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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;~~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~~ 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)~~ (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,~~purposes: ~~1)~~*1*) as a preliminary site investigative tool and ~~2)~~2) for the monitoring of ongoing remediation ~~activities.~~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 ~~will likely~~ 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 ~~(1,2,3, 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 *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 ~~suggests~~offers a ~~variety of approaches useful to conducting successful soil gas surveys but~~ 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

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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**

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~~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 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.~~

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

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

1.11 *This ~~practice~~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 ~~practice~~standard to establish appropriate ~~safety~~ safety, health, and ~~health~~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

~~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

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

~~2.2 *EPA Standards:*[5]~~

~~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 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 ~~critical~~ 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.

~~3.1.3 *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.~~

[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.

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.

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

3.2.5 *partitioning, n—in vadose zone,* 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.~~

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

3.2.7 *volatile organic compound (VOC), n*—an organic compound with ~~a saturation vapor pressure greater than 10-2kPa at 26 °C.~~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 ~~contaminants~~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 ~~Previously,~~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,~~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. ~~This new direction in soil~~ 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 ~~guide~~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 The leading principle behind this guide is that there is a difference between soil gas surveys and soil gas investigations (**1**,**2**,3).~~

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.

4.6 Soil gas surveys need to ~~be more~~ use 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~~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 ~~are no exception, with~~ have the primary procedures common to ~~all~~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 ~~must~~should be handled, field screened, or transported, or combinations thereof, in such a way as to ~~assure preservation~~ 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. ~~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~~ ground water, or both, and present ~~a problem~~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 ~~an investigation into~~ the preliminary site investigation ~~of~~for determining the existence and extent of volatile or ~~semivolatile~~ semi volatile organic contamination, and determination of location of highest ~~conectrations,~~concentrations, as well as, monitoring the effectiveness of on-going remedial ~~activities.~~activities (D6196).

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.~~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 ~~must~~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 ~~a single data set;~~ 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 ~~technology~~ or manual driven hand (D1452) sampling equipment (Figs. 1 and 2). Table 1 provides a summary of ~~possible~~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 ~~0.25 to 12 in.~~0.65 cm to 0.3 m [0.25 to 12 in.] in length (Figs. ~~3~~1 and ~~4~~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. ~~3~~1 and ~~4~~2). A list of acceptable sample containers or monitoring devices is included in Table 2.

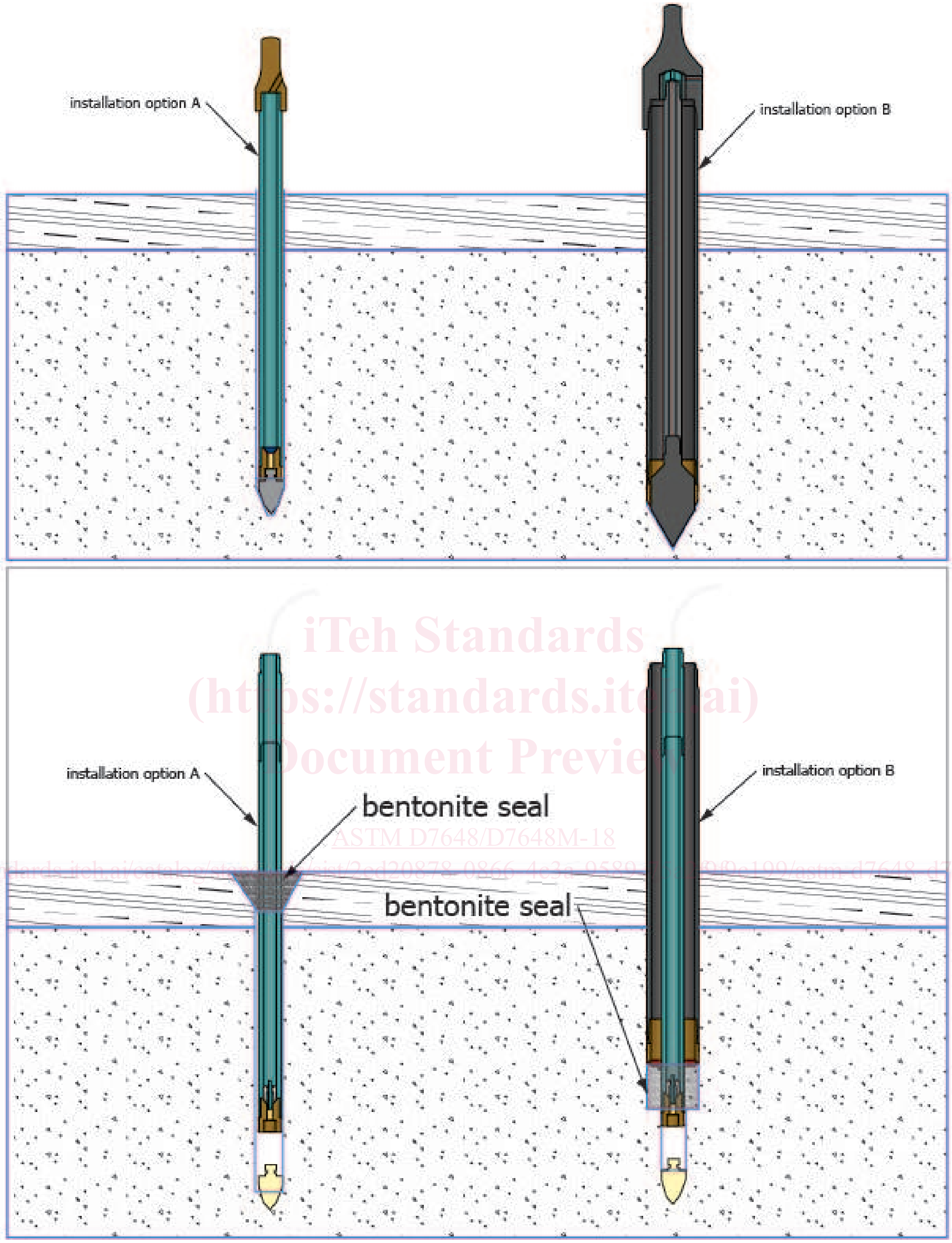

FIG. 1 Direct Push

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~~3 and ~~6~~4).

6.5 Once the ambient air and a purge volume equal to ~~two~~three times the total volume of the sample train has been purged the sample train ~~must~~should be isolated to ~~ensure~~ make sure 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.~~

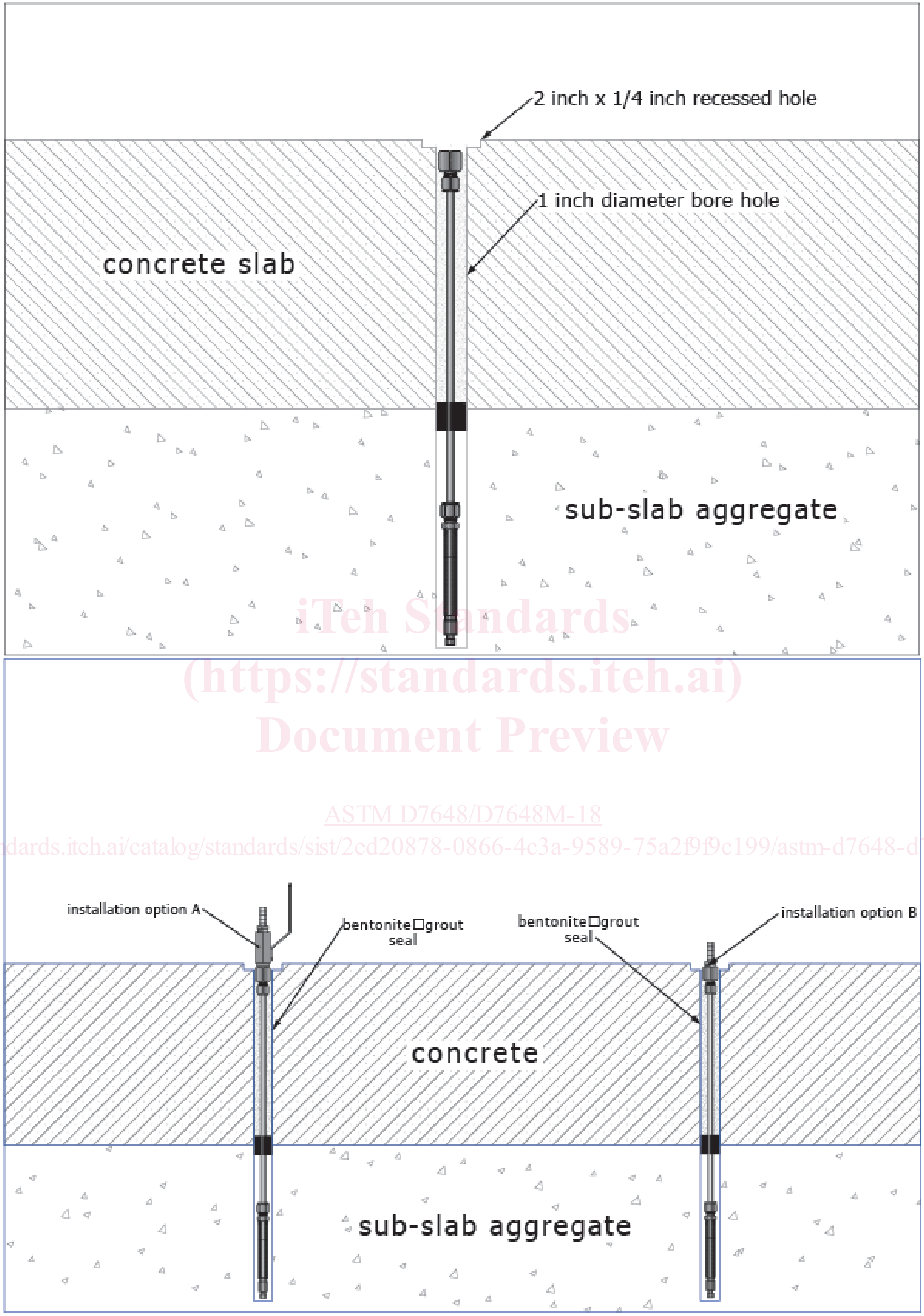

FIG. 2 Hand Sampling

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.