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Standard Guide for Representative Sampling for Management of Waste and Contaminated Media[1]

This standard is issued under the fixed designation D6044; 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 guide covers the definition of representativeness in environmental sampling, identifies sources that can affect representativeness (especially bias), and describes the attributes that a representative sample or a representative set of samples should possess. For convenience, the term "representative sample" is used in this guide to denote both a representative sample and a representative set of samples, unless otherwise qualified in the text.

1.2 This guide outlines a process by which a representative sample may be obtained from a population. The purpose of the representative sample is to provide information about a statistical parameter(s) (such as mean) of the population regarding some characteristic(s) (such as concentration) of its constituent(s) (such as lead). This process includes the following stages: (*1*) minimization of sampling bias and optimization of precision while taking the physical samples, (*2*) minimization of measurement bias and optimization of precision when analyzing the physical samples to obtain data, and (*3*) minimization of statistical bias when making inferences from the sample data to the population. While both bias and precision are covered in this guide, major emphasis is given to bias reduction.

1.3 This guide describes the attributes of a representative sample and presents a general methodology for obtaining representative samples. It does not, however, provide specific or comprehensive sampling procedures. It is the user's responsibility to ensure that proper and adequate procedures are used.

1.4 The assessment of the representativeness of a sample is not covered in this guide since it is not possible to ever know the true value of the population.

1.5 Since the purpose of each sampling event is unique, this guide does not attempt to give a step-by-step account of how to develop a sampling design that results in the collection of representative samples.

1.6 Appendix X1 contains two case studies which discuss the factors for obtaining representative samples.

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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.8 *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]

D3370 Practices for Sampling Water from Flowing Process Streams

D4448 Guide for Sampling Ground-Water Monitoring Wells

D4547 Guide for Sampling Waste and Soils for Volatile Organic Compounds

D4823 Guide for Core Sampling Submerged, Unconsolidated Sediments

D5088 Practice for Decontamination of Field Equipment Used at Waste Sites

D5681 Terminology for Waste and Waste Management

D5792 Practice for Generation of Environmental Data Related to Waste Management Activities: Development of Data Quality Objectives

D5956 Guide for Sampling Strategies for Heterogeneous Wastes

D6051 Guide for Composite Sampling and Field Subsampling for Environmental Waste Management Activities

D6169 Guide for Selection of Soil and Rock Sampling Devices Used With Drill Rigs for Environmental Investigations

D6286 Guide for Selection of Drilling and Direct Push

[1] This guide is under the jurisdiction of ASTM Committee D34 on Waste Management and is the direct responsibility of Subcommittee D34.01.01 on Planning for Sampling.

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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.

Methods for Geotechnical and Environmental Subsurface Site Characterization
D6634 Guide for Selection of Purging and Sampling Devices for Groundwater Monitoring Wells
D6771 Practice for Low-Flow Purging and Sampling for Wells and Devices Used for Ground-Water Quality Investigations
D7929 Guide for Selection of Passive Techniques for Sampling Groundwater Monitoring Wells

3. Terminology

3.1 *Definitions*—For definitions of terms used in this standard, refer to Terminology D5681.

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *analytical unit, n*—the actual amount of the sample material analyzed in the laboratory.

3.2.2 *bias, n*—a systematic positive or negative deviation of the sample or estimated value from the true population value.

3.2.2.1 *Discussion*—This guide discusses three sources of bias: sampling bias, measurement bias, and statistical bias.

3.2.2.2 *Discussion*—There is a sampling bias when the value inherent in the physical samples is systematically different from what is inherent in the population.

3.2.2.3 *Discussion*—There is a measurement bias when the measurement process produces a sample value systematically different from that inherent in the sample itself, although the physical sample is itself unbiased. Measurement bias can also include any systematic difference between the original sample and the sample analyzed, when the analyzed sample may have been altered due to improper procedures such as improper sample preservation or preparation, or both.

3.2.2.4 *Discussion*—There is a statistical bias when, in the absence of sampling bias and measurement bias, the statistical procedure produces a biased estimate of the population value.

3.2.2.5 *Discussion*—Sampling bias is considered the most important factor affecting inference from the samples to the population.

3.2.3 *biased sampling, n*—the taking of a sample(s) with prior knowledge that the sampling result will be biased relative to the true value of the population.

3.2.3.1 *Discussion*—This is the taking of a sample(s) based on available information or knowledge, especially in terms of visible signs or knowledge of contamination. This kind of sampling is used to detect the presence of localized contamination or to identify the source of a contamination. The sampling results are not intended for generalization to the entire population. This is one form of authoritative sampling (see *judgment sampling*).

3.2.4 *composite sample, n*—a combination of two or more samples.

3.2.5 *constituent, n*—an element, component, or ingredient of the population.

3.2.5.1 *Discussion*—If a population contains several contaminants (such as acetone, lead, and chromium), these contaminants are called the constituents of the population.

3.2.6 *error, n*—the random or systematic deviation of the observed sample value from its true value (see *bias* and *sampling error*).

3.2.7 *homogeneity, n*—the condition of the population under which all items of the population are identical with respect to the characteristic(s) of interest.

3.2.8 *judgment sampling, n*—taking of a sample(s) based on judgment that it will more or less represent the average condition of the population.

3.2.8.1 *Discussion*—The sampling location(s) is selected because it is judged to be representative of the average condition of the population. It can be effective when the population is relatively homogeneous or when the professional judgment is good. It may or may not introduce bias. It is a useful sampling approach when precision is not a concern. This is one form of authoritative sampling (see *biased sampling*).

3.2.9 *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 is collected.

3.2.9.1 *Discussion*—A representative sample can be a single sample, a collection of samples, or one or more composite samples. A single sample can be representative only when the population is highly homogeneous.

3.2.10 *sample, n*—one or more items or portions collected from a lot or population.

3.2.10.1 *Discussion*—Sample is a term with numerous meanings. The scientist collecting physical samples (for example, from a landfill, drum, or monitoring well) or analyzing samples considers a sample to be that unit of the population that was collected and placed in a container. A statistician considers a sample to be a subset of the population, and this subset may consist of one or more physical samples. To minimize confusion, the term *sample*, as used in this guide, is a reference to either a physical sample held in a sample container, or that portion of the population that is subjected to in-situ measurements, or a set of physical samples. See *representative sample*.

3.2.10.2 *Discussion*—The term *sample size* also means different things to the scientist and the statistician. To avoid confusion, terms such as sample mass/sample volume and number of samples are used instead of sample size.

3.2.11 *sampling error, n*—the systematic and random deviations of the sample value from that of the population. The systematic error is the *sampling bias*. The random error is the *sampling variance*.

3.2.11.1 *Discussion*—Before the physical samples are taken, potential sampling variance comes from the inherent population heterogeneity (sometimes called the “fundamental error”; see *heterogeneity*). In the physical sampling stage, additional contributors to sampling variance include random errors in collecting the samples. After the samples are collected, another contributor is the random error in the measurement process. In each of these stages, systematic errors can occur as well, but they are the sources of bias, not sampling variance.

3.2.11.2 *Discussion*—Sampling variance is often used to refer to the total variance from the various sources.