SLOVENSKI STANDARD
SIST-TP CEN/TR 15310-1:2007

01-april-2007

Karakterizacija odpadkov - Vzorļenje odpadkov - 1. del: Navodilo za izbiro in uporabo kriterijev za vzorļenje pri razliļnih pogojih

Characterization of waste - Sampling of waste materials - Part 1: Guidance on selection and application of criteria for sampling under various conditions

Charakterisierung von Abfall - Probenahme - Teil 1: Richtlinien zur Auswahl und Anwendung von Kriterien für die Probenahme unter verschiedenen Bedingungen

Caractérisation des déchets - Prélèvement des déchets - Partie 1 : Guide relatif au choix et a l'application des criteres d'échantillonnage dans diverses conditions

Ta slovenski standard je istoveten z: **CEN/TR 15310-1:2006**

ICS:

13.030.10	Trdni odpadki	Solid wastes
13.030.20	Tekoļ i odpadki. Blato	Liquid wastes. Sludge

SIST-TP CEN/TR 15310-1:2007 **en**

TECHNICAL REPORT

RAPPORT TECHNIQUE

TECHNISCHER BERICHT

CEN/TR 15310-1

November 2006

ICS 13.030.10; 13.030.20

English Version

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This Technical Report was approved by CEN on 21 February 2006. It has been drawn up by the Technical Committee CEN/TC 292.

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EUROPEAN COMMITTEE FOR STANDARDIZATION
COMITÉ EUROPÉEN DE NORMALISATION
EUROPÄISCHES KOMITEE FÜR NORMUNG

Management Centre: rue de Stassart, 36 B-1050 Brussels

Ref. No. CEN/TR 15310-1:2006: E

Contents

Foreword

This Technical Report (CEN/TR 15310-1:2006) has been prepared by Technical Committee CEN/TC 292 “Characterization of waste”, the secretariat of which is held by NEN.

This Technical Report has been prepared under a mandate given to CEN by the European Commission and the European Free Trade Association.

This Technical Report is one of a series of five Technical Reports dealing with sampling techniques and procedures, and provides essential information and instructions for the application of the EN-standard:

EN 14899 Characterisation of Waste - Sampling of waste materials - Framework for the preparation and application of a Sampling Plan

The principal component of the EN Standard is the mandatory requirement to prepare a Sampling Plan. This EN 14899 standard can be used to:

– produce standardised sampling plans for use in regular or routine circumstances (i.e. the elaboration of daughter/derived standards dedicated to well defined sampling scenarios);
– incorporate specific sampling requirements into national legislation;
– design and develop a Sampling Plan on a case by case basis.

The Technical Reports display a range of potential approaches and tools to enable the project manager to tailor his sampling plan to a specific testing scenario (i.e. a ‘shop shelf’ approach to sampling plan development for waste testing). This approach allows flexibility in the selection of the sampling approach, sampling point, method of sampling and equipment used.

This Technical Report describes the statistical principles related to sampling, and provides methods based on these principles enabling a testing programme to be defined that will produce results sufficiently reliable for the decision-making process for which they are required.

Wastes arise in a wide variety of types (e.g. pastes, liquids, granular materials, mixes of different materials) and sampling situations (e.g. during a waste production process, stockpiles, tanks, drums). There can also be a variety of sampling objectives within each of the three broad categories (basic characterisation, compliance testing and on-site verification). Consequently the Report cannot provide definitive instructions for each and every case on the practical details of the testing programme, such as the required number of samples, the size of these samples, and whether they should be spot or composite samples. Instead, its aim is to expose the factors that influence the choice of these detailed components of the sampling exercise, and to provide statistical tools that can then be applied to determine the most appropriate testing programme for any given sampling scenario.

Introduction

Wastes are materials, which the holder discards, or intends or is required to discard, and which may be sent for final disposal, reuse or recovery. Such materials are generally heterogeneous and it will be necessary therefore to specify in the testing programme the amount of material for which the characteristics of interest need to be defined. The testing of wastes allows informed decisions to be made on how they should be treated (or not), recovered or disposed of. In order to undertake valid tests, some sampling of the waste is required.

The principal component of the standard EN 14899 is the mandatory requirement to prepare a Sampling Plan, within the framework of an overall testing programme as illustrated in Figure 1 of EN 14899:2005 and can be used to:

- produce standardised sampling plans for use in regular or routine circumstances (elaboration of daughter/derived standards dedicated to well defined sampling scenarios);
- incorporate the specific sampling requirements of European and national legislation;
- design and develop a Sampling Plan for use on a case by case basis.

The development of a Sampling Plan within this framework involves the progression through three steps or activities:

1) define the Sampling Plan;
2) take a field sample in accordance with the Sampling Plan;
3) transport the laboratory sample to the laboratory.

This Technical Report provides information to support Key Step 1 of the Sampling Plan process map and describes the selection of sampling approach that can be used in the recovery of a sample for a wide variety of waste types and arisings. Specifically this Technical Report provides information to support 4.2.7 (Select sampling approach) of the Framework Standard. Due consideration and selection of statistical criteria is of key importance in the production of a Sampling Plan as it provides the sole means of ensuring that, wherever possible, the type and number of samples taken will address a clearly identified objective and will provide results that achieve a tolerable level of reliability.

Table 1 - Main statistical steps in defining a sampling plan for a testing programme

Step	Subject
Specify the objective of the Testing Programme	
1	Specify the objective of the Testing Programme
Develop the Technical Goals from the objective	
2	Define the population to be sampled
3	Assess variability
4	Select the sampling approach
5	Identify the scale
6	Choose the required statistical approach
7	Choose the desired reliability
Determine the practical instructions	
8	Choose the sampling pattern
9	Determine the increment/ sample size
10	Determine the use of composite or individual samples
11	Determine required number of samples
Define the Sampling Plan	
12	Define the Sampling Plan

To illustrate the application of these principles, a series of 14 examples of sampling scenarios for a single waste stream are provided in Annex E.

This Technical Report should be read in conjunction with the Framework Standard for the preparation and application of a Sampling Plan as well as the other Technical Reports that contain essential information to support the Framework Standard. The full series comprises:

– EN 14899 Characterization of waste - Sampling of waste materials - Framework for the preparation and application of a Sampling Plan;

– CEN/TR 15310-1, Characterization of waste – Sampling of waste materials – Part 1: Guidance on selection and application of criteria for sampling under various conditions;

– CEN/TR 15310-2, Characterization of waste – Sampling of waste materials – Part 2: Guidance on sampling techniques;

– CEN/TR 15310-3, Characterization of waste – Sampling of waste materials – Part 3: Guidance on procedures for sub-sampling in the field;

– CEN/TR 15310-4, Characterization of waste – Sampling of waste materials – Part 4: Guidance on procedures for sample packaging, storage, preservation, transport and delivery;

– CEN/TR 15310-5, Characterization of waste – Sampling of waste materials – Part 5: Guidance on the process of defining the Sampling Plan.

The Technical Reports contain procedural options (as detailed in Figure 2 of EN 14899:2005) that can be selected to match the sampling requirements of any testing programme.

1 Scope

This Technical Report discusses the statistical principles of sampling, and provides a number of statistical tools to assist in the design of testing programmes for application to sampling under various conditions.

NOTE 1 Given the great variety of waste types, sampling situations and objectives, this Technical Report cannot provide definitive instructions that cover all scenarios. Instead, it discusses the basic statistical approach to be followed, and provides statistical tools that can be applied to determine the amount and type of sampling (e.g. number of samples and sample size) in any given situation to achieve results of adequate reliability (i.e. precision and confidence).

NOTE 2 The document provides considerable detail on current best practice, but is not exhaustive.

NOTE 3 To clarify the text, the document provides a number of worked examples.

2 Terms and definitions

For the purposes of this Technical Report, we have used or adapted the definitions of ISO 3534 Parts 1, 2 and 3 wherever possible. In a minority of cases, however, those definitions are couched in technical statistical language, which is likely to be unhelpful to the intended readership. In these instances we have either supplemented the formal definition with an additional note, or provided an alternative simpler definition.

NOTE In order to keep the list of definitions as compact as possible, some terms that are used only occasionally in the main text have been omitted. B.1 provides an additional list of definitions that are specifically relevant to the various annexes.

2.1

analytical error

collective term for the imprecision and bias associated with the analytical method

2.2

characteristic

property, which helps to identify or differentiate between items of a given population
[ISO 3534-1]

NOTE The characteristic may be either quantitative (by variables) or qualitative (by attributes).

2.3

coefficient of variation

for a non-negative characteristic the ratio of the standard deviation to the average
[ISO 3534-1]

2.4

compliance (and non-compliance)

compliance is achieved when the sample values from a monitoring programme meet a pre-defined set of criteria. Conversely, non-compliance occurs when the sample values fail to meet the pre-defined criteria

NOTE Examples of compliance criteria are:

- The estimated mean should be ≤ 20 mg/kg;
- Fewer than 3 sample values out of 20 should exceed 50 μg/l.

2.5

composite sample

two or more increments / sub-samples mixed together in appropriate proportions, either discretely or continuously (blended composite sample), from which the average value of a desired characteristic may be obtained
[ISO 11074-2]

2.6

confidence interval

interval within which a particular population parameter may be stated to lie at a specified confidence level. The bounds of the confidence interval are termed the upper and lower confidence limits

2.7

fundamental variability

inherent variability shown by a material at the smallest scale of measurement

2.8

heterogeneity

degree to which a property or a constituent is not uniformly distributed throughout a quantity of material

NOTE 1 A material may be heterogeneous with respect to one analyte or property but not with respect to another.

NOTE 2 The degree of heterogeneity is a key-determining factor in sampling error.

2.9

increment

individual portion of material collected by a single operation of a sampling device

NOTE 1 Increments may be reduced and tested individually or combined with other increments, with the resulting composite reduced in size and tested as a single unit.

NOTE 2 Increments are created by the sampling operation and are usually taken from parts of a lot separated in time or space.

2.10

judgemental sampling

samples collected using at best a partially-probabilistic procedure and at worst a non-probabilistic approach. Usually these samples are taken from a sub-population which is substantially more restrictive than the overall population.

2.11

mean (arithmetic mean)

sum of values divided by the number of values
[ISO 3534-1]

NOTE For example, the arithmetic mean of the five values 12, 4, 11, 9 and 6 is 8.4.

2.12

overall population

entire volume of material about which information is required.

NOTE 1 For example, the overall population might be the output of waste over the whole lifetime of the plant.

NOTE 2 See ‘population’.

2.13

percentile

P-percentile of a population is the value below which P% of the values in the population fall, and hence is exceeded by (100-P)% of the population.

NOTE For example, 95 % of the values in a population are less than or equal to the 95-percentile, and 5 % of the population values exceed it.

2.14

physical sampling error

error attributable to the activity of taking the sample

2.15

population

totality of items under consideration. [ISO 3534-1:1993, definition 2.3]

NOTE The population will generally be a convenient, well-defined subset of the overall population (e.g. a year's production of waste) that is believed to be typical of that wider population.

2.16

precision

closeness of agreement between independent test results obtained under stipulated conditions
[ISO 3534-1]

NOTE 1 Precision depends only on the distribution of random errors and does not relate to the true value or the specified value.

NOTE 2 The measure of precision usually is expressed in terms of imprecision and computed as a standard deviation of the test results. A lower precision is reflected by a larger standard deviation.

2.17

probabilistic sampling

sampling conducted according to the statistical principles of sampling

NOTE 1 The essential principle of probabilistic sampling is that every individual particle or item in the population has an equal chance of being sampled.

NOTE 2 Probabilistic sampling results in boundary conditions for the type of sampling equipment used, the method of sampling (where, when, how) and the minimum size of increments and (composite) samples.

2.18

probability

real number in the scale 0 to 1 attached to a random event
[ISO 3534-1]

NOTE An event with a probability close to zero is very unlikely to happen. For example, the probability of obtaining 'heads' in each of 10 consecutive spins of a coin is about 0.001. Conversely, an event with probability close to 1 is very likely to happen. For example, the event of obtaining at least one 'six' when rolling 25 dice is about 0.99.

2.19

probability distribution (of a random variable)

function giving the probability that a random variable takes any given value or belongs to a given set of values
[ISO 3534-1]

NOTE The probability distribution is a mathematical description of the relative frequencies with which different values arise in the population. It is commonly represented graphically, and can be thought of as the curve that the histogram of random sample values would tend towards as the number of samples becomes indefinitely large.

2.20

random sample

sample of n sampling units taken from a population in such a way that each of the possible combinations of n sampling units has a particular (known) probability of being taken
[ISO 3534-1]

2.21

random sampling

process of taking a random sample
[ISO 3534-1]

2.22

reliability

collective term for the degree of precision and confidence achieved by a given sampling scheme

2.23

representative

sample resulting from a sampling plan that can be expected to reflect adequately the properties of interest in the parent population
[ISO 11074-2]

2.24

representative sample

sample in which the characteristic(s) of interest is (are) present with a reliability appropriate for the purposes of the testing programme

2.25

sample

portion of material selected from a larger quantity of material. [ISO 11074-2:1998, definition 1.5]

NOTE 1 The manner of selection of the sample should be described in a sampling plan.

NOTE 2 The use of the term ‘sample’ should be supported with a preface as far as possible as it does not indicate to which step of the total sampling procedure it is related when used alone e.g. field sample, laboratory sample.

2.26

sample size

number of items or the quantity of material constituting a sample.

NOTE In statistical sampling theory, the term ‘sample size’ is commonly used to denote the *number* of samples. To lessen the risk of confusion, that usage has been avoided in this Technical Report; thus ‘sample size’ refers unambiguously to the volume or mass of any one sample.

2.27

sampling error

that part of the estimation error, which is due to the fact that only a sample of size less than the population size, is observed
[ISO 3534-1]

2.28

sampling pattern

collective term for the method of sampling to be adopted, such as random, systematic, stratified random or judgemental

2.29

scale

stated size or volume that is considered appropriate for assessing the material

NOTE 1 It follows that variations occurring in the material on any finer scale than this are deemed not to be of relevance.

NOTE 2 Annex A provides further explanation of the concept of scale.

2.30

simple random sample

sample of *n* sampling units taken from a population in such a way that all possible combinations of n sampling units have the same probability of being taken
[ISO 3534-1]

2.31

spatial variability

general term for the variability between locations in the material to be sampled

2.32

spot sampling

sample of a specified number or size taken from a specified place in a material or at a specified place and time in a stream of material and representative of its own immediate or local environment
[ISO 11074-2]

NOTE Form of sampling in which each sample is individually analysed (in contrast to composite sampling).

2.33

standard deviation

positive square root of the variance
[ISO 3534-1]

NOTE This is the most commonly used measure of variability of a data set or statistical population. For example, the standard deviation of the values 3.7, 5.5, 2.8, 9.1 and 6.0 is 2.43.

2.34

stratum/strata

strata are mutually exclusive and exhaustive parts of a population. They are identified either, because they are believed to be different from each other or for the purposes of sampling

2.35

stratified sampling

in a population which can be divided into mutually exclusive and exhaustive strata (i.e. sub-populations), sampling carried out in such a way that specified proportions of the sample are drawn from the different strata and each stratum is sampled with at least one sampling unit
[ISO 3534-1]

NOTE The objective of taking stratified samples is to obtain a more representative sample than that which might otherwise be obtained by random sampling.

2.36

sub-population

defined part of the population that will be targeted for the purposes of sampling

2.37

systematic error (or Bias)

difference between the expectation of the test results and an accepted reference value
[ISO 3534-1]

NOTE Bias is a systematic tendency for the observations in a set of samples to be displaced above or below the true or accepted value.

2.38

systematic sampling

sampling by some systematic method
[ISO 3534-1]

NOTE Examples are where samples are taken at regular intervals through time (e.g. weekly) or through space (e.g. every tenth skip).

2.39

temporal variability

general term for the variability through time

2.40

uncertainty

an estimate attached to a test result, which characterises the range of values within which the true value is asserted to lie
[ISO 3534-1]

NOTE In general, uncertainty of measurement comprises many components. Some of these may be estimated on the basis of the statistical distribution of the results of a series of measurements and can be characterised by standard deviations. Estimates of other components can only be based on experience or other information.

2.41

within-population variability

dispersion of observations or test results obtained within a population
[ISO 3534-2]

NOTE The within-population variation may be estimated from data from a single population, or by pooling the estimates for several populations, as appropriate.

3 Specify the objective of the Testing Programme

The objective of the Testing Programme consists of a general statement of overall purpose. The objective should be made clear prior to selecting a sampling strategy, as it is an essential first step towards defining the type and quality of the information that is to be obtained through sampling. A clearly defined objective is required to identify the material population that will be characterized through sampling.

NOTE 1 In most cases a Testing Programme can only have one objective. In other words, each single objective will generally result in a separate Testing Programme.

NOTE 2 Examples of possible objectives of the Testing Programme are:

– to compare the quality of the test material with quality levels defined in national or international legislation;

- to characterise the test material following a change in ownership;
- to determine the reusability of the test material;
- to determine the leachability of the test material;
- to assess the human health and / or environmental risks posed by the test material.

NOTE 3 The Landfill Directive (1999/31/EC) requires technical instruments to fulfil its role in setting European policy goals on waste disposal. The technical instruments on sampling are provided by CEN/TC 292 (WG1), which has developed the Framework Standard EN 14899 on waste sampling supported by a series of Technical Reports (see the Introduction). Examples of testing requirements relating to the Landfill Directive are:

- basic (comprehensive) characterisation, consisting of a thorough determination of the behaviour and properties of interest of the material.
- compliance testing, consisting of (periodic) testing to determine compliance with specific conditions or reference conditions e.g. legislation or contract.
- on-site verification, consisting of 'quick check' methods to establish consistency with other tests or other formulated documentation.

This Technical Report can be applied to meet the needs of the Landfill Directive but has not been written exclusively for that purpose, as it deals with the sampling of wastes and associated materials in a wider context.

NOTE 4 Sampling will not be necessary in every case for meeting the objective. For example, the objective of an on-site verification may be simply to establish the identity of the waste material received. (Is it a liquid? Is its colour blue?)

In the majority of cases, the objective is too general and non-specific for it to lead directly to the detailed instructions necessary for the Sampling Plan. It is therefore necessary to translate the objective into technical goals. These provide a more detailed specification of the sampling activity, and are sufficiently comprehensive to enable all aspects of the sampling plan to be determined - the type, size, scale and number of samples to be taken, the way they are selected from the material under investigation, and so on. The process of developing the technical goals from the objective is discussed in detail in Clause 4.

4 Develop the technical goals from the objective

4.1 General

Once the objective of the Sampling Plan has been agreed (see Clause 3), the next step is to develop the technical goals. This is a critical step, because once the technical goals have been defined, we can determine specific sampling and data analysis requirements and identify the statistical analytical tools that will provide a consistent means of assessing and interpreting testing data. Such tools ultimately provide the means of verifying whether or not the technical goals have been met.

In the process of deriving the technical goals from the objective, it is important to remain focussed on the conclusions that the sampling is intended to deliver, and their implications for the technical specification of the testing programme.

In some cases the translation from the objective to the technical goals is straightforward because details such as the type of sample to be taken, or the statistical parameter to be determined from the results, may already be laid down in national or international legislation. Otherwise, however, the project manager needs to define the technical goals in close consultation with all involved parties, as the technical goals will lead directly to the practical instructions that are given to the sampler prior to sampling. Conflicts can often arise between (a) the desired reliability and scope of the sampling, and (b) the available resources, in which case compromises will be necessary. This makes it all the more essential that the involved parties do agree on the technical goals and their implications prior to sampling.

Some technical goals can be sufficiently well defined that they can be directly implemented into the Sampling Plan (for example, the material to be sampled and the constituents to be tested), whilst