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Designation: D7648/D7648M − 18

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/D7648M; 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 (DP) 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 (D7663).

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 may 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 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 *Units*—The values stated in either SI units or Inch-pound units [given in brackets] are to be regarded separately as standard. The values stated in each system may not be exact equivalents; therefore, each system shall be used independently of the other. Combining values from the two systems may result in non-conformance with the standard.

1.7 All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026.

1.7.1 The procedures used to specify how data are collected/recorded and calculated in the standard are regarded as the industry standard. In addition, they are representative of the significant digits that generally should be retained. The procedures used do not consider material variation, purpose for obtaining the data, special purpose studies, or any consideration for the user's objectives; and it is common practice to increase or reduce significant digits of reported data to be commensurate with these considerations. It is beyond the scope of this standard to consider significant digits used in analysis methods for engineering data.

1.8 This practice offers a set of instructions for performing one or more specific operations. This standard 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. The word "Standard" in the title of this document means only that the document has been approved through the ASTM consensus process.

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

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

1.11 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the*

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[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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*A Summary of Changes section appears at the end of this standard

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responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.

1.12 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.

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

1.14 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D653 Terminology Relating to Soil, Rock, and Contained Fluids

D1452 Practice for Soil Exploration and Sampling by Auger Borings

D3249 Practice for General Ambient Air Analyzer Procedures

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

D3740 Practice for Minimum Requirements for Agencies Engaged in Testing and/or Inspection of Soil and Rock as Used in Engineering Design and Construction

D5314 Guide for Soil Gas Monitoring in the Vadose Zone (Withdrawn 2015)[3]

D6026 Practice for Using Significant Digits in Geotechnical Data

D6196 Practice for Choosing Sorbents, Sampling Parameters and Thermal Desorption Analytical Conditions for Monitoring Volatile Organic Chemicals in Air

D7663 Practice for Active Soil Gas Sampling in the Vadose Zone for Vapor Intrusion Evaluations

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

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

3.2.2 *capillary fringe, n—in vadose zone*, 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.

3.2.3 *free vapor phase, n—in vadose zone*, 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.

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

3.2.5 *partitioning, n—in vadose zone*, the act of movement of contaminants from one soil residence phase to another.

3.2.6 *soil gas, n—in vadose zone*, vadose zone atmosphere.

3.2.7 *volatile organic compound (VOC), n*—an organic compound with boiling points typically ranging from a lower limit between 50°C and 100°C, and an upper limit between 240°C and 260°C, where the upper limits represent mostly polar compounds.

4. Summary of Guide

4.1 Sampling of soil gases (volatile compounds 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 Originally, 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 have 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. Soil gas sampling is now 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 investigation and the monitoring of on-going remediation efforts. This practice refers to this method as a 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 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.

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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.

4.6 Soil gas surveys need to use quick, time efficient, and cost effective soil gas 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 cost to survey as to investigate, then investigators will not utilize this tool/practice.

4.7 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 have the primary procedures common to most 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.

4.7.1 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.

4.7.2 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.

4.7.3 As samples are being recovered or collected, they should be handled, field screened, or transported, or combinations thereof, in such a way as to preserve the sample 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. VOCs can potentially migrate through the soil, or ground water, or both, and present an impact to the environment and human health.

NOTE 1—Not all VOCs in soil gas are due to spills or leaks. Simple VOCs, such as acetone, methanol, and ethanol may also arise from natural biological processes.

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 the preliminary site investigation for determining the existence and extent of volatile or semi volatile organic contamination, and determination of location of highest concentrations, as well as, monitoring the effectiveness of on-going remedial activities (D6196).

5.3 Samples are collected by inserting a sampling device into a borehole with hydraulically-driven direct push drilling or manually-driven driven hand sampling equipment (see Note 2).

NOTE 2—Soil gas sampling can be performed beneath impervious surfaces, such as concrete slabs or pavement by drilling or boring through the surface.

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 should 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 final decisions; 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 or manual driven hand (D1452) sampling equipment (Figs. 1 and 2). Table 1 provides a summary of potential 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 0.65 cm to 0.3 m [0.25 to 12 in.] in length (Figs. 1 and 2).

NOTE 3—The use of bentonite slurries for sealing in the vadose zone for more than short term can be problematic as the bentonite lacking moisture will potentially shrink and allow air leakage. An extensive research program on annular sealants was conducted from 2001 through 2009 and subsequent years by the Nebraska Grout Task Force. This research included cement and bentonite grouts. The general finding of the study indicates all sealing methods suffer from some shrinkage in the unsaturated zone. The best grouts were cement-sand, bentonite chips, neat cements and bentonite slurries with more than 20 % solids bentonite. Bentonite slurry was not recommended in the unsaturated zone regardless of solids content for longer term use. When bentonite is used for sealing, it should be properly hydrated to form an adequate seal with cautions to avoid the intrusion of water into the sampling zone.

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. 1 and 2). 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. 3 and 4).

6.5 Once the ambient air and a purge volume equal to three times the total volume of the sample train has been purged the sample train should be isolated to make sure that ambient air does not reenter the sample train.

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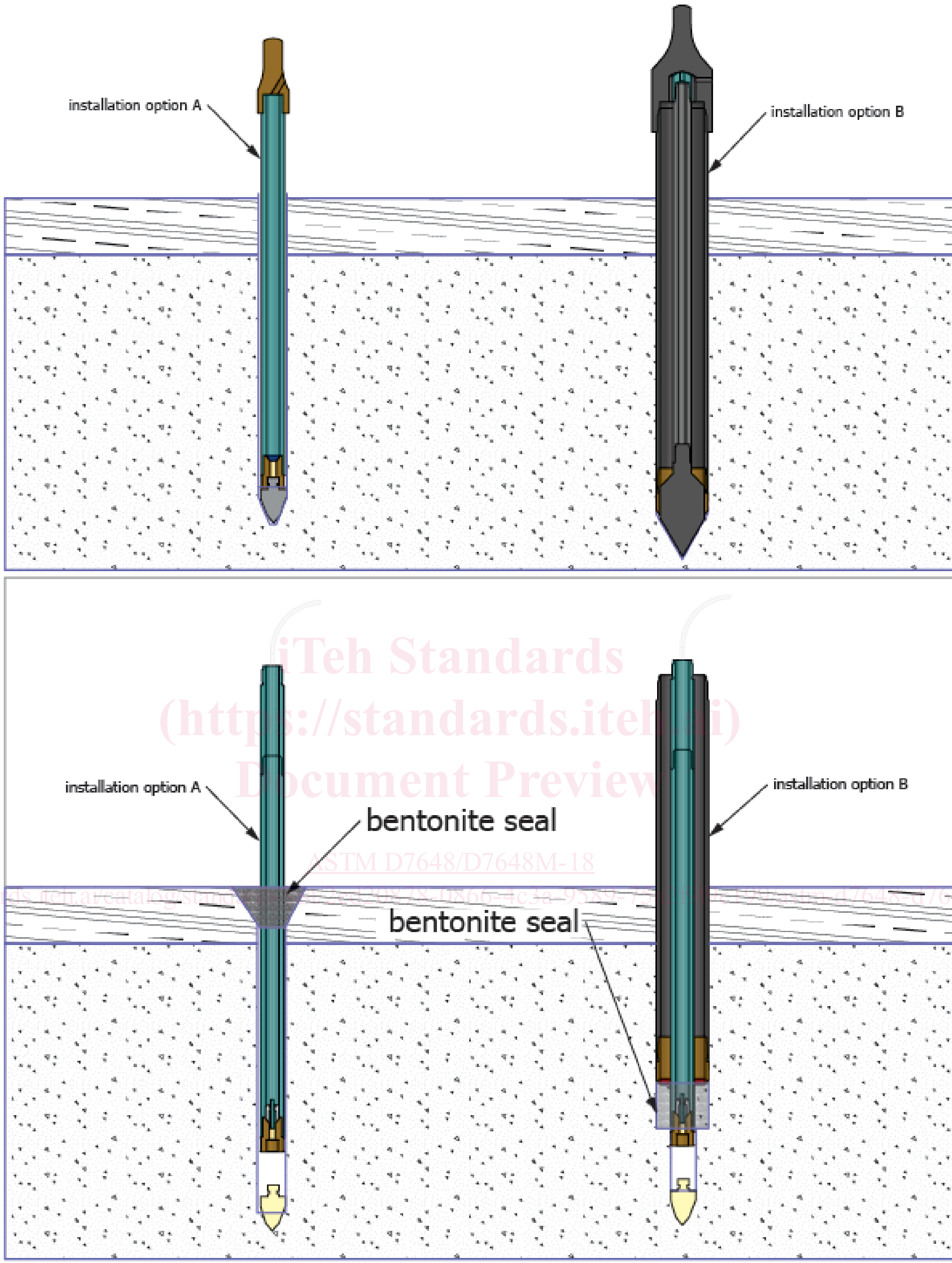

FIG. 1 Direct Push

6.6 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.

6.7 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.

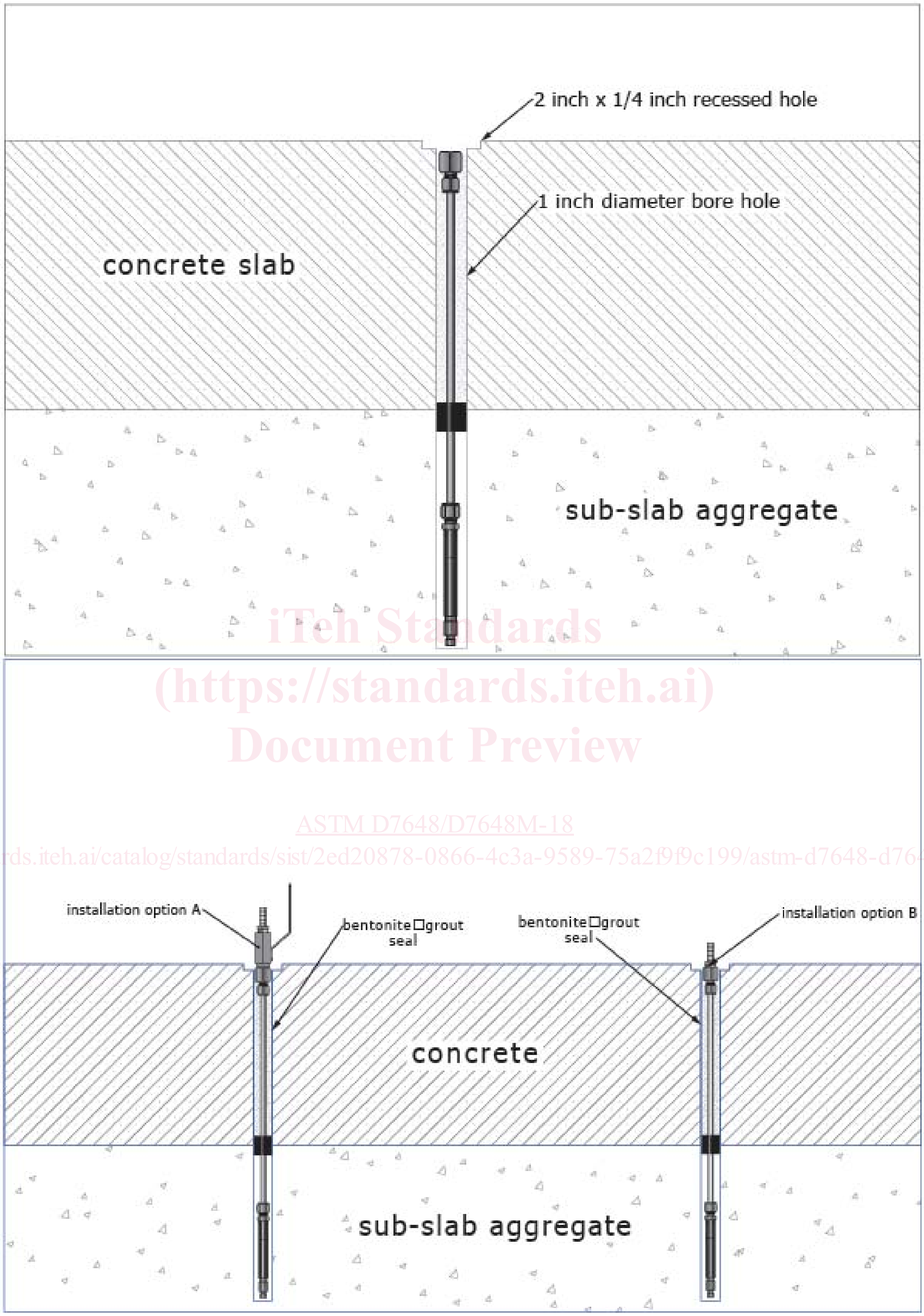

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FIG. 2 Hand Sampling

6.8 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

TABLE 1 Summary of Potential Explanations for Unexpected Results

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.

TABLE 2 Soil Gas Containers or Monitoring Devices

Type	Application	Advantages	Limitations	References
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	Higher cost Bulky to transport/store Incomplete recovery of less volatile cpds (> n-C10), for example, 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 Useful for sampling reduced sulfur compounds (RSCs)	Significant analyte losses after extended storage (>24 hrs) Incomplete recovery of less volatile cpds, for example, middle distillate fuels, and polars Some bags can introduce contaminants Not easily 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 for example, with large gas syringe, bellows pump or constant flow pump Versatile analyte range—for example, butadiene to n-C30 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 needed Eliminates losses due to condensation or dissolution in condensed water during sample storage/transport	Not suitable for ultra-volatiles (for example, 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) Potential for artifacts if tubes are incorrectly stored or incompletely desorbed. Potential for background contamination.	ASTM D6196 ASTM D7663 USEPA TO-17
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 only the most volatile compounds Syringe needs to be stringently cleaned between uses	
Direct read-out detector (PID, OVM, FID, etc.)	Real time monitoring	Easy to use No expensive analytical equipment needed Only means of producing real time data Great for quick screening of 'hot spots'	Very limited sensitivity Doesn't provide speciated information Recommended to provide relative information	

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to provide preliminary indications as to what has happened or is happening in the subsurface.

6.9 It is up to the project manager, remedial engineer, or regulatory oversight personnel, or combinations thereof, to