment (Figs. 1 and 2). Table 1 provides a summary of possible causes of false positive and false negative values.

6.2 Whether the sampling device is driven by direct push equipment or by hand it should be sealed and isolated at the depth to which it is opened and exposed, so that soil gas that is drawn comes from the specific target depth. The sampling inlet can range from less than 0.25 to 12 in. in length (Figs. 3 and 4).

6.3 The inlet of the sampling device should eliminate or minimize the chance of soil particles or other debris from being drawn to the surface or into the sample container (Figs. 3 and 4). A list of acceptable sample containers or monitoring devices is included in Table 2.

6.4 The sample train from the inlet to the container of choice should be of closed loop configuration and valving components that will allow for purging of ambient air existing from the installation and set up (Figs. 5 and 6).

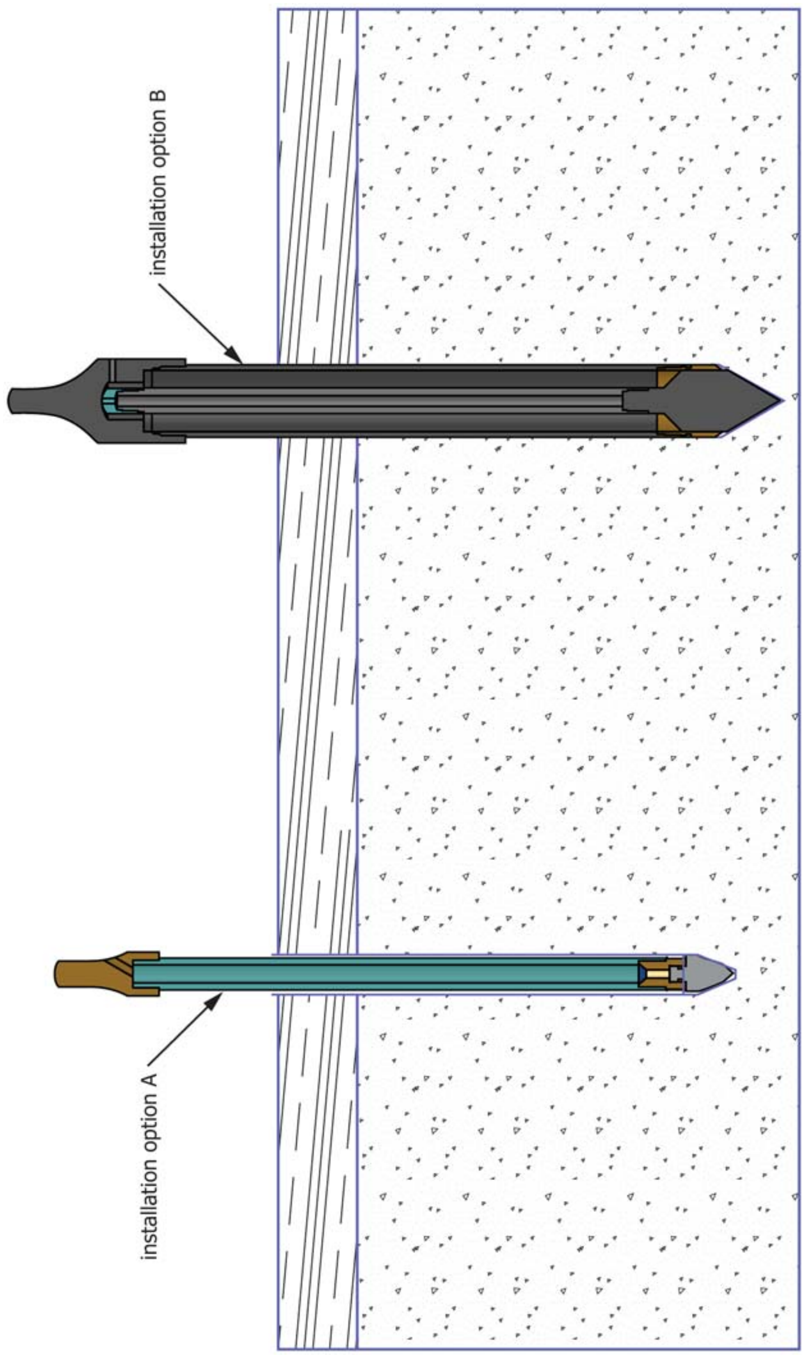

FIG. 1 Direct Push

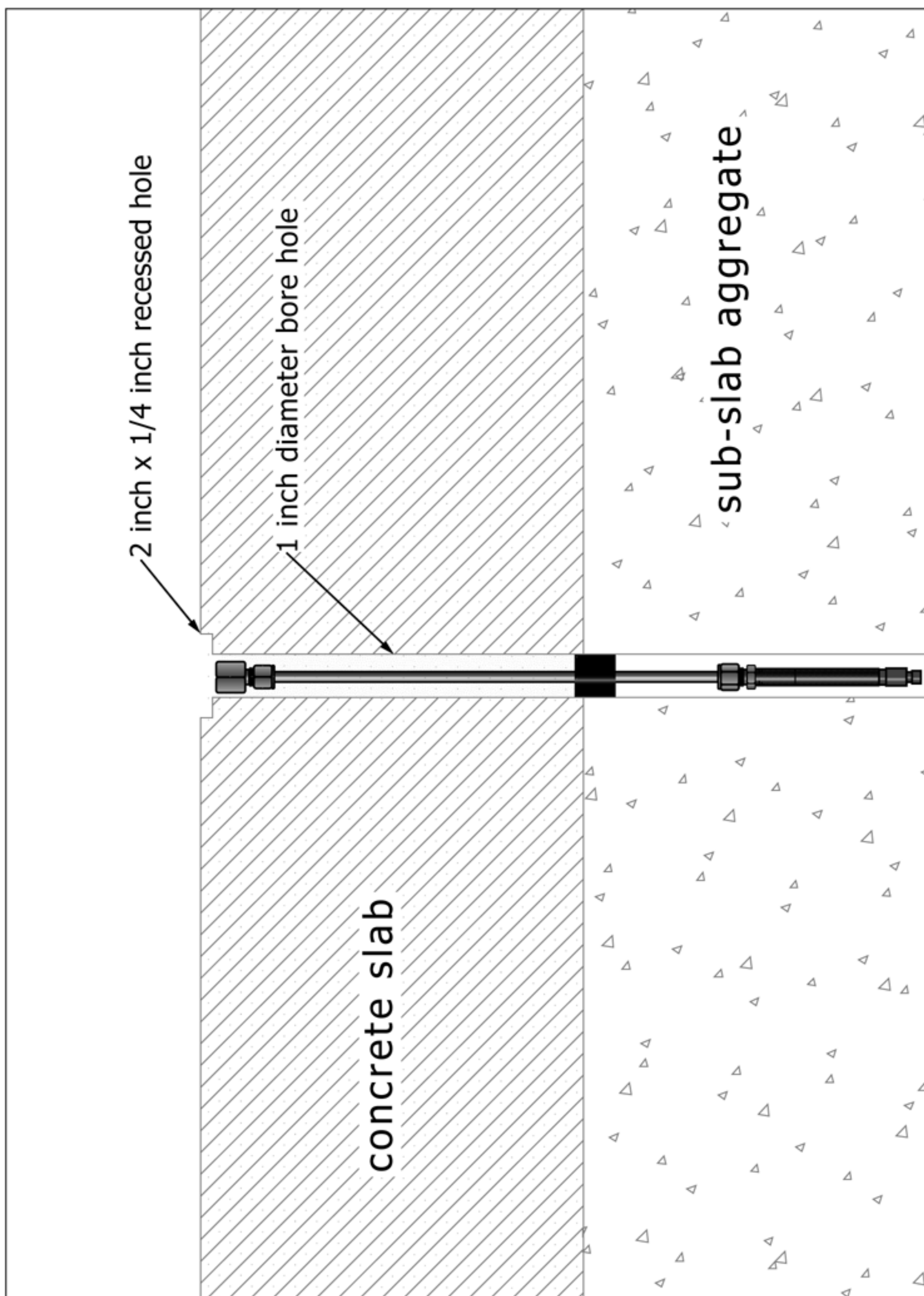

FIG. 2 Hand Sampling

TABLE 1 Summary of Possible Causes of False Positive and False Negative Values

Result	Causes
False negatives, that is, falsely low values	Barriers to gaseous diffusion, such as perched water, clay lenses, impervious man-made debris, saturation of soil pores with water (as from rain), low subsurface temperatures. Biological or chemical degradation. Leakage or blockage in the sample train, improper purge procedure, loss of sample from sample container, problem with analytical system.
False positives, that is, falsely high values	Contamination in sampling train, sample container, or analytical system. Contribution of volatile organic contaminants from vegetation. Significant contamination in overlying soil.

6.5 Once the ambient air and a purge volume equal to two times the total volume of the sample train has been purged the sample train must be isolated to ensure that ambient air does not reenter the sample train.

6.6 The maximum flow of the purging and subsequent sample collection should be between 100 to 200 ml per minute.

6.7 As the sampling device is opened or exposed it should be of the design so that ambient air from internal or external area of the direct push or hand sampling equipment is prevented from being drawn into the inlet.

6.8 It is important that soil gas samples are collected in the same procedure from every boring and depth so that the relative results analysis or field screening can be compared to each other.

6.9 Lithology can affect the existence of a contaminant or the ability of the contaminant to migrate in the subsurface. Soil gas sampling as part of a survey can provide useful information to provide preliminary indications as to what has happened or is happening in the subsurface.

6.10 It is up to the project manager, remedial engineer, or regulatory oversight personnel, or combinations thereof, to determine how to use the analytical results or field screening readings for planning or reporting on different phases of the site investigation and remedial activities.

7. Sampling Method or Procedure

7.1 *Sampling Methodology*—Soil gas sampling methodology has evolved over time and through practice in several industries. The equipment with which to perform this monitoring technique is highly varied; however, no single method or procedure is recommended to the reader due to the variation in site specific factors. The selection of a soil gas sampling method involves consideration of three primary issues. These are the type of sampling system, the methodology of application of that sampling system and the rigor of the field QA/QC protocol. Informed investigators must assume the responsibility of selecting the technique most appropriate to the subject application, whether that technique is commercially available from contractors or equipment suppliers, or reliant upon the ingenuity of the investigator in the field utilizing commonly available materials. Success in choosing an appropriate sampling device or an entire sampling system is dependent upon the investigator's level of understanding of vadose zone processes, contaminant properties and appropriate applicability of the soil gas method. The target analyte volatility range is a key criteria affecting sampling method selection.

7.1.1 The application of any of these methods must be controlled by strict adherence to a standard operating procedure. Occasional deviations as dictated by unusual field conditions should be recorded in the project field notebook. Inadvertent minor deviations in field procedure can result in misinterpretation of the data acquired.

7.2 *Soil types* should be taken into consideration as soil gas samples are collected across a given site. Although the level of concentration of VOCs in soil gas samples collected from different lithologies is expected to be different as migration of soil gas can be influenced by the parameters of a particular lithology.

7.3 *Active Soil Gas Surveying*—Active methods are those that obtain a soil gas sample by positioning a sampling device in the subsurface and the withdrawal of soil atmosphere through the device from the sampling horizon. (Passive methods are those that obtain a soil gas sample by placing a collection device in the soil or on the soil surface, and allowing the atmosphere within the device to come into compositional equilibrium with the soil atmosphere.)

7.4 *Methodology in Application of a Sampling Technique*—The likelihood of success of the soil gas sampling technique selected is controlled in part by the methodology in application of that sampling technique. This methodology should be guided by the objectives of the subject project and the perceived spatial and temporal array of the potential sampling targets.

7.4.1 *Grids*—Many problems suitable for soil gas monitoring are best solved by obtaining data distributed over a geographic area. Sampling in grid patterns of variable design and spacing can be a very effective way to provide data coverage over a large area for a very low cost of acquisition. Common applications of soil gas grid sampling are environmental contaminant assessments, exploration for natural resources and the siting of locations for other monitoring or exploratory techniques. Compositional analyses in conjunction with properly designed grid systems are often fundamental to successful evaluation of soil gas monitoring.

7.4.2 *Strategic Soil Gas Survey*—A strategic soil gas survey can be developed based upon known site history, historical records, historical aerial photography, current site status, site visit, and future plans for the subject site.

7.4.3 *Profiling*—Profiling is a soil gas sampling methodology useful to test a linear array for the existence of contaminants. Profiling is most often performed by sampling at closely spaced intervals in a linear array and is displayed as contaminant concentration or composition versus distance sampled on

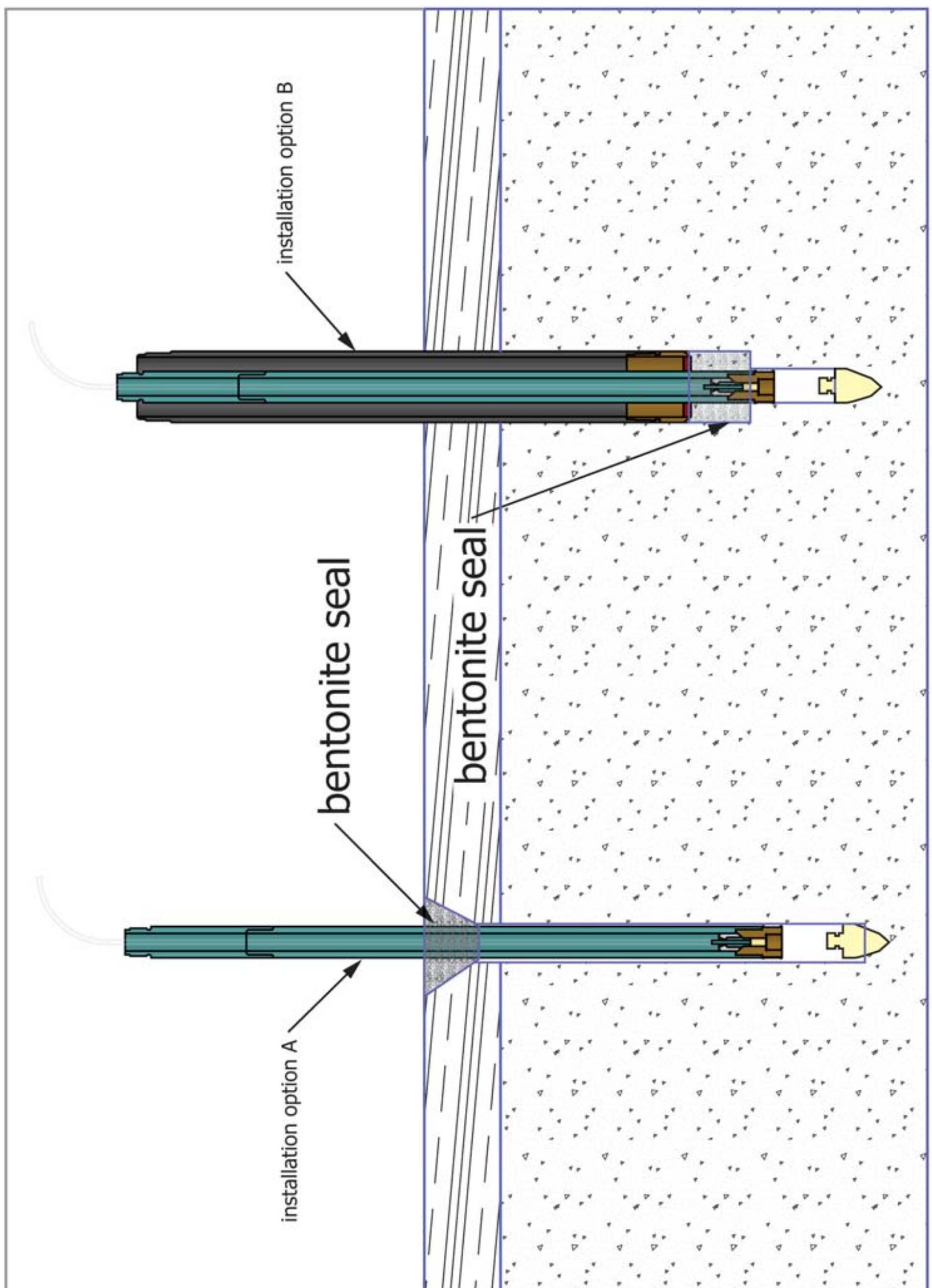

FIG. 3 Direct Push

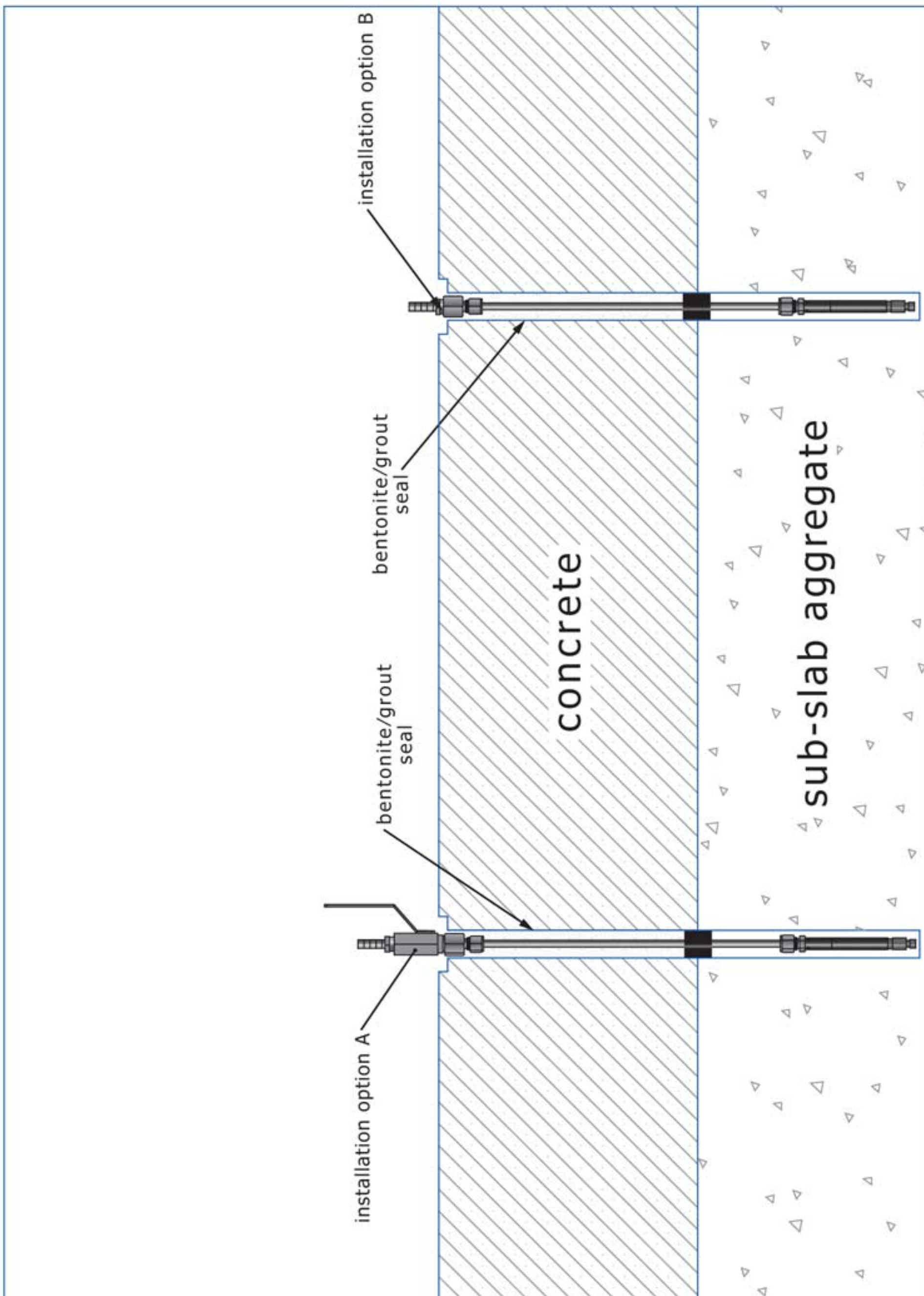

FIG. 4 Hand Sampling

TABLE 2 Soil Gas Containers or Monitoring Devices

Type	Application	Advantages	Limitations
Summa canisters	Sample collection for offsite analysis	Durability Ease of sample collection Re-usable More stable than other containers—especially for very volatile, non-polar compounds Allow replicate analysis Sampling of very volatiles	Expense Bulky to transport/store Incomplete recovery of less volatile cpds (> n-C10), e.g. middle distillate fuels, and polar compounds Regeneration requires expensive vacuum equipment Can be difficult to decontaminate Can't be used for TWA monitoring
Tedlar bags	Sample collection for offsite analysis	Lower cost Good for very volatiles Allow replicate analysis	Significant analyte losses after extended storage (>24 hrs) Incomplete recovery of less volatile cpds, e.g. middle distillate fuels, and polars Some bags can introduce contaminants Not readily re-usable Leaks in valves
Active sampling onto sorbent tubes using large gas syringe/hand pump or low cost bellows pumps	Sample collection for offsite analysis	Low cost Reusable Most commercial apparatus now compatible with repeat analysis Easy to use e.g. with large gas syringe, bellows pump or constant flow pump Versatile analyte range—e.g. butadiene to n-C20 on a single tube, plus compatible with polars Cheap to store/transport Proven storage stability Allows TWA or grab sampling Facilitates sampling of large air/gas volumes for trace analysis Self re-generate during analysis—no extra cleaning required Eliminates losses due to condensation or dissolution in condensed water during sample storage/transport	Not suitable for ultra-volatiles (e.g. C2 hydrocarbons or CF4) Multi-sorbent tubes require refrigeration for storage over 7 days Repeat analysis requires modern TD instrumentation (but the 2 main commercial brands now offer this capability)
Syringe	Sample collection for onsite analysis	Ease of sample collection Does not require special instrumentation to introduce sample to GC(/MS)	Very limited sample volume limits sensitivity Higher boiling compounds will condense on syringe walls and will not be completely recovered Requires very fast transfer from field to analyzer Can't be used for TWA monitoring Very unlikely to provide quantitative data for all but the most volatile compounds Syringe must be stringently cleaned between uses
Direct read-out detector (PID, OVM, FID, etc)	Real time monitoring	Easy to use No expensive analytical equipment required Only means of producing real time data Great for quick screening of 'hot spots'	Very limited sensitivity Doesn't provide speciated information Best used to provide relative information

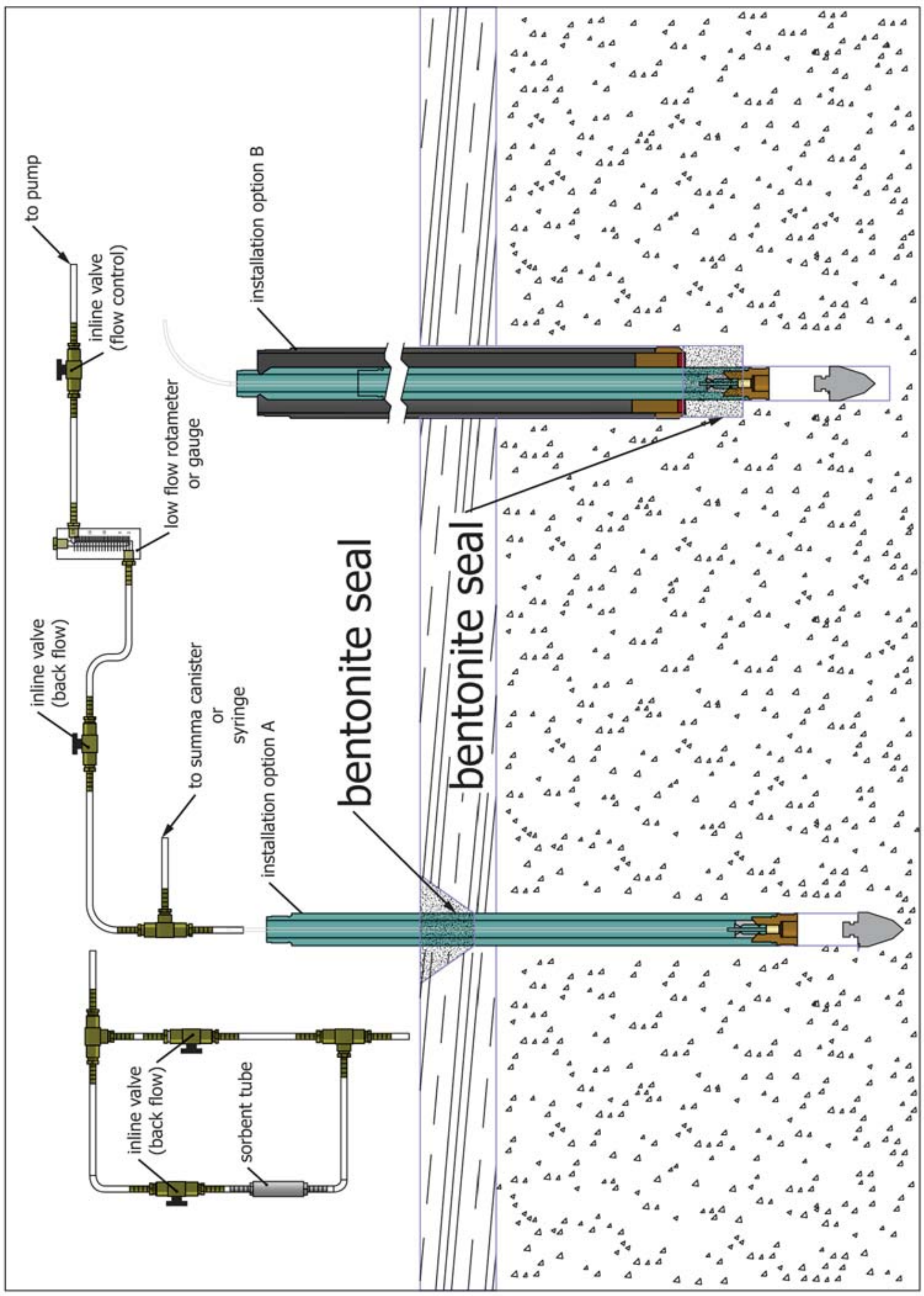

FIG. 5 Direct Push

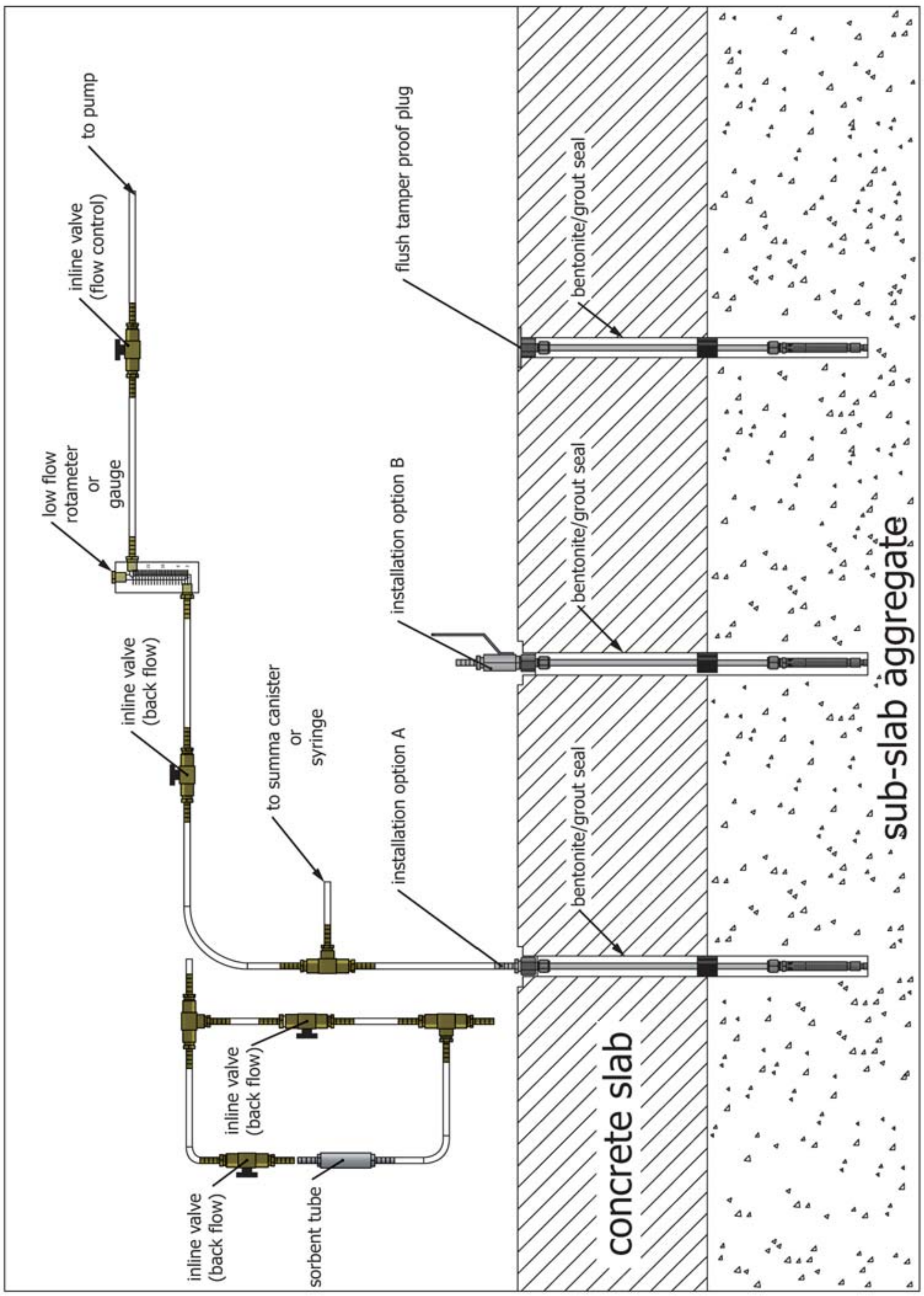

FIG. 6 Hand Sampling

an $X - Y$ plot. Concentration data are often displayed logarithmically on the ordinant (Y) axis, while single components or ratios of compositional data are often displayed linearly on the ordinant axis.

7.4.3.1 For environmental applications such as leak detection along the length of a pipeline or monitoring of contaminant encroachment across a property boundary, soil gas samples are recovered along a profile at intervals from 25 to 100 ft (8 to 30 m). Profiling for natural resource exploration can be performed at sample intervals from 50 to 500 ft (15 to 50 m), depending upon the application.

7.4.3.2 Profiling is useful as a corroborative tool for other monitoring or exploration methods. For example, a soil gas sample profile acquired coincident with a seismic profile can suggest primary contaminant migration pathways or the boundaries of confining layers in shallow, complex geologic settings. This technique has been demonstrated as highly effective in reducing exploratory risk prior to drilling for petroleum and natural gas, by suggesting the presence of hydrocarbon seepage coincident with structures with reservoir potential defined by the seismic method.

7.4.4 *Multiple Depth Sampling*—Methodologies encompassing multiple depths sampling normally have one of two goals, that is, to monitor changes in soil gas contaminant fractions versus depth, and to closely follow a single sampling horizon for an entire soil gas grid or profile.

7.4.4.1 When the goal of a survey is to monitor contaminants over varying depths, some sampling systems can recover soil gas samples as probes are advanced deeper into the vadose zone. This practice is helpful in determining the optimum sampling depth for a particular site or to demonstrate the presence or absence of soil atmosphere contamination in a certain horizon. Soil gas contaminant concentrations often increase with depth as the sampling horizon approaches contaminated ground water or other source of soil gas contaminants. Caution must be exercised when soil gas sampling tools are advanced to increasing depths due to the fact that cross contamination of some or all of the sampling system is unavoidable. This situation limits quality control for this type of multiple depth sampling. Attempts to eliminate cross contamination in multiple depths sampling by replacement or decontamination of sampling equipment with each new sample aliquot also result in limited quality control. Tool withdrawal and tool reinsertion result in venting of the sampling environment via an open hole. The open hole behaves as a macroporous pore space, allowing enhanced partitioning into the vapor phase and convective migration to the atmosphere. The end result is a reduction in representativeness for each subsequently recovered soil gas sample.

7.4.4.2 Multiple depth sampling can also be used to focus a sampling program into a single geologic unit or suite of units without regard to depth. This practice is helpful at sites with complex lithologic changes in the vadose zone. Samples can be recovered from lithologies with greater permeability to vapor or greater storage capacity for vapor when bias in sampling depth is necessary to accomplish project goals. This practice involves greater effort and expense than most methodologies due to the necessity to establish the presence, thickness, and depth of the target horizons prior to soil gas sampling. The most common application of this methodology is the sampling of soil gas at the top of the capillary fringe.

7.5 *Field QA/QC*—Quality assurance and quality control procedures (QA/QC) are essential to establishing support for any interpretation of measurement data and can be used to identify error due to sampling or analytical methodologies and chain-of custody procedures or both. Soil gas surveying data requires a thorough QA/QC protocol confirming that data have been generated to satisfy the data quality objectives for the survey. Justification for interpretations based upon data of unknown quality is not possible.

7.5.1 QA/QC requirements are dependent upon the data quality objectives defined in the planning phase of the survey. For example, soil gas surveying with the objective or gathering relative data, requires a less demanding QA/QC protocol than other soil gas sampling methods with the objective focused on the gathering of a single data source, such as vapor intrusion investigations. If appropriate and applicable, leak detection tracer gases can be used to verify that there is no ambient air being drawn from the surface down around the probe rods to the sample inlet/intake. Or leak detection tracer gasses such as helium are required by regulatory agencies in some states. These tracers are used to detect leaks in the sample train or in the seal along the probe rods. They are introduced into the air in a small hood or tent surrounding the top of the probe rod. The detection of up to 10 % or less of leak detection tracer gas has been used by regulators to reject active soil gas sample results.

Details of QA/QC are in Guide D5314.

7.6 *Sample Handling and Transport*—Soil gas sampling and analysis usually involve the monitoring of contaminants at very low levels. Consideration of sample handling and transport is not trivial to this exercise.

7.6.1 The period of sample handling and transport represents the greatest opportunity for loss or gain of contaminants from or to sample containers. Loss occurs by contaminant condensation within the sampling train, sorption onto materials within the sampling train, solution into condensed water in the sampling train, chemical changes, or leakage to the atmosphere through defects in the sampling apparatus or sample container. Gain of contaminants from sources other than the sampling horizon can occur through related mechanisms working in reverse. Both processes can severely limit the value of data obtained from a survey, and they must be minimized. Losses due to condensation or dissolution into condensed water or both, specifically affect sample containers and not sorbent tubes (See Guide D5314).

7.7 *Analysis of Soil Gas Samples*—Soil gas analysis procedure is based upon pre-existing protocol established for the analysis of contaminants in ambient air. A common reference practice defining terms, sampling information, calibration techniques and methods for validating results may be applied to all automatic analyzers (See Practice D3249). Basic laboratory practice common to investigators engaged in sampling and analysis of atmospheres applies to soil gas analysis. Note that air sampling protocols and soil gas sampling protocols are not equivalent; geophysical and geochemical factors as well as definition of air sample volume contribute to this lack of equivalency. This guide includes the criteria, guidelines and recommendations for analytical segments including the mode of operation of the laboratory and data validation (See Practice D3614).

7.7.1 *Basic Analytical Approach*—Soil gas analysis is performed to identify the presence of contaminants, their type and relative concentrations. Various analytical methods are highly general, satisfying only the most rudimentary requirements of contaminant screening. Others are sophisticated, providing identification and relative concentration information for numerous chemical compounds determined to be present in a soil gas sample. The choice of basic analytical approach in soil gas analysis is driven by the purpose of the soil gas survey, quality assurance objectives, and budgetary constraints placed upon investigators (See Guide D5314).

7.8 *Interpreting Soil Gas Data Profiles*—Soil gas data from survey profiles displayed on an $X - Y$ plot are an effective aid to data interpretation. This display is useful to examine the overall context for soil gas measurement data potentially indicating contamination. If the profile is displayed as a cross section through a grid pattern or as a linear array of sample points, the profile display can illustrate spatially significant groupings of data subpopulations (See Guide D5314).

8. Report: Data Records/Reporting Requirements

8.1 The data records or field logs that contain information, measurements, or readings (data) collected in the field before, during, and after soil gas sample collection shall be kept in order, and made available to be accessed by anyone who needs to review them in conjunction with final generation or report review or both. The data reports should contain, but are not limited to what the sample identifications (IDs) were, where the samples were collected, how deep they were collected, how they were collected, any applicable field readings, such as line pressure, barometric pressure, and temperature.

8.2 *Purpose of Records*—Of primary concern in records of findings pertaining to a soil gas survey is that the records includes the information necessary to describe the results of that survey performed for a particular application. As appropriate and applicable the records should follow the guidelines indicated in D18.91. At a minimum, where the sample was collected and its unique identification, such as boring number, sample number, and depth (a site plan or map indicating the sample locations should be included), how the sample was collected, quality control and decontamination procedures, field readings/measurements (if taken), and the laboratory results should be included in every report. In many instances, certain interpretative methods or data reporting formats useful to end users for one particular application are not relevant to the needs of end users applying the information to a different application. Examples of these differing applications that require unique records subject matter are soil gas contaminant determinations for real property environmental assessments, soil gas monitoring of volatile organic contaminants from underground storage tanks and soil gas sampling as a tool useful in the exploration for natural resources. Certain applications require a thorough treatment of a significant number of factors impacting the meaning and usefulness of soil gas data interpretations. Examples of such applications include damage assessments, contaminant source identification or tests of the effectiveness of remediation. Other applications command minimum record requirements. An example of such an application is the monitoring of releases from underground storage tanks over time.

9. Keywords

9.1 active soil gas sampling; contaminant; direct push; environmental monitoring; geochemistry; ground water; petroleum hydrocarbon; preliminary site investigation; sampling; soil gas; soil gas sampling; soil gas surveying; unsaturated flow; vadose zone; vapor monitoring; volatile organic compound

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