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Standard Guide for Sampling Strategies for Heterogeneous Wastes[1]

This standard is issued under the fixed designation D5956; 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 is a practical, nonmathematical discussion for heterogeneous waste sampling strategies. This guide is consistent with the particulate material sampling theory as well as inferential statistics, and may serve as an introduction to the statistical treatment of sampling issues.

1.2 This guide does not provide comprehensive sampling procedures, nor does it serve as a guide to any specification. It is the responsibility of the user to ensure appropriate procedures are used.

1.3 *Units*—The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard. All observed and calculated values shall conform to the guidelines for significant digits and rounding established in Practice D6026. Reporting of test results in units other than SI shall not be regarded as nonconformance with this standard.

1.4 *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.*

1.5 *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]

D5681 Terminology for Waste and Waste Management

D6026 Practice for Using Significant Digits and Data Records in Geotechnical Data

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *component, n*—an easily identified item such as a large crystal, an agglomerate, rod, container, block, glove, piece of wood, or concrete.

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

3.2.2.1 *Discussion*—When compositing samples to detect hot spots or whenever there may be a reason to determine which of the component samples that constitute the composite are the source of the detected contaminant, it can be helpful to composite only portions of the component samples. The remainders of the component samples then can be archived for future reference and analysis. This approach is particularly helpful when sampling is expensive, hazardous, or difficult.

3.2.3 *correlation, n*—the mutual relation of two or more things.

3.2.4 *item, n*—a distinct part of a population (for example, microscopic particles, macroscopic particles, and 20-ft long steel beams).

3.2.4.1 *Discussion*—The term *component* defines a subset of items. Components are those items that are easily identified as being different from the remainder of items that constitute the population. The identification of components may facilitate the stratification and sampling of a highly stratified population when the presence of the characteristic of interest is correlated with a specific component.

3.2.5 *practical homogeneity, n*—the condition of the population under which all items of the population are not identical. For the characteristic of interest, however, the differences between individual physical samples are not measurable or significant relative to project objectives.

3.2.5.1 *Discussion*—For practical purposes, the population is homogeneous.

3.2.6 *random, n*—lack of order or patterns in a population whose items have an equal probability of occurring.

3.2.6.1 *Discussion*—The word *random* is used in two different contexts in this guide. In relation to sampling, random means that all items of a population have an equal probability of being sampled. In relation to the distribution of a population

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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.

characteristic, random means that the characteristic has an equal probability of occurring in any and all items of the population.

3.2.7 *sample variance, n*—a measure of the dispersion of a set of results. Variance is the sum of the squares of the individual deviations from the sample mean divided by one less than the number of results involved. It may be expressed as $s^2=\sum (x_i-\bar{x})^2/(n-1)$.

4. Significance and Use

4.1 This guide is suitable for sampling heterogeneous wastes.

4.2 The focus of this guidance is on wastes; however, the approach described in this guide may be applicable to non-waste populations as well.

4.3 Sections 5 – 10 describe a guide for the sampling of heterogeneous waste according to project objectives. Appendix X1 describes an application of the guide to heterogeneous wastes. The user is strongly advised to read Annex A1 prior to reading and employing Sections 5 – 10 of this guide.

4.4 Annex A1 contains an introductory discussion of heterogeneity, stratification, and the relationship of samples and populations.

4.5 This guide is intended for those who manage, design, or implement sampling and analytical plans for the characterization of heterogeneous wastes.

5. Sampling Difficulties

5.1 There are numerous difficulties that can complicate efforts to sample a population. These difficulties can be classified into four general categories:

5.1.1 Population access problems making it difficult to sample all or portions of the population;

5.1.2 Sample collection difficulties due to physical properties of the population (for example, unwieldy large items or high viscosity);

5.1.3 Planning difficulties caused by insufficient knowledge regarding population size, heterogeneity of the contaminant of interest, item size, or a combination thereof; and

5.1.4 Budget problems that prevent implementation of a workable, but too costly, sampling design.

5.2 The difficulties included in the first three categories are a function of the physical properties of the population being sampled. The last sampling difficulty category is a function of budget restraints that dictate a less costly sampling approach that often results in a reduced number of samples and a reduced certainty in the estimates of population characteristics. Budget restraints can make it difficult to balance costs with the levels of confidence needed in decision-making. These difficulties may be resolved by changing the objectives or sampling/analytical plans since population attributes or physical properties of the population can seldom be altered. Documents on DQOs discuss a process for balancing budgets with needed levels of confidence.

5.3 Population access and sample collection difficulties often are obvious and, therefore, more likely either to be addressed or the resulting limitations well documented. A field notebook is likely to describe difficulties in collecting large items or the fact that the center of a waste pile could not be accessed.

5.4 Population size, heterogeneity, and item size have a substantial impact on sampling. The cost and difficulty of accurately sampling a population usually is correlated with the knowledge of these population attributes and characteristics. The least understood population attribute is heterogeneity of the characteristic of interest. If heterogeneity is not known through process knowledge, then some level of preliminary sampling or field analysis is often required prior to sampling design.

5.5 Sampling of any population may be difficult. However, with all other variables being the same, nonrandom heterogeneous populations are usually more difficult to sample. The increased difficulty in sampling nonrandom heterogeneous populations is due to the existence of unidentified or numerous strata, or both. If the existence of strata is not considered when sampling a nonrandom heterogeneous population, the resulting data will average the measured characteristics of the individual strata over the entire population. If the different strata are relatively similar in composition, then the mean characteristic of the population may be a good predictor for portions of the population and will often allow the project-specific objectives to be achieved. As the difference in composition between different strata increases, average population characteristics become less useful in predicting composition or properties of individual portions of the population. In this latter case, when possible, it is advantageous to sample the individual strata separately and, if an overall average of a population characteristic is needed, it can be calculated mathematically using the weighted averages of the sampling stratum means (**1**).[3]

6. Stratification

6.1 Strata can be thought of as different portions of a population which may be separated in time or space, with each portion having internally similar concentrations or properties, which are different from adjacent portions of the population (that is, concentrations/properties are correlated with space, time, component, or source). Fig. 1 is a graphical depiction of different types of strata.

6.1.1 A landfill may display spatially separated strata since old cells may contain different wastes than new cells (stratification over space).

6.1.2 A waste pipe may discharge temporally separated strata if night-shift production varies from the day shift (stratification over time).

6.1.3 Lead-acid batteries will constitute a strata separate from commingled soil if lead is the characteristic of interest (stratification by component).

6.1.4 Drums from an inorganic process may constitute a different strata from those co-disposed drums generated by an organic process (a subtype of stratification by component referred to as stratification by source).

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