Horizontal standard on selection of operational sampling standards

Sampling of solid granular material and liquids

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CONTENTS

FOREWORD

Two documents have been prepared within the Nordic Innovation Centre project “Development of Nordic generic horizontal standards for sampling (06135)”:

1. A structural approach to horizontal sampling standards.
2. Draft horizontal standard on selection of operational sampling standards for solids and liquids (present document).

The first document considers giving guidance on reading and application of the horizontal standard and development of the horizontal approach. The present document is an example of a standard on identification of the best available operational sampling standard related to sampling of solid granular material in stationary and dynamic situations and liquids in dynamic situations.

The project has been carried out by:

- DHI (Denmark).
- SP Swedish national testing and Research Institute (Sweden).
- Aquateam AS (Norway).
- Swedish Geotechnical Institute (Sweden).
- VTT Technical Research Centre (Finland).

The project was initiated in September 2006 and finalized in October 2008.

The project supports and refers to earlier completed Nordtest and NICe projects on sampling, laboratory quality control and field measurements. In addition several projects carried out within the last few years have been focusing on uncertainty arising from sampling and within these projects, quality control has been an important issue (Nordic Innovation Centre 2006, 6th Committee of Eurachem 2006 and Eurofins 2005):

- Handbook on wastewater and sludge sampling (Nordtest 2005).
- Uncertainty from sampling Nordtest/Eurachem (ongoing work) (Eurachem 2006).
- Quality control manual for field measurements (NT tec 581).
- Nordtest Sampler Certification (NT ENVIR 008).
- Nordtest Sampler Certification network (ongoing work).
- Two Nordtest methods on sampling of waste (NT ENVIR 001 and NT ENVIR 004).
- A CEN/STAR workshop was held in April 2005 in Brussels.

The principal scientists and authors of this document within the project are: Bodil Mose Pedersen, Jette Bjerre Hansen, Anke Oberender (DHI), Bertil Magnusson (SP), Margareta Wahlström and Jutta Laine-Ylijoki (VTT), Ragnar Storhaug (Aquateam) and Johan Nordbäck (SGI). Christian Grøn (DHI) is gratefully acknowledged for fruitful comments and discussions.

The output from this NICe project on Horizontal sampling standards will be transferred to CEN so that the structural approach can form part of European Standardization work on horizontal sampling standard(s).

The foundation of the horizontal approach and the horizontal standard is environmental sampling. Although the selection, formulation and interpretation of criteria in sampling and the selection of the best available operational standards have been achieved from an objective point of view, the work reflects the expertise represented by the people in the project group.

INTRODUCTION

How sampling (box A5) is integrated in the complete measurement cycle is illustrated by Figure A. Furthermore, the figure shows the typical elements of the measurement cycle and highlights, how the sampling process can be expanded into a sampling cycle. A more detailed description of the measurement cycle and sampling cycle, respectively, can be found in the document “A structural approach to horizontal sampling standards “ (Pedersen et al. 2008).

The measurement cycle typically starts with a clients issue, e.g. does the composition of a certain waste material that is incorporated in pavement material fulfil environmental requirements. The complete measurements process ends with the reporting and recommendations and subsequently a decision (A11) based upon the measuring results. Similarly the sampling cycle (B) consists of a number of typical activities or elements.

This horizontal standard identifies the best available operational standards (or sections of standards) related to sampling of solid granular material in stationary and dynamic sampling situations and liquids in dynamic sampling situations. Sampling liquids from stationary situations and sampling of gasses is not included in this project.

In this context “best available operational standard” refers to standards that fulfil a number of criteria which are defined based on the authors´ interpretation of the *Theory of Sampling* (ToS). The *Theory of Sampling* was developed by Pierre Gy and it covers the principle of correct sampling (sample representativeness), the origin of the seven types of sampling errors and a definition of sampling dimensions.

In chapters 1 to 3 of this horizontal standard the scope, normative references, as well as terms and definitions are given. Chapters 4 and 5 provide information on sampling principles and the use of this standard, respectively. The subsequent chapters 6 to 10 focus on different elements of the sampling cycle and contain:

- Description: A short description of each element of the sampling cycle, including a justification of the importance of each element for sampling.
- Criteria: A list of criteria based on which the best available operational standard can be identified.
- Identification: A table containing the identified standard(s) or relevant sections in the standards for elements of the sampling cycle. Where no appropriate standard is available, a gap and consequently the need for standardisation, is identified.

Appendices A to C contain three supporting documents for the identification of the best available operational standard with regard to equipment and sampling procedure for specific sampling targets. The assessment of best available operational standard is for those documents primarily based on empirical experience.

In addition, appendix D includes several tables covering all the reviewed sampling standards. The list of reviewed standards contains standards for the sampling of solid and liquid materials as well as materials in between the two categories, such as suspensions.

Furthermore the standards cover sampling within various technical fields, i.e. sampling of iron ores, waste, or paint.

The application of the *Theory of Sampling* for the identification of best available operational standard makes it possible to develop a horizontal standard, where good sampling practise is related to generic sampling situations, rather than technical fields.

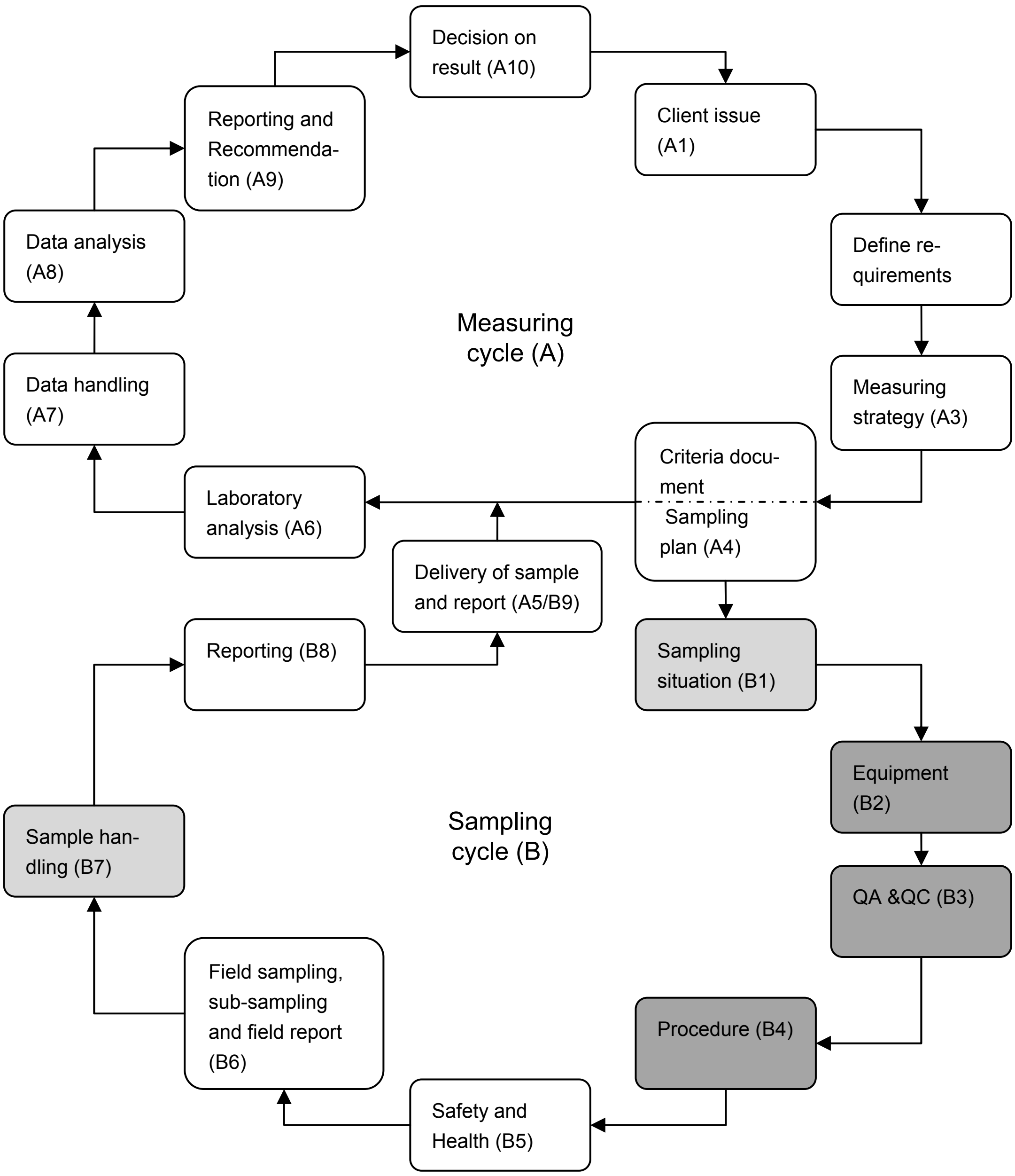

Figure A *Diagram of a typical measurement process including sampling, physical sample preparation (including transport) and analysis. Sampling step B5-B7 is the actual process of taking a sample and delivering it to the laboratory. Grey shaded boxes indicate those activities which have special focus in this horizontal standard.*

1 SCOPE

This document identifies and selects best available operational sampling standards (or sections of standards). The horizontal standard focuses on selected activities of the sampling cycle – sampling situation, sampling equipment, sample handling, quality assurance/quality control and sampling procedure. As illustrated in Figure 1.1, this horizontal standard covers sampling of solid granular material from dynamic and stationary systems, and sampling of liquid material from dynamic situations. Sampling of liquids from stationary situations and sampling of gasses is not part of the scope.

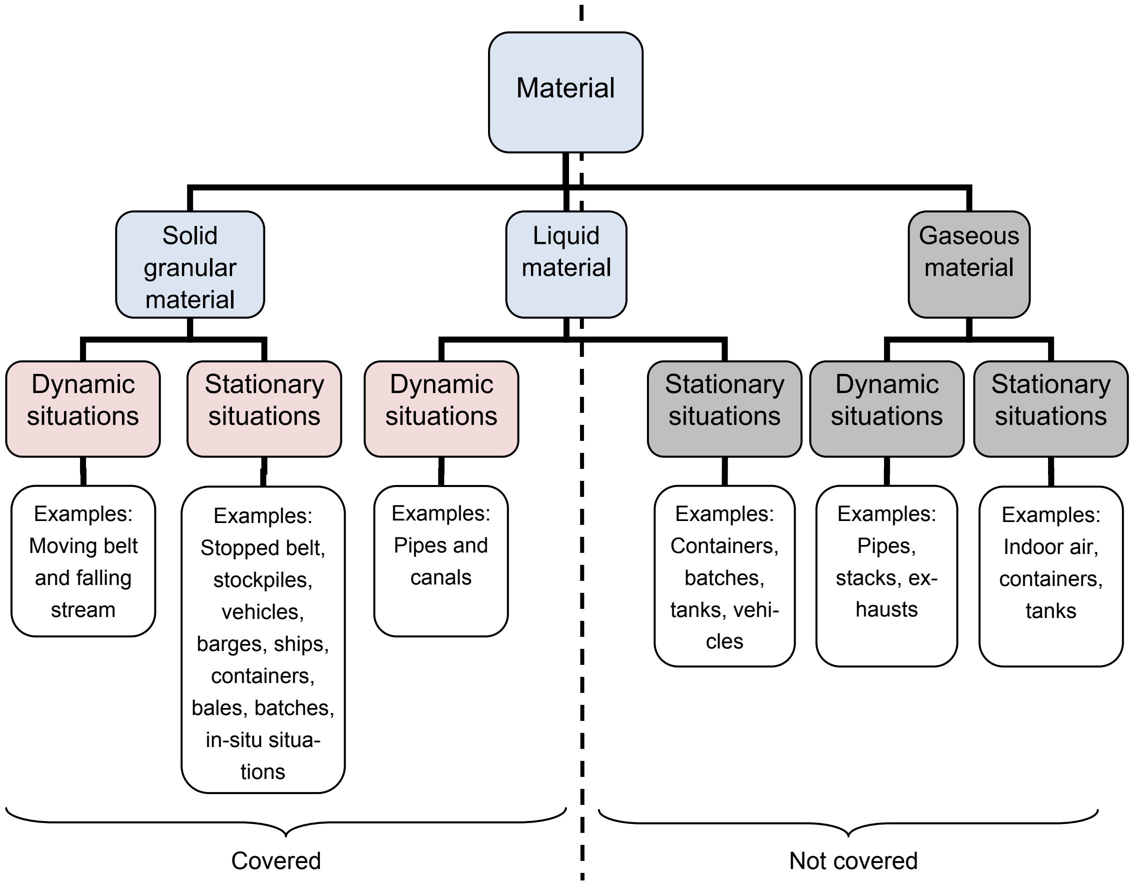

Figure 1.1 Scope and delimitation of this horizontal standard: Both sampling of solid material from dynamic and stationary situations is covered as well as sampling of liquid materials from dynamic situations (boxes on the left-hand side of the dashed line). The grey shaded boxes on the right hand side of the dashed line show what is not included in the scope of this standard. The white boxes in the lower part of the figure list some examples for typical sampling situations.

Based on criteria that are derived from the *Theory of Sampling* best operational standards (or section hereof) are identified for the above described activities of the sampling cycle. The identified standards and sections can be used to develop an operational standard and subsequently to prepare a sampling procedure prior to sampling in the field.

It is not the aim of this document to offer specific guidance on the development of a sampling plan. However, in the appendix D a list of standards that deal with sampling design, sampling schemes and sampling plans can be found. ISO 10381-8 and DS/EN 14899:2006 can be recommended for the elaboration of a sampling plan. Furthermore, a list of standards including health and safety considerations can be found which can be used to define health and safety measures for the specific sampling issue.

2 INFORMATIVE REFERENCES

The following reference documents are indispensable for the application of this document. For dated references only the edition cited applies. For undated references the last edition of the referenced document applies.

- CEN/CENELEC Internal Regulation-Part 3 2003-10 Rules for the structure and drafting of CEN/CENELEC publications (ISO/IEC Directives – Part 2, modified).
- ISO/IEC 17025:2005: General requirements for the competence of testing and calibration laboratories.
- Nordic Horizontal standard for sampling – A structural approach to categorization of sampling standards.
- Appendix D – containing a number of sampling standards that have been reviewed as part of this project.

3 TERMS AND DEFINITIONS

For the purpose of “Nordic horizontal standard for sampling” the following definitions apply. Definitions from compiled standards and guidelines within this project are included as well.

Bias: The difference between the average amounts from many samples and the true lot. (Smith, 2001).

Composite sample: Two or more increments/sub-samples mixed together in appropriate portions, either discretely or continuously (blended composite sample), from which the average value of a desired characteristic may be obtained.
ISO11074-2: 3.10 (1998), adopted by AMC Subcommittee.

Duplicate sample or replicate sample: One of the two (or more*) samples or subsamples obtained separately at the same time by the same sampling procedure or subsampling procedure *for replicate sample.
Adapted from ISO11074-2: 2.14 (1998); ISO1998 was formally adopted from ISO3534-1 (2006); Similar definition has been adopted by AMC Subcommittee.

Fitness for purpose: The degree to which data produced by a measurement process enables a user to make technically and administratively correct decisions for a stated purpose.
Note: As defined for analytical science Thompson and Ramsey, 1995.

Fragments: The smallest inseparable physical parts of the lot. A fragment is most often a single particle for instance a grain of sand or suspended substances.
(Smith, 2001).

Homogeneity, heterogeneity: The degree to which a property or constituent is uniformly distributed throughout a quantity of material.
Note 1. A material may be homogenous with respect to one analyte or property but heterogeneous with respect to another
Note 2. The degree of heterogeneity (the opposite of homogeneity) is the determining factor of sampling error.
IUPAC (1990)]; ISO 11074-2: 1.6 (1998)].

Non-uniformity in all the chemical and physical aspects of interest (Smith, 2001).

Increment*:* Individual physical portions that are combined to form a sample. Fragments are characterised by being extracted simultaneously by the sampling tool/equipment. (Smith, 2001).

Laboratory sample: Sample as prepared for sending to the laboratory and intended for inspection or testing.
ISO Standard 78-2 (1999), adopted by CAC.

Lot: see sampling target.

Parameter: Particular quantity subject to measurement.
Note: Definition of measurand according to Ramsey & Ellison (2007).

Precision: The closeness of agreement between independent test results obtained under stipulated conditions.
ISO3534-1: (2006).

Primary sample: The collection of one or more increments or units initially taken from a population.
IUPAC (1990), adopted by AMC Subcommittee.

Principle of correct sampling: The principle that every part of the target has equal chance of being in the sample and the integrity of the sample is preserved during and after sample (Smith 2001)

Random error of result: A component of the error which, in the course of a number of test results for the same characteristic, remains constant or varies in an unpredictable way.
Note: It is not possible to correct for random error.
ISO 3534-1: 1993 (3.9)].

Reference sampling: Characterisation of an area, using a single sampling device and a single laboratory, to a detail allowing the set-up of a distribution model in order to predict element concentrations, with known uncertainty, at any sampling point.
IUPAC (2005).

Representative sample: A sample that has the same properties of interest as the target. The bias has been reduced as much as possible. (Smith, 2001).
Sample resulting from a sampling plan that can be expected to reflect adequately to properties of interest in the parent population IUPAC (1990); [ISO 11074-2: 1.9 (1998)] AMC (2005).

Sample: A portion of material selected from a larger quantity of material.
IUPAC (1990); ISO11074-2 (1998), adopted by AMC Subcommittee.

Sampler: Person (or group of persons) carrying out the sampling procedures at the sampling point.
Adapted from ISO11074-2 (1998).

Sample preparation: The set of material operations (such as reduction of sizes, mixing, dividing, etc.) that may be necessary to transform an aggregated or bulk sample into a laboratory or test sample.
Adapted from ISO3534-1 (2006).

Sample pre-treatment: Collective noun for all procedures used for conditioning a sample to a defined state which allows subsequent examination or analysis or long-term storage.
Adapted from ISO11074-2: 6.1 (1998).

Sample size: Number of items or the quantity of material constituting a sample.
ISO11074-2: 4.26 (1998); ISO7002: A.40 (1986).

Sampling: Process of drawing or constituting a sample.
ISO11074-2 (1998); ISO3534-1 (2006).

Sampling bias: The part of the measurement bias attributable to the sampling.
AMC (2005)

Sampling dimension: The dimensions remaining in the target, if increments are taken across the other dimensions.
(Smith, 2001).

Sampling error: The total of all the errors generated when taking, handling and analysing a sample.
(Smith, 2001).

Sampling location: The place where sampling occurs within the sampling target. Perhaps used for location within which duplicate (or replicate) samples are taken at sampling points.

Sampling method: See sampling procedure

Sampling plan: Predetermined procedure for the selection, withdrawal, preservation, transportation and preparation of the portions to be removed from a population as a sample.
IUPAC (1990); ISO11074-2 (1998), adopted by AMC Subcommittee.

Sampling precision: The part of the total measurement precision attributable to the sampling.
Adopted by AMC Subcommittee.

Sampling principle: See Principle of correct sampling.

Sampling procedure: Operational requirements and/or instructions relating to the use of a particular sampling plan; i.e. the planned method of selection, withdrawal and preparation of sample(s) from a target to yield knowledge of the characteristic(s) of the target.
ISO3534-1 (2006); ISO11704-2 (in part), adopted by AMC Subcommittee.

Sampling situation: Defines whether the sampling target is in motion at the time of sampling
Note: Two types of sampling situations are usually distinguished – stationary and dynamic.

Sampling strategy: Strategy includes sampling method/procedure and techniques

Sampling target: Portion of material at a particular time, which the sample is intended to represent.
Note 1. The sampling target should be defined prior to designing the sampling plan.
Note 2. The sampling target may be defined by regulations (e.g. target size).
Note 3. If the properties and characteristics (e.g. chemical composition) of the certain area or period are of interest and must be known then it can be considered a sampling target. AMC (2005).
Adopted by AMC Subcommittee.
Sampling target is comparable to **Lot**: The entirety of the material of interest to be sampled. In process sampling the lot is for instance an elongated stockpile, a material stream (extended in time) production batch units, etc. The name lot is used within the Theory of Sampling.

Sampling techniques: All appropriate procedures and sampling devices used to obtain and describe samples either in the field or during transportation and in the laboratory.
ISO 11074-2

Sub-sample: A sample taken from a sample of a population.
ISO3534-1 (2006).

Note: Two or more sub-samples are combined to form a composite sample

Sub-sampling: Process of selection one or more sub-samples from a sampler of a population.
ISO11074-2 (1998).

ToS Theory of Sampling: Provides a description of all errors involved in sampling of heterogeneous material as well as all necessary tools for their evaluation, elimination and/or minimization.
(Petersen, 2005)

Uncertainty from sampling: The part of the total measurement uncertainty attributable to sampling. IUPAC (2005).

4 SAMPLING PRINCIPLES

The key to optimal sampling is to make sure that every unit in the sampling target has an equal chance of ending up in the sample. This will ensure that a sample can be obtained that is representative of the specific sampling target. Random sampling based on the principle of correct sampling is often difficult when sampling bulk materials, e.g. sampling of stockpiles were it would be very difficult to extract a random sample from the middle of the pile. In order to understand and implement correct sampling one needs to be aware of the different sources of sampling errors and possibilities for reducing and/or eliminating them.

The *Theory of Sampling* was developed by Pierre Gy and defines essential sampling principles:

- The principle of sampling correctness (see Table 4.1),
- The seven sampling errors (see Table 4.2) and
- The concept of the sampling dimensions (see Table 4.3).

The text in this chapter is mainly based on the *Theory of Sampling.*

Table 4.1 Definition of the principle of correct sampling for bulk solids, liquids and gases (after Smith, 2001).

Principle of correct sampling:
• Every part of the sampling target has an equal chance of being in the sample.
• The integrity of the sample is preserved during and after sampling.

The first aspect of correct sampling can be ensured by theoretically defining the sample (sample delimitation) to be taken and physically obtaining the sample (sample extraction) that has been defined correctly. The second part of correct sampling – ensuring the sample integrity – not only means preserving its integrity while it is being taken but also between the time it is taken and the time it is analysed.

The total sampling error stems from 3 overall sources of variation: material heterogeneity, process variations and variation that stems from sampling tools, techniques and sample handling. These sources can then be subdivided into seven sampling errors which are shown in Table 4.2.

Sampling targets can be defined with respect to their dimensions. In *Theory of Sampling* this does not refer to the physical dimensions (height, width, and length) of the sampling target, but corresponds to a theoretical mathematical concept of the target geometry. Table 4.3 offers a description of the sampling dimensions. The dimension of the sampling target depends on how the sample is taken and which dimension it covers fully. The number of dimensions remaining is referred to as the sampling dimension (Smith, 2001). This is the dimension that has to be taken into account when planning the sampling. In order to illustrate the concept of the sampling dimensions Table 4.3 includes some examples.

Table 4.2 Seven sampling errors and sources of variation (based on Smith, 2001).

Sources of variation	Sampling errors
Material heterogeneity	1. The fundamental error (FE) springs from the constitution heterogeneity (CH), which describes the constitution (shape, size etc.) of the material. If CH is large the individual fragments of the material (i.e. soil particles) are very different in composition. For more homogeneous materials, the CH is lower. 2. The grouping and segregation error (GSE) is a result of the physical and spatial distribution of the fragments in a lot – the distribution heterogeneity (DH). Fragment size and density can cause segregation and stratification in a lot and will thus influence DH.
Process variation	3. The long-range non-periodic heterogeneity fluctuation error arises if shifts and trends in the process are not identified. 4. The long-range periodic heterogeneity fluctuation error arises if cycles in the process are not identified.
Variation due to tools, techniques and handling	5. The delimitation error (DE) stems from the deviation between the shape of the actual extracted increment to the defined and delimited increment. 6. The extraction error (EE) occurs when the sample is not or cannot be taken correctly according to the sample delimitation or sampling boundaries. 7. The preparation error (PE) covers errors that are introduced from the point in time where the sample has been extracted and until it is analysed (e.g. from sample handling and preservation).

Table 4.3 Sampling dimensions (based on Petersen et al., 2005, Pitard, 1993 and Smith, 2001).

Sampling dimension	Description	Examples
Zero-dimensional (0-D)	A zero-dimensional sampling target can be described as a set of random and unarranged units (Pitard, 1993). One can refer to 0-D sampling if the entire sampling target is taken as a sample (in this case the total sampling error becomes zero) or if increments are randomly taken.	• Sampling all the bags of flour from the production line. • Sampling one container of paint from a sampling target consisting of 20 containers.
One-dimensional (1-D)	In one-dimensional sampling targets the width and height are small compared to the length. In 1-D sampling the sample fully covers two dimensions (height and width) whilst one dimension remains – the length. 1-D sampling targets can be defined as “strings of fragments” , “process streams” (Petersen et al., 2001) or “continuous and elongated piles, material on conveyor belts [...], as long as these objects are considered as a set of non-random, discontinuous units making up the lot, the order of which is highly relevant” (Pitard, 1993).	Three types of one-dimensional sampling targets can be identified (Pitard, 1993): • Stationary or moving stream of particulates, • Stationary or moving stream of liquids, • Stationary or moving stream of a chronological set of units, i.e. bags
Two-dimensional (2-D)	In two-dimensional sampling the sampling target has the basic layout of a plane but with a defined and relatively small thickness compared to the other two dimensions. The extracted sample covers the entire thickness of the sampling target. Two dimensions remain – the length and width.	• Sampling of soil at defined depth • Sampling the content of a container, truck or barge by extracting a core sample that covers the entire depth
Three-dimensional (3-D)	In three-dimensional sampling a 3-D object is the sampling target. None of the three dimensions can be covered fully, i.e. all three dimensions “remain”.	• Sampling of stockpiles • Sampling of groundwater

Table 4.4 explains the correlation of sampling situation and sampling dimensions. As can be seen, zero-dimensional sampling is only possible from stationary sampling situations. The same applies for two-dimensional and three-dimensional sampling. However, the principles for one-dimensional sampling can be applied to both dynamic situations (e.g. sampling from falling stream) and stationary situations (e.g. sampling from stopped belt).

Table 4.4 Correlation of sampling dimensions and sampling situations (based on Pitard, 1993).

Dynamic sampling situations	Stationary sampling situations
-	Zero-dimensional sampling
Temporal one-dimensional sampling targets can be defined as moving streams of particulate solids, slurries, pulps, liquids etc. It can also be referred to in case or larger units, such a truck loads, containers or batches that can be arranged in a chronological order as a one-dimensional lot.	Spatial one-dimensional sampling targets – elongated piles were width and height are relatively small as compared to the length (e.g. content of a stationary belt, elongated and prehomogenized pile of input material to a process
-	Two-dimensional sampling
-	Three-dimensional sampling

Part of the concept of sampling dimensions is the definition of correct sample delimitation which is depending on the sampling dimension:

- A slice of material in one-dimensional sampling.
- A cylinder of material in two-dimensional sampling.
- A sphere of material in three-dimensional sampling.

This in turn will have an influence on what type of sampling equipment and which sampling procedure can be used to extract the correctly define sample.

4.1 Principles for minimizing sampling errors

An overview of the principles that can be applied to minimize and/or eliminate the sampling errors is given in Table 4.5 and the principles are discussed in more detail in chapter 7 to 10, where specific criteria for the selection of best available operational standards are given. The principles can be translated into more specific criteria, e.g. for sampling from a one-dimensional sampling target the sampling tool shall have parallel sides and take a rectangular sample.

Table 4.5 Principles that can be applied to reduce the different sampling errors (based on Smith, 2001).

Error	Principle for reducing the error
1) Fundamental error and 2) grouping and segregation error	• Increasing the mass of the total physical sample reduces the fundamental error, since a larger number of particles have a chance of ending up in the sample and the sample thus becomes more representative of the entire lot. • Solid granular material can be crushed or ground before sampling. This may however not be applied if it may affect the sample integrity, e.g. when the target parameter is a volatile component. • Mixing of the material or medium before sampling reduces the grouping or segregation error. Special care must be taken for volatile components. • Collecting several increments and combining them into one sample can reduce the grouping and segregation error, e.g. if there is the possibility that the material or medium is not or cannot be mixed well.
3) long-range periodic and 4) non-periodic heterogeneity fluctuation error	• Identification of trends and shift is essential for adjusting the sampling frequency • Time plot, control chart and variogram can be applied to plot measurements and to identify changes and cycles and the effect of sampling frequency.
5) Delimitation, 6) extraction and 7) preparation error	• If possible the sampling dimension should be reduced to be able to sample across one or even two of the dimensions. • Sample delimitation – defining the correct sample and its boundaries – has to ensure that every part of the population has an equal chance of being on the sample. This includes the definition of the right sampling geometry for the defined sampling dimension. • When extracting a sample, particles with their centre of gravity within the defined sample, shall end up in the sample extracted to avoid an extraction error. • The sampling tool has to be capable of extracting the correctly defined sample, e.g. it has to be able to take the entire slice from a conveyor belt without omitting fine particles. • The tool has to be used correctly, as defined by the principles of sampling. • The sample integrity has to be preserved and only representative principles for sub-sampling shall be employed.

5 GUIDANCE FOR THE USE OF THIS STANDARD

The starting point in the identification and selection of best operational standards is the client issue (see Figure 5.1). Based on the client issue the following points can be defined:

- Sampling target
- Parameters to be determined
- Sampling and quality objectives

This information is input that is necessary before proceeding with the use of this standard.

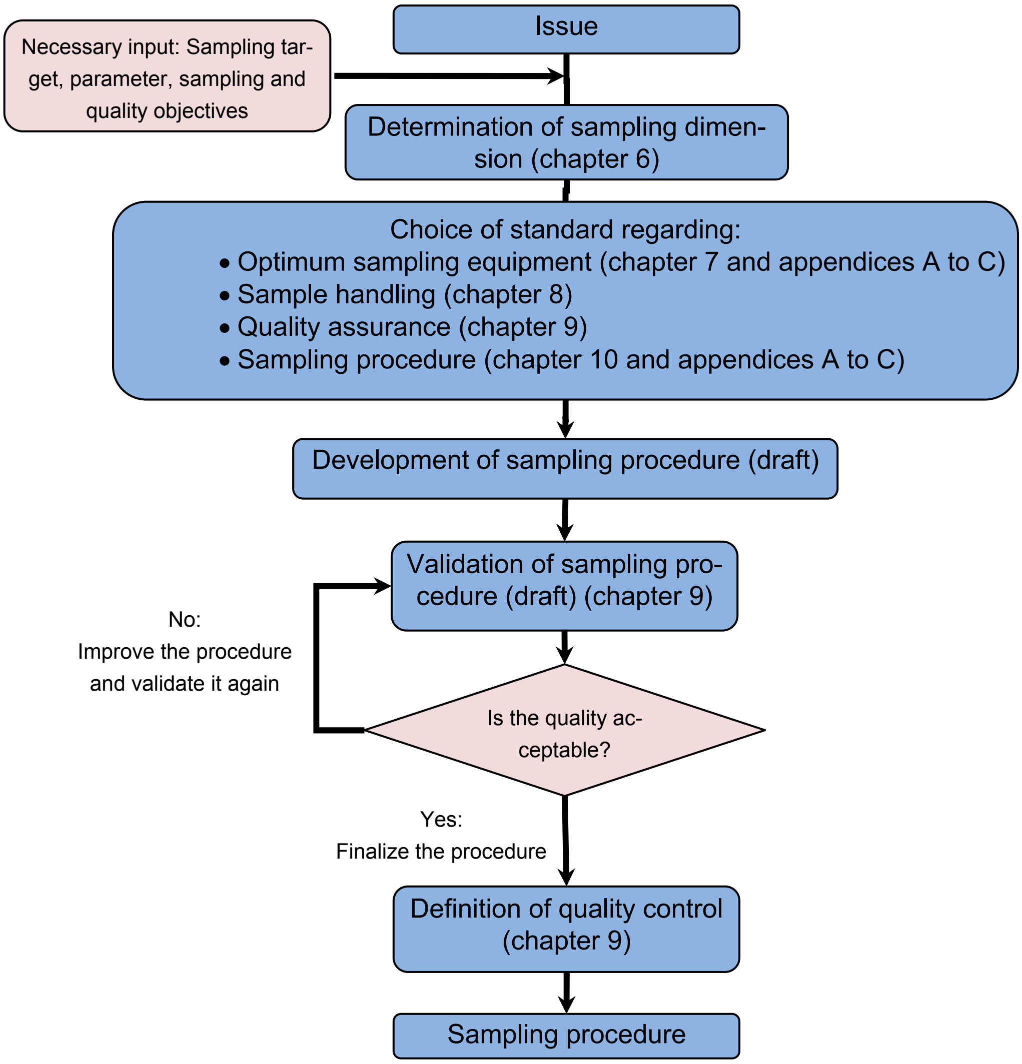

Figure 5.1 Methodology and use of this document. Based on necessary input (sampling target, material etc.) and a specific sampling issue the sampling dimension is defined and subsequently best available operational standards can be identified.

Chapter 6: Based on the description of the sampling target it is known whether sampling is going to be conducted from a stationary or dynamic situation and thus, the sampling dimension can be defined. However, there might be a possibility to reduce the sampling dimension in order to make representative sampling possible and/or easier, maybe even more economical. The reader should refer to chapter 6 to assess this possibility for the specific issue in question.

In chapter 7 to 10 the best available operational standards are identified. The selection of best operational standards can be done based on empirically based criteria and expert knowledge (bottom-up approach, see Appendices A to C), or based on theoretical criteria – here derived from the *Theory of Sampling* (top-down approach). See "A structural approach to horizontal sampling standards" (Pedersen et al. 2008) for more information.

In many instances is it not possible or appropriate to give a specific criterion (e.g. the sampling equipment shall be 10 cm in length) for the selection of standards, since the sampling target, the material to be sampled, or parameters of interest can be very different from case to case. Therefore, the list of criteria comprises a combination of rather specific criteria (were possible) and more qualitative ones (e.g. in terms of a headline, the critical issues to be covered by the standard).

Chapter 7: Based on the information on sampling target and sampling dimension and criteria based on *Theory of Sampling* it is possible to select the optimum sampling equipment.

Chapter 8: The selection of best available operational standards for sample handling focuses on on-site pre-treatment in terms of preservation and transport and storage of samples.

Chapter 9: Procedures for quality assurance are presented and best available operational standards and guidance documents are selected for different aspects of quality assurance, such as validation and quality control.

Chapter 10: Based on qualitative criteria best available operational standards regarding sampling procedures are identified.

Chapter 11: In this chapter an example for the preparation of a "new" operational standard is given. Based on the identified standards or sections of operational standard an operational standard can be developed. An example for this is given in chapter 11. Based on this the draft for a sampling procedure can be developed. The subsequent step is to demonstrate that this procedure is fit for the intended purpose – validation (see chapter 9). If the validation shows that the procedure is not fit for the purpose the procedure has to be adjusted. From the results of the validation relevant quality control of sampling can be specified in the procedure, which is then finalised.

5.1 Selection of best available operational standard

To give a better overview for the reader the tables in the following chapters distinguish between solid and liquid material, followed by the selection of a specific sampling dimension. The decision on material and the sampling dimension (e.g. one-dimensional sampling of liquid material) will therefore be the starting point for selecting the relevant table for identifying optimum sampling equipment, sample handling, quality control and sampling procedure in the subsequent chapters.

In most instances the tables indicate that several standards have been identified as best available operational standard, and they differ for example only in the type of material covered (waste, milk, iron ore). In those cases the reader must decide and select a standard that fits best the specific sampling issue.

6 SAMPLING DIMENSION

In chapter 4 the correlation between sampling situation and sampling dimension was explained. This correlation is here illustrated by Figure 6.1. Neither sampling of liquids from stationary situations nor sampling of gasses is included here.

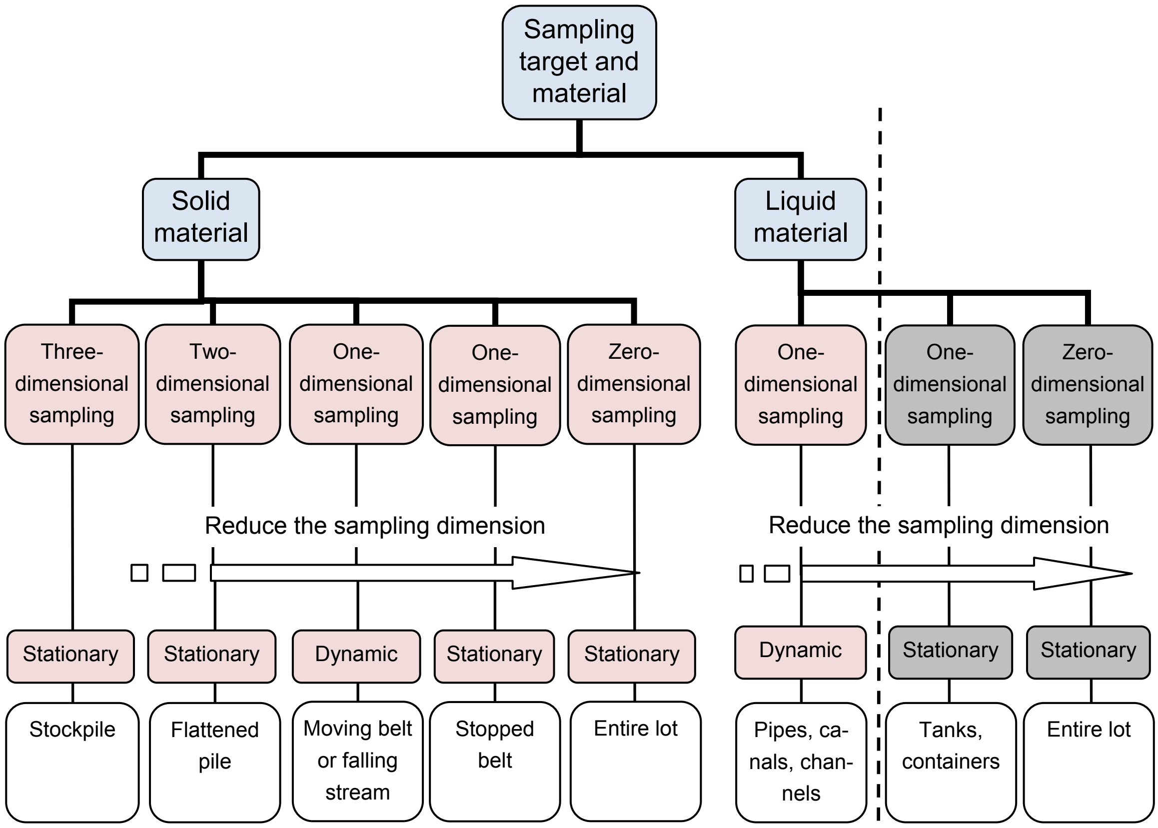

Figure 6.1 Review of the sampling situation and reduction of the sampling dimension. Sampling of liquids from stationary situations is not included in this horizontal standard (illustrated by grey shaded boxes). The white boxes in the lower part of the figure include examples.

As can be seen, the sampling planner should review the sampling dimensions. Taking sampling from a stockpile as an example: The preferred option would be to sample the entire stockpile (0-D sampling). Alternatively it might be possible to sample the material before it ends up in a stockpile or when the stockpile is moved again, e.g. sample when the material is transported on a conveyor belt (1-D sampling). This might be feasible for stockpiles up to a certain size, but will be impossible when sampling soil in-situ at a contaminated site, taking samples from an ore body or extracting groundwater samples.

One-dimensional sampling of liquids from dynamic situations makes up a large part (if not the largest) of the sampling activities for liquid material, and in this case it might not be possible to reduce the sampling situation. Stopping the flow in a channel to sample the entire cross section of a stream would be impossible in practise. Sampling the entire sampling target is probably not feasible either, whereas sampling individual containers of liquid might be possible (e.g. milk in cartons or bottles).

It should be remembered that criteria for the selection of best available operational standard are based on the *Theory of Sampling* and represent a minimum demand for good sampling practise. As illustrated in Figure 6.1, if a sample/increment can be taken from a 0-D or 1-D sampling target this should be the preferred option as compared to sampling from 2-D situations or 3-D sampling targets. Sampling from 2-D and 3-D sampling targets is from the point of view of *Theory of Sampling* problematic or even an unsolvable problem and should therefore be avoided. Due to problems with increment delimitation and extraction in 2-D and 3-D sampling, higher sampling uncertainties might be expected.

The *Theory of Sampling* was developed for solid granular material. Sampling of liquids from dynamic situations is defined as one-dimensional sampling, and the principles that apply for one-dimensional sampling of solids can also be applied in this case. In practise however it is rather difficult to sample the entire cross-section of a stream of liquid material in one operation. For practical reasons perfect homogenization in the sampling point is therefore assumed and thus it is permissible to sample part of the stream.

There are a number of situations where one cannot reduce the sampling dimension. Nonetheless, this does not necessarily mean that this will be regarded as bad sampling. Even though higher sampling uncertainties might be expected e.g. for 2-D and 3-D sampling, this be acceptable, as long as the obtained sampling uncertainty fulfils the defined quality objectives and is fit for the purpose.

Consequently, before proceeding with this document, the sampling dimension should be reviewed and “reduced” if possible. The selection of sampling dimension will subsequently be the starting point for selecting relevant tables with best available operational standards.

7 SAMPLING EQUIPMENT

A large number of sampling equipment exists and whilst some equipment can be used in different sampling situations other types of equipment are exclusively used for specific sampling situations. Therefore it is important to know the advantages and limitations or problems of certain types of equipment with regards to specific situations. The choice of sampling equipment will ultimately depend on the sampling objectives and the sampling target, however, aspects to be considered are:

- Size (diameter, length): The sampling equipment shall be capable of extracting the correctly defined sample, including the largest and/or smallest particles. Furthermore, the size of the tool shall be such that it can hold the well defined increment/sample, without loss or spillage of material.
- Shape/ geometry: The sampling geometry shall fit the sampling dimension. For 3-D, 2-D and 1-D sampling the extracted sample should be an undisturbed volume delimited by a sphere, cylinder or cross section, respectively. This is challenging in 1-D sampling of liquids.
- Material: The equipment material shall not influence the sample integrity, e.g. metal equipment may contribute to the metal content of a sample. Material causing surface tension shall be avoided, since smaller particles may adhere to the tool. The tool shall be robust enough for the sampling.
- Cross-contamination: Corrosion and abrasion can cause contamination of the sample and shall be avoided. Furthermore, equipment shall be cleaned before and after operation and/or in between sampling to avoid cross-contamination.
- Operation: The tool shall not unintentionally alter the sample or change the sample integrity, e.g. crushing particles.

ISO 13909-2:2001 (section 6.7) gives good examples for general requirements that should be taken into account when designing mechanical sampling systems. The following table illustrates some of the problems in 2-D sampling associated with sampling equipment.

Table 7.1 Sampling devices used in 2-D sampling and evaluation of their characteristics regarding correct increment delimitation and extraction (based on Pitard, 1993).

Sampling equipment	Material	Evaluation	
		Delimitation	Extraction
	Solid		
Auger	Sand, packed powders, soil	Poor	Bad
Trier	Sludges, moist powders, granules	Bad	Poor
Thief	Dry powders, granules	Very bad	Very bad
Shovel	Most materials	Very bad	Very bad

Since the choice of equipment depends on the sampling objectives and the sampling target including parameters, criteria for equipment material choice and cross-contamination will not be set up. Validation and quality control will address this issue, e.g. by defining tools that can be employed to evaluate whether the choice of equipment or cross-contamination procedure is fit for the purpose.

In the following tables criteria are listed for the selection of the correct type of equipment for the different sampling situations and subsequently the best operational standards are selected. Annex E offers a selection of operational standards regarding sampling equipment for solid material for 1-dimensional, 2-dimensional and 3-dimensional sampling. The standards are primarily evaluated based on geometry and size.

7.1 Zero-dimensional sampling

Table 7.2 identifies the criteria to be fulfilled for equipment used in zero-dimensional sampling.

Table 7.2 Criteria for the selection of best operational standard for 0-D sampling of solids and liquids.

Material	**Solid and liquid**
Situation	**Stationary systems**
Dimension	**Zero-dimensional**
Criteria	
1. Principle	The entire sampling target is sampled or one/several units are sampled.
2. Geometry, size and operation	The equipment has to be of a shape and size that make it possible to extract the entire sampling target or the unit(s) chosen, e.g. one bag with powder paint, one container with liquid paint. Furthermore, is has to be operated in such a way that the extraction of the sample is possible.

Any equipment that fulfils the above mentioned criteria can be employed for zero-dimensional sampling of solid material. In case of units/ bags (depending on the size and weight of one unit) it might be possible to sample manually; simply pick up one bag or all of the bags without the use of any equipment. In general the same type of equipment that can be used on one-, two- and three-dimensional sampling may fulfil the criteria shown in Table 7.2. Based on the information about the sampling issue and sampling situation, the reader should therefore refer to section 7.2 to 7.4 to identify the best equipment.

7.2 One-dimensional sampling

The next sections show the criteria and selected standards for sampling equipment used in one-dimensional sampling of solid granular material and liquid material, respectively.

7.2.1 Solid material

Table 7.3 and Table 7.5 show the list of criteria that should be covered – at least quantitatively – for the selection of best operational standards regarding sampling equipment for sampling of solid material from one-dimensional systems. The identified operational standards can be found in Table 7.4 and Table 7.6, respectively. In the “criteria” column it can be seen which criteria are covered (fully, partly, or not at all) by the operational standards.

Table 7.3 Criteria for the selection of best operational standard regarding equipment for 1-D sampling of solids from stationary systems (based on Smith, 2001 and Pitard, 1993).

Material	**Solid**
Situation	**Stationary systems**
Dimension	**One-dimensional**
Criteria	
1. Principles	• A rectangular slice of material of constant thickness shall be taken. • The tool shall cross the entire stream in one movement during a small fraction of distance or time, respectively. • All material between the parallel planes of the cutter shall be removed and included in the increment/sample.
2. Geometry	• Cutter removes a square section of material and has parallel sites that are perpendicular to the flat bottom. • Parallel planes fit the curvature of the belt. • Material at the leading edge belongs to the sample, and material at the trailing edge shall be excluded. • In case of 1-D sampling from a stationary of a chronological set of discrete units (e.g. bags, jars etc.) the equipment shall be able to extract one unit (e.g. bag or jar) at a time to be correct.
3. Size	The cutter shall cover the entire width and height of the stream and be able to hold the defined increment. • Critical width (Wo) and width (W) of the cutter opening; (ratio Wo/d varies between 2 to 4, median at 3); d ─ nominal particle size. o d ≥ 3 mm; W ≥ Wo = 3*d. o d < 3 mm; W ≥ Wo = 10 mm. If cutter edges are relatively thick, they shall be perfectly symmetrical (leading and trailing edge shall be perfectly superposable. If edges are at an angle, this should be ≤ 45°. Minimum length (L in m) of the belt along which the sample is collected: L ≥ 0.03 m and L = 0.003 * d_{max} (d_{max} ─ maximum particle size in mm)
4. Operation	• The tool shall cross the entire stream and the sample shall be extracted in one operation/movement

Table 7.4 Selection of best operational standard regarding equipment for 1-D sampling of solids from stationary systems.

Material	**Solid**					
Situation	**Stationary**					
Dimension	**One-dimensional**					
			Criteria *			
Equipment type	**Selection of standard**	**Relevant section in standard**	**1**	**2**	**3**	**4**
Sampling frame	NT ENVIR 004:1996 Solid waste, particulate materials: sampling	Sections 5.8.1.1, 5.8.1.2, 5.9.4.1 and 5.9.4.2	X	X	X	X
Sampling frame	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling	Sections 6.1 and 6.2.7	X	X	X	X

* Criteria: "X" -indicates criterion is covered, "/" -indicates criterion is partly covered, " " ─ indicates criterion is not covered

Table 7.5 Criteria for the selection of best operational standard regarding equipment for 1-D sampling of solids from dynamic systems (based on Smith, 2001 and Pitard, 1993).

Material	**Solid**
Situation	**Dynamic systems**
Dimension	**One-dimensional**
Criteria	
1. Principles	• A rectangular slice of material of constant thickness shall be taken. • The tool shall cross the entire stream in one movement during a small fraction of distance or time, respectively. • All material between the parallel planes of the cutter shall be removed and included in the increment/sample. In case of falling stream cutter angel, size shall ensure that no fragments are lost.
2. Geometry	• Cutter removes a square section of material and has parallel sites that are perpendicular to the flat bottom. • Parallel planes fit the curvature of the belt. • Circular path cutters shall have radial edges. • Material at the leading edge belongs to the sample, and material at the trailing edge shall be excluded. • In case of 1-D sampling from a moving stream of a chronological set of discrete units (e.g. bags, containers etc.) the equipment shall be able to extract one unit (e.g. bag or container) at a time to be correct.
3. Size	The cutter shall cover the entire width and height of the stream and be able to hold the defined increment. • Critical width (Wo) and width (W) of the cutter opening; (ration Wo/d varies between 2 to 4, median at 3). o d ≥ 3 mm; W ≥ Wo = 3*d. o d < 3 mm; W ≥ Wo = 10 mm. Specific for falling stream: • Rule of thumb for length of cutter opening: 3* width of stream. • Cutter depth: 3*d, minimum 100 mm, capacity: 2-3 times largest increment. If cutter edges are relatively thick, they shall be perfectly symmetrical (leading and trailing edge shall be perfectly superposable). If edges are at an angle, this should be ≤ 45°.
4. Operation	• The tool shall cross the entire stream in one movement and at constant speed. o Critical cutter speed (Vo) and cutter speed V for all d, W = n* Wo; n ≥1: V ≤ Vo = (1+n) * 0.3 m/s; Optimum W=Wo; V=Vo= 0.6 m/s. • The stream shall move at a constant speed. • Distance of the cutter to the stream shall be sufficient to reach travel speed. • Stream shall fall in the centre of the cutter. Specific for falling stream: • Distance (u) between liberation point of stream and cutter edge is to be minimized, rule of thumb: u = 3*d + 1 cm, where d is the diameter of the largest fragments.

Table 7.6 Selection of best operational standard regarding equipment for 1-D sampling of solids from dynamic systems.

Material	**Solid**					
Situation	**Dynamic**					
Dimension	**One-dimensional**					
			Criteria*			
Equipment type	**Selection of standard**	**Relevant section in standard**	**1**	**2**	**3**	**4**
Cross-belt sampler for moving conveyor belt	NT ENVIR 004:1996 Solid waste, particulate materials: sampling	Sections 5.8.3.1, 5.8.3.2 and 5.9.4.3	X	X	X	/
Cross-belt sampler for moving conveyor belt	ISO 13909-2:2001 Hard coal and coke – Mechanical sampling – part 2: Coal – sampling from moving streams	Section 6.9	X	X	X	X
Cutter (Cross-cut bucket) for falling stream from the discharge end of moving conveyor belt	NT ENVIR 004:1996 Solid waste, particulate materials: sampling	Sections 5.8.2.2 and 5.9.4.2	X	X	X	/
Cutter (chute) for falling stream from the discharge end of moving conveyor belt	NT ENVIR 004:1996 Solid waste, particulate materials: sampling	Sections 5.8.2.3 and 5.9.4.2	X	X	X	/
Cutter (chute) for falling stream from the discharge end of moving conveyor belt	ISO 13909-2:2001 Hard coal and coke – Mechanical sampling – part 2: Coal – sampling from moving streams	Section 6.8	X	X	X	X
Scoops for falling stream from the discharge end of moving conveyor belt	NT ENVIR 004:1996 Solid waste, particulate materials: sampling	Sections 5.8.2.6, 5.8.2.7 and 5.8.2.8	X	X	X	/
Manual cutters for falling stream from the discharge end of moving conveyor belt	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling	Sections 6.1 and 6.2.6	X	X	X	X

* Criteria: "X" -indicates criterion is covered, "/" -indicates criterion is partly covered, " " – indicates criterion is not covered

7.2.2 Liquid material

Table 7.7 shows the list of criteria that should be covered – at least quantitatively – for the selection of best operational standards regarding sampling equipment for sampling of liquid material from one-dimensional systems. The identified operational standards can be found in Table 7.8. In the "criteria" column it can be seen which criteria are covered (fully, partly, or not at all) by the operational standards.

Table 7.7 Criteria for the selection of best operational standard for 1-D sampling of liquids (based on Pitard, 1993).

Material	**Liquid**
Situation	**Dynamic systems**
Dimension	**One-dimensional**
Criteria	
1. Principle	The entire cross-section of the stream shall be sampled in one operation. Note: For practical reasons perfect homogenization of the liquid at the sampling point is assumed, and consequently it is permissible to sample only part of the stream.
2. Geometry	• Distance of the sampling equipment to the sampling point shall be minimized. • Distance of sampling point from baffles shall be approx. 3 times the width of the channel or diameter of the pipe. • Distance of sampling point from aeration shall be approx. 3-5 m.
3. Size	• Minimal internal diameter for sampling pipes (connecting sample intake point and sample delivery point) is ≥ 9 mm. • Minimum sample size (sub-sample for composite sampling) of 50 ml; preferably 200-300 ml • The delivered sub-sample volume shall be > 5% of the intended volume.
4. Operation	• Contact time between sample and equipment shall be minimized. • Minimum intake liquid velocity ≥ 0.5 m/s. • Flushing of sampling pipes before sampling.

Table 7.8 Selection of best operational standard regarding equipment for 1-D sampling of liquids from dynamic systems.

Material	**Liquid**					
Situation	**Dynamic**					
Dimension	**One-dimensional**					
			Criteria*			
Equipment type	**Selection of standard**	**Relevant section in standard**	**1**	**2**	**3**	**4**
Automatic wastewater sampler	ISO 5667-10:1992 Part 10: Guidance on sampling of waste waters	Sections 5.1.2 Sampling from sewers , channels and manholes and 4.2.2 Automatic sampling equipment	X	/	X	X

* Criteria: "X" -indicates criterion is covered, "/" -indicates criterion is partly covered, " " — indicates criterion is not covered

7.3 Two-dimensional sampling

Table 7.9 shows the list of criteria that should be covered – at least quantitatively – for the selection of best operational standards regarding sampling equipment for sampling of solid material from two-dimensional systems.

Table 7.9 Criteria for the selection of best operational standard for 2-D sampling of solids from stationary situations (based on Pitard, 1993).

Material	**Solid**
Situation	**Stationary systems**
Dimension	**Two-dimensional**
Criteria	
1. Principle	A cylinder of material covering the entire depth of the sampling target shall be extracted. Fragments with their centre of gravity inside the defined increment, belong to the increment and shall be extracted, i.e. material within the core and with its centre of gravity within the core belongs to the sample. Material within the wall boundaries of the tool shall not be part of the recovered sample.
2. Geometry	• A cylinder with top and bottom perpendicular to the mantle and a constant cross section. • Avoid conical top of the sampling equipment. • Ideal tool for delimitation: Two half cylinders that are pushed through the entire depth, then one half slides around to form a complete cylinder. • Should prevent material from being spilled during extraction.
3. Size	• Sufficient in size to hold the increment/sample. • Sufficient in length to cover the entire depth to be sampled. • Diameter large enough with respect to largest particles. • Openings in the equipment shall be large enough to handle the largest particles to be sampled.
4. Operation	• The entire thickness shall be covered and all particles shall be extracted.

7.3.1 Solid material

The identified operational standards can be found in Table 7.10. In the “criteria” column it can be seen which criteria are covered (fully, partly, or not at all) by the operational standards.

Table 7.10 Selection of best operational standard regarding equipment for 2-D sampling of solids from stationary systems.

Material	**Solid**					
Situation	**Stationary**					
Dimension	**Two-dimensional**					
			Criteria*			
Equipment type	**Selection of standard**	**Relevant section in standard**	**1**	**2**	**3**	**4**
Sampling probe	NT ENVIR 004:1996 Solid waste, particulate materials: sampling	Sections 5.8.4.3, 5.8.5.1 and 5.8.6.1	X	/	X	X
Sampling probe	ISO 10381-2: Soil quality- Guidance on sampling techniques	Annex A	/	/	/	/
Sampling probe	ASTM D6232-03: Standard guide for selection of sampling equipment for waste and contaminated media data collection activities	Several specific tables	X	/	X	X
Augers	NT ENVIR 004:1996 Solid waste, particulate materials: sampling	Sections 5.8.4.4 and 5.8.6.1	/	/	/	/
Augers	ISO 10381-2: Soil quality- Guidance on sampling techniques	Annex A	/	/	/	/
Augers	ASTM D6232-03: Standard guide for selection of sampling equipment for waste and contaminated media data collection activities	Several specific tables	/	/	/	/
Scoop	ASTM D6232-03: Standard guide for selection of sampling equipment for waste and contaminated media data collection activities	Several specific tables	/	/	/	/
Scoop	NT ENVIR 004:1996 Solid waste, particulate materials: sampling	Section 5.8.4.4	/	/	/	/
Scoop	ISO 10381-2: Soil quality- Guidance on sampling techniques	Annex A	/		/	

* Criteria: "X" -indicates criterion is covered, "/" -indicates criterion is partly covered, " " – indicates criterion is not covered

7.4 Three-dimensional sampling

Table 7.11 shows the list of criteria that should be covered – at least quantitatively – for the selection of best operational standards regarding sampling equipment for sampling of solid material from three-dimensional systems.

Table 7.11 Criteria for the selection of best operational standard for 3-D sampling of solids from stationary situations (based on Pitard, 1993).

Material	**Solid**
Situation	**Stationary systems**
Dimension	**Three-dimensional**
Criteria	Access to the defined sampling point is often unpractical or economically impossible. Furthermore the sampling equipment often alters the material before reaching the defined sampling point. Three-dimensional sampling is regarded as unsolvable problem under *Theory of Sampling* and should therefore be avoided. The criteria applied for two-dimensional sampling can in part be applied for three-dimensional sampling if it is not possible to reduce the sampling dimension and/or if validation shows that sampling in this way is fit for purpose.
1. Principle	Delimitation and extraction of a sphere.
2. Geometry and size	• Sufficient in size to hold the increment/sample. • Sufficient in length to cover the desired depth to be sampled. • Diameter large enough with respect to largest particles. • Openings in the equipment shall be large enough to handle the largest particles to be sampled. • Should prevent material from being spilled during extraction.

7.4.1 Solid material

The identified operational standards can be found in Table 7.12. In the "criteria" column it can be seen which criteria are covered (fully, partly, or not at all) by the operational standards.

Table 7.12 Selection of best operational standard regarding equipment for 3-D sampling of solids from stationary systems.

Material	**Solid**			
Situation	**Stationary**			
Dimension	**Three-dimensional**			
			Criteria*	
Equipment type	**Selection of standard**	**Relevant section in standard**	**1**	**2**
Sampling probe	NT ENVIR 004:1996 Solid waste, particulate materials: sampling	Sections 5.8.4.3, 5.8.5.1 and 5.8.6.1	/	X
Sampling probe	ISO 10381-2: Soil quality- Guidance on sampling techniques	Annex A	/	/
Sampling probe	ASTM D6232-03: Standard guide for selection of sampling equipment for waste and contaminated media data collection activities	Several specific tables	/	/
Augers	NT ENVIR 004:1996 Solid waste, particulate materials: sampling	Sections 5.8.4.4 and 5.8.6.1		X
Augers	ISO 10381-2: Soil quality- Guidance on sampling techniques	Annex A		/
Augers	ASTM D6232-03: Standard guide for selection of sampling equipment for waste and contaminated media data collection activities	Several specific tables		/
Scoop	ASTM D6232-03: Standard guide for selection of sampling equipment for waste and contaminated media data collection activities	Several specific tables	/	/
Scoop	NT ENVIR 004:1996 Solid waste, particulate materials: sampling	Section 5.8.4.4	/	/
Scoop	ISO 10381-2: Soil quality- Guidance on sampling techniques	Annex A	/	/

* Criteria: “X” -indicates criterion is covered, “/” -indicates criterion is partly covered, “ ” – indicates criterion is not covered

8 SAMPLE HANDLING

To avoid changes in sample integrity during sample handling it is essential to have a basic understanding of the characteristics of the parameter to be analysed. Consequently, the correct equipment and procedures shall be employed as to avoid, e.g. adhesion of material or contaminants to the equipment, sorption of contaminant to the equipment, release of contamination from the equipment, evaporation of the substance of interest, degradation (chemical or biological), other changes in composition (physical, chemical, biological) – thus reducing or eliminating the preparation error.

In this context sample handling covers the following headlines:

- On-site pre-treatment in terms of sample preservation.
- Transport and storage (type of samples containers used, cleaning of sample containers, labelling).

It is the combination of target parameter and analysis/test to be carried out on the sample, which determines correct sample handling. In other words correct sample handling does not depend on the sampling situation but on the target parameters and the sampling objectives. Therefore, the list of criteria for best operational standard for sample handling will cover sample handling of liquid and solid material from all sampling situations. Furthermore, focus will be on the combination of target parameter, type of sample containers (including cleaning), sample preservation, storage and storage duration.

Table 8.1 Criteria for the selection of best operational standard for sample handling – as defined in this context.

Material	**Solid and liquid**
Situation	**Stationary and dynamic systems**
Dimension	**Zero-, one-, two and three-dimensional**
Criteria	In order to be an operational standard, the four mentioned criteria shall be covered, i.e. in form of a table or matrix which makes it possible based on the knowledge of the target parameter to choose the correct sample container, preservation, etc.
1. Parameter or group of parameters	Information about the parameter or a group of parameters (e.g. volatile components) and consequently the correct choice of sample container, preservation and storage conditions for a sample. Information is preferably given in one table
2. Sample container material and cleaning	List of possible sample containers that are suitable for the parameter/parameters in question. Instructions for cleaning of containers
3. Preservation	Suggestion for correct preservation procedures depending on the target parameter(s) and analysis
4. Storage and duration	Description of the storage conditions to be used depending on the target parameter

Table 8.2 Selection of best operational standard regarding sample handling (parameter, preservation, container, cleaning, storage and storage duration).

Material	**Solid**				
Situation	**Stationary and dynamic situations**				
Dimensions	**Zero-dimensional, one-dimensional, two-dimensional, three-dimensional**				
		Criteria*			
Selection of standard	**Relevant section in standard**		**2**	**3**	**4**
ISO 10381-8:2006 Soil quality – sampling – Part 8: Guidance on sampling of stockpiles	Section 9	/	/	X	X
ISO 10381-2:2003 Soil quality – sampling – Part 2: Guidance on sampling techniques	Section 8.2	/	/		/
prCEN/TR XXXX-4:2007 Sludge, treated biowastes, and soils in the landscape - Sampling - Part 4: Guidance on procedures for sample packaging, storage, preservation, transport and delivery (CEN BTTF 151, CSS99059)	Annex A	X	/	X	X
prCEN/TS 15442:2006 Solid recovered fuels – Methods for sampling	Annex I	X	/		X
CEN/TS 15310-4:2006 Characterisation of waste – sampling of waste materials – part 4: Guidance on procedures for sample packaging, storage, preservation, transport and delivery	Section 4, 5, table 1 and Annex A	X	X	X	X
EN ISO 707:1007 Milk and milk products – guidance on sampling	Section 8			X	X

* Criteria: "X" -indicates criterion is covered, "/" -indicates criterion is partly covered, " " — indicates criterion is not covered

Table 8.3 Selection of best operational standard regarding sample handling (parameter, preservation, container, cleaning, storage and storage duration).

Material	**Liquid**				
Situation	**Stationary and dynamic situations**				
Dimensions	**Zero-dimensional, one-dimensional, two-dimensional, three-dimensional**				
		Criteria*			
Selection of standard	**Relevant section in standard**	**1**	**2**	**3**	**4**
ISO 5667-3:2003 Water quality – sampling – Part 3: Guidance on the preservation and handling of samples	Section 3, tables 1, 2, 3 and 4	X	X	X	X
EN ISO 707:1007 Milk and milk products – guidance on sampling	Section 8			X	X
CEN/TS 15310-4:2006 Characterisation of waste – sampling of waste materials – part 4: Guidance on procedures for sample packaging, storage, preservation, transport and delivery	Sections 4 and 5, table 1 and Annex A	X	X	X	X

* Criteria: "X" -indicates criterion is covered, "/" -indicates criterion is partly covered, " " — indicates criterion is not covered

9 QUALITY ASSURANCE OF THE SAMPLING PROCESS

Quality assurance of the sampling process consists of several issues, starting with the sampling quality requirements, competence requirements for personnel/organisations, validation, quality control and finally documentation of the sampling process.

It is not possible to define quantitative criteria, as might be done for selection of sampling equipment. Furthermore, criteria are based on ISO/IEC 17025. Table 9.1 shows the different criteria that should be fulfilled and the selected standards and guidance documents can be found in Table 9.2 to Table 9.4.

Table 9.1 Criteria for the selection of best operational standard for quality assurance.

Material	**Solid and liquid**
Situation	**Stationary and dynamic systems**
Dimension	**Zero-, one-, two and three-dimensional**
Criteria	Criteria for selection of sampling standard on quality assurance are given in ISO/IEC 17025. Sampling is an integral part of measurement and the most of the requirements on quality assurance according to ISO/IEC 17025 also apply to sampling. The paragraphs that apply to quality of sampling for a predefined or selected sampling procedure are given below.
1. Competence requirements	Competence requirements – ISO/IEC 17025 5.2 *The management shall authorize specific personnel to perform particular types of sampling.*
2. Validation	Validation – ISO/IEC 17025 5.4.5 *NOTE 1 Validation may include procedures for sampling, handling and transportation.* Equipment – ISO/IEC 17025 5.5 *Before being placed into service, equipment (including that used for sampling) shall be calibrated or checked to establish that it meets the laboratory's specification requirements and complies with the relevant standard specifications.*
3. Uncertainty	Uncertainty – ISO/IEC 17025 5.4.6 – Sampling is part of the measurement uncertainty treated in this section.
4. Sampling	Sampling – ISO/IEC 17025 *5.7 Sampling* states *The laboratory shall have a sampling plan and procedures for sampling when it carries out sampling of substances, materials or products for subsequent testing or calibration.*
5. Quality Control	Quality Control – ISO/IEC 17025 5.9 *The laboratory shall have quality control procedures for monitoring the validity of tests…*

9.1 Sampling quality and competence requirements

The formulation of the quality criteria is strongly related to the measurement objectives which in turn make it possible to define the requirements for sampling. In order to ensure quality in sampling and that sampling is conducted by competent personnel there might be additional requirements with regard to the competence of sampling personnel or organisations.

Competence requirements can apply to either organisations – accreditation or to personnel – certification. Selected standards and guidance documents on competence requirements are listed in Table 9.2.

Table 9.2 Selection of standard and guidance documents regarding competence requirements.

Material	**Solid and Liquid**	
Situation	**Stationary and dynamic situations**	
Dimensions	**Zero-dimensional, one-dimensional, two-dimensional, three-dimensional**	
Standard/ document	**Name**	**Remarks**
EPA 540/R-95	Representative sampling guidance Volume 1: Soil Volume 4: Waste	Also general on quality assurance in sampling
NT ENVIR 008	Nordtest Sampler Certification Scheme NT ENVIR 008 http://www.nordicinnovation.net/nordtestfiler/envir008.pdf	according to ISO 17024: 2003 Conformity assessment - General requirements for bodies operating certification of persons
NT POS 012	Chemical and Environmental Sampling – Quality through Accreditation, Certification and Industrial Standards NT POS 012 from Nordicinnovation.net http://www.nordicinnovation.net/_img/pos_12.pdf	General position paper about competence requirements

9.2 Validation and estimation of measurement uncertainty

The validation shall confirm that the requirements can actually be fulfilled, e.g. validation of a sampling procedure to estimate the contribution of the sampling process to the total measurement uncertainty and to ensure that it is fit for the intended purpose. A major part of sampling validation is estimation of sampling uncertainty (sampling precision and trueness). A validation scheme should also cover the vital sampling errors that can be found. Detailed parts of sampling validation e.g. control of heterogeneity, contamination, transport and stability of analytes are also performed in quality control.

In effect, validation demonstrates what can be achieved and, if that conforms to the quality requirements, the procedures are deemed suitable for routine use. Selected standards and guidance documents dealing with validation can be found in Table 9.3.

A major part of validation is estimating uncertainty. The *uncertainty of sampling* shall be combined with the *uncertainty of analysis* to obtain the *measurement uncertainty*. The approach to estimate uncertainty for a given sampling protocol can be regarded as very general and in most cases this general approach can be used for any sampling target independent of the material (gaseous, liquid or solid) or on sampling equipment. A list of selected standards and guidance documents that address uncertainty of sampling in a general way as well as documents for estimating precision and bias can be found in Table 9.3.

The general approach to bias estimation is either by replication of the sampling protocol with a reference sampling protocol on several sampling targets or sampling where a nominal value for the sampling target is available. The obtained bias is then tested for significance. If a maximum allowed bias, δ is defined, the observed bias is compared with the maximum allowed bias.

Table 9.3 Selection of standard and guidance documents regarding validation and measurement uncertainty.

Material	**Solid and Liquid**	
Situation	**Stationary and dynamic situations**	
Dimensions	**Zero-dimensional, one-dimensional, two-dimensional, three-dimensional**	
Standard/ Document	**Name**	**Remarks**
Eurachem	Measurement uncertainty arising from sampling: a guide to methods and approaches Eurachem (2007).	
NT TR 604	Uncertainty from sampling – A Nordtest handbook for sampling planners on sampling quality assurance and uncertainty estimation NT TR 604	Nordtest: The Nordtest guide was developed together with the Eurachem guide
ISO648-1 (2003)	Statistical aspects of sampling from bulk materials – Part 1 General principles,	Several detailed examples of calculations in Annex D
ISO 13909 (2002)	Hard coal and coke ─ Mechanical sampling – Part 7: Methods for determining the precision of sampling, sample preparation and testing	Estimate of precision (random part of the uncertainty) with a replicate design with three split levels. For estimating the number of primary increments also variogram is used
	Hard coal and coke ─ Mechanical sampling ─ Part 8: Methods of testing for bias,	
ISO 3085 (2002)	Iron ores -- Experimental methods for checking the precision of sampling, sample preparation and measurement, ISO 3085 (2002)	Estimate of precision (random part of the uncertainty) with a replicate design
ISO 3085 (2003)	Iron ore – Experimental methods for checking the bias of sampling, ISO 3086 (2006)	Estimate of measurement bias using a replicate design by comparison with reference sampling. Annex B contains five numerical examples
ISO 13530	Water quality — Guide to analytical quality control for water analysis, ISO13530	Annex D Gives examples on how to estimate measurement uncertainty for ammonium in water according to a Nordtest document TR 537

9.3 Quality Control

The purpose of quality control is to assess whether the quality requirements have been met and quality control in sampling ensures that the sampling procedure used today for the current sampling target is still as fit for purpose as it was at the time of validation. The control shall address the process of taking samples – from the sampling target to the laboratory door and includes variation in heterogeneity, performance of sampling equipment, contamination/losses during transport and storage.

Quality control in sampling is in general focused on the repeatability or precision. However the trueness can also be estimated.

General guidance on quality control in sampling is given in the Eurachem International Guide: Estimation of measurement uncertainty arising from sampling (2007) and Nordtest handbook Uncertainty in sampling (2007). The general ISO standard for control charts is ISO 7870 (see Table 9.4).

Table 9.4 Selection of standard and guidance documents regarding quality control in general and specific for sampling.

Material	**Solid and Liquid**	
Situation	**Stationary and dynamic situations**	
Dimensions	**Zero-, one-, two-, three-dimensional**	
Standard/Document	**Name**	**Remarks**
Eurachem (2007)	Measurement uncertainty arising from sampling: a guide to methods and approaches Eurachem	
NT TR 604	Uncertainty from sampling – A Nordtest handbook for sampling planners on sampling quality assurance and uncertainty estimation NT TR 604	The Nordtest guide was developed together with the Eurachem guide
ISO 7870	Control Charts – General guide and introduction	General document with an introduction on statistical process control (SPC)
ISO 7873	Control charts for arithmetic average with warning limits	General document on statistical process control (SPC) with both warning and action limits.
Nordtest report 569	Internal Quality Control- Handbook for Chemical Laboratories,. http://www.nordicinnovation.net/nordtestfiler/tec569.pdf	General guidelines for X and R charts
EPA 540/R-95	Representative sampling guidance Volume 1: soil Volume 4: waste	Also general on quality assurance in sampling
ISO 5667-14	Water quality – Sampling Part 14: Guidance on quality assurance of environmental water sampling and handling (1991)	Both standards discuss • Field blanks • Field controls • Duplicate samples The standards may also be applicable to sediment
ISO 13530	Water quality — Guide to analytical quality control for water analysis, ISO/CD 13530 (2005)	

10 SAMPLING PROCEDURE

A sampling procedure is a written document that contains the operational requirements and/or instructions that relate to a particular sampling plan and define i.e. the planned method of sample selection, withdrawal and preparation of sample(s) from a lot to yield knowledge of the parameters to be determined of the lot.

Each sampling procedure is elaborated for a specific sampling situation and describes the steps in the sampling process to be followed. If a generic sampling method (e.g. a standard) is available, it can be the basis for developing a sampling procedure. A good sampling procedure is sufficiently detailed to ensure that different samplers can repeat the sampling process in the same way and this includes instructions on:

- Sampling steps, such as how to select the samples from a lot, how to withdraw them and the number of samples and sample size to be taken.
- Type of equipment to be used and instructions for operation.
- Sub-sampling, pre-treatment.
- Preservation and storage of samples.
- How to control and reduce sampling errors and instructions on quality control.

On the one hand a sampling procedure may be rather generic and can thus be used for many different sampling targets, and on the other hand one procedure may be used repeatedly for one specific sampling target. In the latter case – and if local conditions, such as material heterogeneity have been investigated – it is possible to standardise a sampling procedure.

Representative sampling means probabilistic sampling, i.e. the random selection of samples. A good sampling procedure should therefore emphasise that sampling is conducted as probabilistic sampling instead of sampling from predefined sampling points, such as “always sample from the centre of the barrel”. Consequently, judgemental sampling – where the sampling point is chosen based on expert knowledge – is not included here, when criteria for “sampling steps” are defined. However, the remaining criteria, for instance regarding equipment, will be equally relevant in case of judgemental sampling.

The procedures for sub-sampling as well as the equipment used shall follow the principles of *Theory of Sampling* to ensure representativeness. In general, the criteria that apply for sampling equipment are also relevant for sub-sampling equipment. Refer therefore to chapter 7 for a list of criteria for sampling equipment.

Table 10.1 shows the list of criteria that shall be covered – at least quantitatively – for the selection of best operational sampling procedure. The list covers both sampling of solid and liquid material and sampling from stationary and dynamic situations. The identified operational standards can be found in Table 10.2 to Table 10.4.

Table 10.1 Criteria for the selection of best operational sampling procedure.

Material	**Solid and liquid**
Situation	**Stationary and dynamic systems**
Dimension	**Zero-dimensional, one-dimensional, two-dimensional, three-dimensional**
Criteria	
1. General	• It is a practical and step-by-step description. • It emphasises the reduction of sampling dimensions in particular and the random selection of a sampling point. Note: Judgemental sampling ─ where the sampling point is defined based on expert knowledge ─ is therefore not included
2. Validation and quality control	• It addresses validation and quality control, e.g. calculation of uncertainty, control and reduction of sampling errors.
3. Sampling steps	• Samples/ increments shall be selected at random, or in case of systematic sampling with a random starting point. • It addresses the number of samples to be taken and the samples size, e.g. a rule of thumb or how to calculate the number of samples to be withdrawn.
4. Equipment	• The correct equipment for the sampling situation in questions is suggested. • It describes how the equipment is used correctly. • It addresses that the choice of equipment material can have an effect on the parameter(s) of interest. • It addresses cleaning of equipment in between sampling to avoid cross-contamination.
5. Sub-sampling	• It describes correct sub-sampling method and equipment.
6. Pre-treatment	• It describes how pre-treatment is to be done, e.g. which pre-treatment method is to be applied for which parameter.
7. Preservation, storage, trans-port	• It addresses which type of sampling container to choose and how to store and transport the sample.

10.1 Solid material

Table 10.2 shows the standards that fulfil the criteria for sampling procedures regarding sampling of solid material from stationary situations. In the "criteria" column it can be seen which criteria are covered (fully, partly, or not at all) by the operational standard.

Table 10.2 Selection of best available operational standard regarding sampling procedure for sampling of solid material from stationary sampling situations.

Material	Solid							
Situation	Stationary							
		Criteria*						
	Selection of standard	1	2	3	4	5	6	7
Dimension	Three-dimensional							
	SOP 2016 (11/17/94) Sediment sampling	/	/	/	/	/	/	/
	SOP 2017 (11/17/94) Waste pile sampling	/	/	X	X	/	/	/
	SOP 2012 (02/18/00) Soil sampling	/	/	/	X	/	/	/
	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling	/	/	X	X	/	X	X
	DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling	/	/	/	/	/		
	ISO 1988:1975 Hard coal – sampling	/	/	X	X	X	X	/
Dimension	Two-dimensional							
	SOP 2012 (02/18/00) Soil sampling	/	/	/	X	/	/	/
	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling	/	/	X	X	/	X	X
	ISO 13909-3:2001 Hard coal and coke – Mechanical sampling – part 3: Coal – sampling from stationary lots	/	/	X	/			/
	ISO 8213:1986 Chemical products for industrial use – sampling techniques – solid chemical products in the form of particles varying from powders to coarse lumps	/		/	/	/		/
	ISO 3082:2000 Iron ores – Sampling and sample preparation procedures	X	/	X	X	/		/
	prEN/ISO 13690:2006 Cereals, pulses and milled products – sampling of static batches	/		/	/	/		/
	ISO 1988:1975 Hard coal – sampling	/	/	X	X	X	X	/
Dimension	One-dimensional							
	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling	/	/	X	X	/	X	X
	ISO 8213:1986 Chemical products for industrial use – sampling techniques – solid chemical products in the form of particles varying from powders to coarse lumps	/		/	/	/		/
	ISO 3082:2000 Iron ores – Sampling and sample preparation procedures	X	/	X	X	/		/
	DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling	/	/	/	/	/		
	DS/EN 1482:1996 (plus corrigendum DS/EN 1482/AC) Sampling of solid fertilizers and liming materials	/	/	/	/	/	/	/
	D2234/D2234M-03 Standard practice for collection of a gross sample of coal	/	/	/	/			
	ISO 1988:1975 Hard coal – sampling	/	/	X	X	X	X	/
Dimension	Zero-dimensional							
	ISO 8213:1986 Chemical products for industrial use – sampling techniques	/		/	/	/		/

	– solid chemical products in the form of particles varying from powders to coarse lumps							
	prEN/ISO 13690:2006 Cereals, pulses and milled products – sampling of static batches	/		/	/	/		/
	DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling	/	/	/	/	/		

* Criteria: “X” -indicates criterion is covered, “/” -indicates criterion is partly covered, “ ” – indicates criterion is not covered

Table 10.3 shows the standards that fulfil the criteria for sampling procedures regarding sampling of solid material from dynamic situations (one-dimensional sampling). In the "criteria" column it can be seen which criteria are covered (fully, partly, or not at all) by the operational standard.

Table 10.3 Selection of best available operational standard regarding sampling procedure for sampling of solid material from dynamic situations.

Material	**Solid**							
Situation	**Dynamic**							
Dimension	**One-dimensional**							
		Criteria*						
	Selection of standard	**1**	**2**	**3**	**4**	**5**	**6**	**7**
(slurries)	ISO/FDIS 20904:2006	/	/	/	/	/		
	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling	/	/	X	X	/	X	X
	ISO 9411-1:1994	/	X	X	X	/		/
	ISO 8213:1986 Chemical products for industrial use – sampling techniques – solid chemical products in the form of particles varying from powders to coarse lumps	/		/	/	/		/
	ISO 3082:2000 Iron ores – Sampling and sample preparation procedures	X	/	X	X	/		/
	DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling	/	/	/	/	/		
	DS/EN 1482:1996 (plus corrigendum DS/EN 1482/AC) Sampling of solid fertilizers and liming materials	/	/	/	/	/	/	/
	D2234/D2234M-03 Standard practice for collection of a gross sample of coal	/	/	/	/			
	ISO 1988:1975 Hard coal – sampling	/	/	X	X	X	X	/

* Criteria: "X" -indicates criterion is covered, "/" -indicates criterion is partly covered, " " — indicates criterion is not covered

10.2 Liquid material

Table 10.4 shows the standards that fulfil the criteria for sampling procedures regarding sampling of liquid material from dynamic situations (one-dimensional sampling). In the “criteria” column it can be seen which criteria are covered (fully, partly, or not at all) by the operational standard.

Table 10.4 Selection of best available operational standard regarding sampling procedure for sampling of liquid material from dynamic situations.

Material	**Liquid**							
Situation	**Dynamic**							
Dimension	**One-dimensional**							
		Criteria*						
	Selection of standard	**1**	**2**	**3**	**4**	**5**	**6**	**7**
	ISO 3171:1988 Petroleum liquids – Automatic pipe-line sampling	X				X		
	ISO 5667-3:2003 Part 3:Guidance on the preserva-tion and handling of water samples, Table 1						X	X
	ISO 5667-10:1992 Part 10: Guidance on sampling of waste waters	X	/	X	X			/
	ISO 5667-14: 1998 Guidance on quality assurance of environmental water sampling, Section 5		/					/

* Criteria: “X” -indicates criterion is covered, “/” -indicates criterion is partly covered, “ ” — indicates criterion is not covered

11 PREPARATION OF AN OPERATIONAL STANDARD

In the previous chapters best operational standards have been identified for sampling equipment, sample handling, quality assurance/quality control and sampling procedures. In order to facilitate the understanding of how to continue from here with the preparation of a "new" operational standard and subsequently the development of a sampling procedure an example will be given for one sampling situation – sampling of liquid material from dynamic situations (see Table 11.1).

Table 11.1 Arrangements that should to be comprised in an operational sampling standard and selected best available operational standards for sampling of liquid material from dynamic situations.

Type of element	Arrangement of elements in document	Selected best available operational standard or sections hereof
Informative preliminary	Title page	**Title:** Sampling of liquid material from dynamic situations (1-dimensional sampling)
	Table of content, foreword and introduction	*Input to "informative preliminary" shall be defined by the user.*
Normative general	Scope, objectives and normative references	*Input to "Normative general" can be adopted from this draft horizontal standard and has to be completed by the user.*
Normative technical	Terms and definitions	*Input to "Normative technical" can be adopted from this draft horizontal standard and has to be completed by the user.*
Sampling	Procedure (general, sampling steps, validation and quality control	**General:** ISO 3171:1988 or ISO 5667-10:1992 Part 10 **Sampling steps:** ISO 5667-10:1992 Part 10 **Validation and quality control:** ISO 5667-10:1992 Part 10 or ISO 5667-14: 1998 address to some extend validation and quality control procedures. Therefore more input is necessary to complete this section. General guidance on the estimation of measurement uncertainty can be found in Eurachem (2007) and NT TR 604. ISO 13530, annex D offers also guidance on the estimation of measurement uncertainty. Information on the development and use of control charts can be found in ISO 7870 and ISO 7873, respectively. Guidance on quality requirements in sampling can be found in NT ENVIR 008 and NT POS 012, respectively.
	Equipment	ISO 5667-10:1992 Part 10
	Sampling handling (sub-sampling, pre-treatment, preservation, transport and storage)	**Sub-sampling:** ISO 3171:1988 **Pre-treatment:** ISO 5667-3:2003 Part 3 **Preservation, transport and storage:** ISO 5667-3:2003 Part 3
Informative supplementary	Bibliography	*Input to "bibliography" shall be defined by the user.*
	Informative annexes	*Input to "informative annexes" shall be defined by the user.*

Input to Table 11.1 is derived from the following tables:

- Table 7.8 Selection of best operational standard regarding equipment for 1-D sampling of liquids from dynamic systems.
- Table 8.3 Selection of best operational standard regarding sample handling (parameter, preservation, container, cleaning, storage and storage duration).
- Table 9.2 Selection of standard and guidance documents regarding competence requirements.
- Table 9.3 Selection of standard and guidance documents regarding validation and measurement uncertainty.
- Table 9.4 Selection of standard and guidance documents regarding quality control in general and specific for sampling.
- Table 10.4 Selection of best available operational standard regarding sampling procedure for sampling of liquid material from dynamic situations.

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APPENDICES

APPENDIX A

Sampling granular solid material in dynamic setting

Nordic horizontal standards for sampling

Selection of appropriate operational sampling standards

Task 3 A - Sampling granular solid material in dynamic setting (moving conveyer belt) DRAFT

WATER • ENVIRONMENT • HEALTH

Nordic Innovation centre

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Nordic horizontal standards for sampling

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CONTENTS

1 INTRODUCTION AND SCOPE

This document identifies operational sampling standard and describes sampling techniques for granular solid waste from a moving conveyer belt. The standards available for sampling of granular solid waste from a moving conveyer belt are summarized and evaluated with respect to sampling equipment and sampling methods. Finally, the decision rules for selecting appropriate standards for the sampling targets have been described.

The document focuses on probabilistic sampling i.e. each element within the population to be assessed has an equal chance of being selected by the sampling process, and random sampling i.e. sub-samples are taken independently and randomly from each other from the waste material under investigation following a detailed sampling plan.

In this context, the scope will be solid granular waste, such as ashes, slags and like waste materials with maximum particle size about 80 mm from a moving conveyer belt.

2 SAMPLING TARGET

2.1 Definition of sampling target

The basic unit for sampling is a lot, which is a discrete amount of waste for which certain properties should be determined. A lot may be a single sampling unit or series of sampling units, e.g.:

- waste despatched or delivered over period of time
- waste produced in a certain period e.g. shift, day, month etc.

A lot of a certain waste may contain several consignments and for sampling purposes it is often divided into sampling units each of which being treated as one separate unit.

3 REVIEWED STANDARDS/DOCUMENTS

The following standards/documents have been reviewed:

- CEN/TS 14778-2: 2005: Solid biofuels - Sampling - Part 2: Methods for sampling particulate material transported in lorries
- D6009-96 (reapproved 2006): Standard guide for sampling waste piles
- D6232-03: Standard guide for selection of sampling equipment for waste and contaminated media data collection activities
- EN 932-1:Tests for general properties of aggregates –Part 1: Methods for sampling

- EN 14899: Characterization of waste – Sampling of waste materials – Framework for prepara-tion of a sampling plan preparation
- US-EPA (2002a). RCA Waste Sampling Draft Technical Guidance – Planning, Implementation and Assessment. EPA530-D-02-002, (aug-2002), www.epa.gov
- ISO 3082: Iron ore – Sampling and sample preparation procedures
- ISO 13909:Hard coal and coke – Mechanical sampling, Part 1-8
- ISO 10381-2: Soil quality- Guidance on sampling techniques
- ISO 10381-8: Soil quality- Guidance on sampling of stockpiles
- ISO 3713 (1987) Ferroalloys - Sampling and preparation of samples - General rules
- ISO 18283 Hard coal and coke – Manual sampling
- Nordtest ENVIR 004: Solid waste, Particulate materials: Sampling
- prCEN/TR 15310, 1-5: Sampling of waste materials
- prCEN/TS 15442 (WI 343006) Solid recovered fuels - Methods for sampling
- prCEN/TS 15442:2006: Solid recovered fuels - Methods for sampling
- SOP 2012 (02/18/00): Soil sampling

4 SAMPLING METHOD/TECHNIQUES

The choice of sampling method (e.g. manual/mechanical sampling) depends on the objective of the study and also on the material characteristics (e.g. material flow). Also safety aspects are of major importance.

Solid material sampling can be carried out either randomly or systematically. In random sampling, sub-samples are taken independently and randomly from each other from the waste material under investigation. Therefore all particles of the material have the same theoretical chance of being sampled. In systematic sampling the sample consists of individual samples taken from the waste material regularly at definite temporal or spatial intervals. In systematic sampling the first lot or unit is however always selected at random. The drawback of this method is the poor precision obtained when there are unknown trends or non systematic variations in material or in its properties under interest. In practise the systematic sampling is despite of some sources of error often more recommended due to its easier controllability.

The volume of the sampler shall be such that it is not completely filled by the required sample size. The representativeness of sampling methods in the order of preference is as follows:

- manually from a stopped conveyer belt, falling stream at the discharge end of the conveyer belt or from a moving conveyer belt
- mechanically from falling stream at the discharge end of the conveyer belt or from a moving conveyer belt

4.1 Falling stream at the discharge end of the conveyer belt

In this technique, solid material is let to fall, for example from the discharge of a moving conveyor belt straight to an appropriate sampling equipment or container. The sampling action should always collect a complete cross-section of the waste stream.

Samples can be collected by means of mechanical samplers e.g. cutter, moving shutter, swinging arm, chute and manual samplers e.g. sampling scoop.

4.1.1 Manual sampling

Three cases can be distinguished as shown in Table 1. The choice of sampling procedure depends on the width and depth of the stream, with which the cross-section of the falling stream can be accessed.

Table 1 Procedures for sampling from falling streams. – Manual sampling.

	Situation	***Procedure***
Case 1:	When the width and the depth of the stream is small	• Put a scoop into the stream, at 90 degrees to the falling stream, using a single one directional action. • Hold the scoop in place for the period specified in the sampling plan. • Remove the scoop in the direction of entry. • Transfer the sample into a sample container.
Case 2:	When the width of the stream is large and the depth is small	• Insert a container at one end of the stream and, at a uniform rate designed to collect the required amount of material, move the container through the width of the stream to the opposite end.
Case 3:	When the width of the stream is large and the depth is large	• Take a first sample following the procedure in case 1. • Repeat the procedure, taking a second sample at 90 degrees to the first direction of sampling. • Transfer both samples to the sample container.

4.1.2 Mechanical sampling

There are several types of mechanical sampling systems. The principle is that a collection tray is moved through the entire flow at constant speed enabling a sufficiently large increment to be taken. All locations from the cross-section of the falling stream shall be sampled. The most convenient way of doing this is for the collection tray to be moved through the falling stream at right angel to the direction of the transport system.

4.2 Moving conveyer belt

Samples can be collected by means of cross-belt sampler. The operation of cross-belt samplers is based on the pivoting movement of sampling cutter on an axis parallel to the centre-line of the belt. As the cutter traverses the full width of the belt in a rotary motion, the leading edges of the side plates cut out the increment and the back plate pushes it off. For normal-sweep type cutters the bearings, in which the cutter shaft is lifted, are fixed in space. In the case of angled-sweep samplers they are mounted on a trolley or sledge, which during the sampling operation is moved in a direction parallel to the belt and at a velocity equal to the belt velocity.

Theoretically, representative samples can be taken if the sampling equipment could be inserted at right angles to the waste stream and moved along the belt at the speed of the belt. This enables an instantaneous cross-section of material stream to be obtained while the equipment itself does not disrupt the flow. This is however usually possible only in a few cases and it requires a special installation. Therefore in situations where the conveyor belt is moving, sampling from the falling stream at the discharge end of the conveyor belt is preferred:

- the sampling equipment shall sample all material that is directly in front of the sampler at the sampling time.
- the particles on the edge of the cutting face shall have equal chance of being included or not included in sample
- the cutting action shall be executed at a constant speed

4.3 Decision rules – sampling methods

Sampling of solid granular waste, such as ashes slags and like waste materials with maximum particle size about 80 mm, from moving conveyer belt or from the falling stream at the discharge end of the conveyer belt is preferred.

In waste sampling the focus is not on the definition of market value of the material. Therefore the usability of standard in practical work is prioritized. Also reasonable sampling costs and EHQS-issues are seen to be important in this case.

5 SAMPLING EQUIPMENT

Basic requirements for sampling equipment are:

- sampling equipment shall be capable of achieving the quality required and shall comply with the specifications as given in the written sampling procedure
- sampling equipment should be appropriate to the type of material being sampled, the sampling location and the size of sample to be collected

- the volume of the sampler shall be such that it is not completely filled by the required sample size
- up-to date instructions for the use and maintenance of the sampling equipment (including any relevant manual provided by the manufacturer of the equipment) shall be readily available for use by the sampler (Typical equipment, control of equipment, maintenance and decontamination, calibration, limitations)

5.1 Falling-stream-type samplers

The operation of falling-stream-type samplers is based on the cutter which is moving through a falling stream of waste at a uniform velocity. The cutter takes a complete cross-section of the stream. The cutter edges (leading and trailing) describe the either the same plane or the same cylindrical surface depending of the type of sampler.

The opening (aperture) of the sampling equipment should be significantly, at least three times, larger, than the nominal top size of the waste material being sampled to ensure a representative sample is taken. The sampling action should always collect a complete cross-section of the waste stream; both the leading and trailing edges should clear the stream in the same path. The depth of the sampling equipment is adequate when the falling material does not rebound from the equipment and the equipment is only half-filled. The dusting of the fine material should also be prevented.

5.2 Cross-belt samplers

The operation of cross-belt samplers is based on the rotating movement of sampling cutter on an axis parallel to the centre-line of the belt. As the cutter traverses the full width of the belt in a rotary motion, the leading edges of the side plates cut out the increment and the back plate pushes it off. For normal-sweep type cutters the bearings, in which the cutter shaft is lifted, are fixed in space. In the case of angled-sweep samplers they are mounted on a trolley or sledge, which during the sampling operation is moved in a direction parallel to the belt and at a velocity equal to the belt velocity.

It is important that sample cutters take a complete cross-section of the material stream. Sample cutters taking only part of the stream are incorrect in design, and cannot be relied upon to provide representative samples, i.e., they may introduce significant uncertainty.

5.3 Scoops

Laboratory scoop can be used for sampling of dry granular or powdered materials in bins, other shallow containers and on conveyor belts. A polypropylene scoop is preferable because it is resistant to corrosion and chemical reactions. It is also disposable.

6 SUMMARIZATION OF DECISION RULES

In the following table, categories and rules for choosing the proper method and equipment are listed and the best available standard or section in the standard identified. It may be used as an aid to plan and decide on the best actions when performing adequate sampling of solid granular material from moving belt.

Summarization of decision rules concerning sampling technique and equipment:

Equipment	Sampling target	Criteria	Standard	Remark
Cross-belt sampler	Moving conveyor belt	- Mechanical sampling - Shape of the belt and sampling equipment; insertion angle of the sampling equipment	NT ENVIR 004 sec. 5.8.3, ISO 13909-2 sec. 6.9	Representative samples can be taken if the sampling equipment is inserted at right angles to the waste stream and moved along the belt at the speed of the belt. This requires special installation.
Sampling frame	Stopped conveyer belt	- Manual sampling - Shape and width of the belt	NT ENVIR 004 sec. 5.8.1.1, ISO 18283 sec. 6.2, sec. 6.2.7	The most reliable method
Cross-cut bucket	Falling stream from the discharge end of moving conveyor belt	- Mechanical sampling - Width of the falling stream, speed of the cutter (± 5 %), the opening width of the sampling equipment	NT ENVIR 004 sec. 5.8.2.2	- In practise the preferred method - EHQS-issues might hider the utilisation of the method - The most commonly used sampling equipment - The opening width shall be at least three times the maximum particle size
Cutter chute	Falling stream from the discharge end of moving conveyor belt	- Mechanical sampling - Width of the falling stream, dimensions of the sampling equipment aperture, time of by pass through the device - Suitability to be evaluated if grain size variability is large	NT ENVIR 004 sec. 5.8.2.3, ISO 13909-2 sec. 6.8	- In practise the preferred method - EHQS-issues might hider the utilisation of the method
Scoop	Falling stream from the discharge end of moving conveyor belt	- Manual sampling - When the width and the depth of the stream is small, direction of the action (90º to the stream)	NT ENVIR 004 sec. 5.8.2.6	- In practise the preferred method - EHQS-issues might hider the utilisation of the method - The opening size of the scoop shall be at least three times the maximum particle size
Scoop	Falling stream from the discharge end of moving conveyor belt	- Manual sampling - When the width of the stream is large and the depth is small, speed and uniformity of the of the scoop movement (0.6-1.5 m/s ± 5 %)	NT ENVIR 004 sec. 5.8.2.7	- In practise the preferred method - EHQS-issues might hider the utilisation of the method - The opening length of the scoop shall be larger than the depth of the falling stream
Scoop	Falling stream from the discharge end of moving conveyor belt	- Manual sampling - When the width of the stream is large and the depth is large, angle to the stream, speed and uniformity of the of the scoop movement (0.6-1.5 m/s ± 5 %)	NT ENVIR 004 sec. 5.8.2.8	- In practise the preferred method - EHQS-issues might hider the utilisation of the method - The opening size of the scoop shall be at least three times the maximum particle size
Manual cutter	Falling stream from the discharge end of moving conveyor belt	- Manual sampling - The opening size of the scoop shall be at least three times the maximum particle size	ISO 18283 sec. 6.1, sec. 6.2.6	

APPENDIX B

Sampling of granular material in stationary situations

Nordic horizontal standards for sampling

Selection of appropriate sampling standards

Task 3 B- Sampling of granular material in stationary situations
DRAFT

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June 2008

Nordic horizontal standards for sampling

June 2008

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Nordic horizontal standards for sampling	NICe 06135 DHI project number 80138
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Key words	Classification
Sampling, granular material, liquids, sampling equipment, sampling methods/techniques	☐ Open ☐ Internal ☒ Proprietary

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CONTENTS

1 INTRODUCTION AND SCOPE

This document identifies and describes sampling of a specific target - sampling of granular material in a stationary situation. The standards available for sampling of granular material in a stationary situation are summarized and evaluated with respect to sampling equipment and sampling methods. Finally the decision rules for the selection of the appropriate standard for the targets are described. The document describes sampling of solid granular material such as soil, ashes, slugs and similar, with focus on primary sampling.

2 SAMPLING TARGET

2.1 Delimitation of sampling target

A sampling target is defined as a portion of material, at a particular time that the sample is intended to represent. This definition is adopted by AMC Subcommittee (see the document “A structural approach to orga…..”).

A sampling lot is comparable to sampling target. **Lot**: The entirety of the material of interest to be sampled. The name lot is used within the Theory of Sampling (Smith 2001)

Sampling of solid granular material is here derived in three typical sampling situations::

1. Sampling from small containers, up to a volume of 0.050 m^3.
2. Sampling from large containers such as lorries or vehicles, volumes over 0.050 m^3 and up to 10 m^3.
3. Sampling from stockpiles, up to 10 m3 in conical shape or greater volumes in elongated rectangular shape.

3 REVIEWED STANDARDS/DOCUMENTS

The following standards/documents have been reviewed:

- Nordtest ENVIR 004: Solid waste, Particulate materials: Sampling (approved 1996-05)
- CEN/TS 14778-2: 2005: Solid biofuels - Sampling - Part 2: Methods for sampling particulate material transported in lorries
- prCEN/TS 15442:2006: Solid recovered fuels - Methods for sampling
- ASTM D6009-96 (reapproved 2006): Standard guide for sampling waste piles

- ASTM D6232-03: Standard guide for selection of sampling equipment for waste and contaminated media data collection activities
- ISO 10381-2: Soil quality- Guidance on sampling techniques
- ISO 10381-8: Soil quality- Guidance on sampling of stockpiles
- SOP 2012 (02/18/00): Soil sampling

4 SAMPLING EQUIPMENT

Sampling equipment may vary a lot in construction and shape depending on the sampling situation and target. There are descriptions of various types of equipment in the reviewed standards that are listed above. For additional reading special references are given to the ASTM D6232-03, ISO 10381-2 (Annex A) and Nordtest Envir 004

4.1 Sampling probe

A sampling probe is a cylindrical tube that can be used for taking samples in various depths of a sampling target (See section 2.1). It is applicable for both 2- and 3-D sampling. 2- dimensional sampling is possible if the sampling probe is long enough to take a sample of full depth of a target such as a container or stockpile. A critical parameter for using a probe is the particle size of the solid granular material. The opening of the probe should be at least 3 times larger than the maximum particle size of the sample but not smaller than 25 mm. This means that a probe is preferred for particles to a limited size. A maximum particle size of 25 mm is a practical limit since it means that the opening of the probe should be between 25- 75 mm, depending on the size of particles. When the opening of the tube is greater than that it becomes less practicle (convenient) to use, especially by hand at larger depths of the sampling target since the sample volume and weight becomes larger.)

4.2 Augers

Augers may vary in their construction. Bucket type augers are better for direct sample recovery because they provide a large volume of sample in a short time. Continious flight, or “screw”, augers can be used to collect a composite sample of the entire depth of the samling target. Augers may be used for larger particle sizes than a probe and they are also easier to force into harder material and to greater depths. There are also different types of machine driven augers to use. Augers are further described in the standards

4.3 Scoop

A sampling scoop can be used in two situations, sampling from a mixed sampling target (small container) or stratified sampling in larger containers or stock piles. In the later case it is used to take samples in pits of the sampling target at specific stratum.

4.4 Front-end loader or excavator

These larger equipment and machines may be used to dig pits in larger stockpiles and also to divide the material in smaller volumes if necessary. It is thereby an aid in sampling but only to make sampling with dedicated sampling equipment possible.

4.5 Decision rules – sampling equipment

Decision rules can be used as an aid to choose the best applicable type of sampling equipment. The following decision rules should be recognized and evaluated in the process of choosing equipment:

- Particle size
- Sampling depth
- Type of sampling scenario
- Type of sampling target
- 2- or 3- dimensional sampling

5 SAMPLING METHOD/TECHNIQUES

5.1 Sampling of full depth or column of sampling target

This method means that samples are collected from the whole body of material in a single action. It may be used in all three kinds of sampling targets (See section 2.1)

You should be aware of that the material could be segregated in a large container or stockpile which means that the surface and bottom layer could have a different particle size distribution. Therefore, the upper layer should be penetrated by digging a pit in which the sampling takes place.

5.2 Stratified sampling

Stratified sampling means that the sampling target is theoretically divided into different stratums of which samples are taken and composed/ mixed to a representative sample. This method is used for larger sampling targets such as stockpiles up to 10 m3 where full depth samples are practically impossible. Each stratum is reached by digging a pit to the specific depth where the sample is taken. An alternative and better choice if possible is to divide or elongate such large sampling targets. In that way it may be possible to reduce one dimension in the sampling from 3-D to 2-D sampling.

5.3 Completely mixed sampling target

If the volume of the sampling target is small enough to fit into a small container (less than 0,050 m3), it may be completely mixed by stirring or shaking. In that situation a representative sample may be taken from the upper layer.

5.4 Decision rules – sampling methods

Decision rules can be used as an aid to choose the best applicable sampling method. The following decision rules should be recognized and evaluated in the process of choosing method:

- Particle size
- Sampling depth
- Type of sampling scenario
- Type of sampling target
- 2- or 3- dimensional sampling

6 SUMMARIZATION OF DECISION RULES

In table 6.1, categories and rules for choosing the proper method and equipment are listed and the best available standard or section in the standard identified. It may be used as an aid to plan and decide on the best actions when performing adequate sampling of solid granular material in stationary situation.

Table 6.1: Summarization of sampling methods and sampling equipment intended for solid granular material in stationary situations (input to the tactic standard)

Sampling scenario	**Material Category**	**Critical parameters**		**Sampling method**		**Sampling equipment**		**Recommendations**
		Parameter 1	**Parameter 2**	**Methods**	**Reference**	**Equipment**	**Reference**	
Solid/granular material - Static situation								
Large container (wagon, vehicle> 0,05 m3)	Particle size Up to 25 mm	Opening size of sampling equipment	Depth of the container	**Full depth of container**	**NT Envir 004 sect 5.8.4.3**	Sampling probe	**NT Envir 004 sect 5.8.4.3**	
Large container (wagon, vehicle> 0,05 m3)	Particle size 25 to 80 mm	Opening size of sampling equipment	Depth of the container	**Stratified sampling**	**NT Envir 004 sect 5.8.4.4**	Auger or scoop	**NT Envir 004 sect 5.8.4.4**	
Large container (wagon, vehicle> 0,05 m3)	Particle size > 80 mm	Representativeness of sample		**Stratified sampling**	**NT Envir 004 sect 5.8.4.4**	Front- end loaders, large scoop	**NT Envir 004 sect 5.8.4.4**	
Small container, < 0,05 m3	Particle size up to 80 mm	Opening size of sampling equipment	Possibility to mix the content of container	**Mixing of content and/ or Full depth of container**	**NT Envir 004 sect 5.8.5.2**	Scoop or sampling probe	**NT Envir 004 sect 5.8.5.1**	
Stockpile	Particle size Up to 25 mm	Opening size of sampling equipment	Segregation of material in pile	**Full depth of stockpile**	**NT Envir 004 sect 5.8.6.3**	Sampling probe	**NT Envir 004 sect 5.8.6.1**	
Stockpile	Particle size 25 to 80 mm	Opening size of sampling equipment	Segregation of material in pile	**Stratified sampling**	**NT Envir 004 sect 5.8.6.2**	Scoop or auger	**NT Envir 004 sect 5.8.6.1**	
Stockpile	Particle size > 80 mm	Representativeness of sample	Segregation of material in pile	**Stratified sampling**	**NT Envir 004 sect 5.8.6.2**	Front- end loaders, large scoop	**NT Envir 004 sect 5.8.6.1**	

APPENDIX C

Sampling of liquid in dynamic situations

Nordic horizontal standards for sampling

Selection of appropriate sampling standards

Task 3 C Sampling of liquid in dynamic situations

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CONTENTS

APPENDICES

1 INTRODUCTION AND SCOPE

This document identifies and describes sampling techniques for liquids in dynamic flow situations. The standards available for sampling of liquid in dynamic situation are summarized and evaluated with respect to sampling equipment and sampling methods. Finally, the decision rules for selecting appropriate standards for the sampling targets have been described.

The document focuses on primary sampling of liquids typical for the following settings: municipal wastewater, storm-water, industrial wastewater or process water, open flow channels or in closed pipes.

2 SAMPLING TARGET

In this context, the sampling target will be volume of any liquid or a mixture of liquid and particulate matter flowing in an open channel or in a closed pipe, passing the sampling point at a given time lag. The present standards give no description of the physical dimensions (width, depth or diameter) of the channel or a pipe.

Based on practical experiences, physical properties of the liquid sample, for example the viscosity of the liquid must be in the same range as the viscosity of water (8.90 × 10−4 Pa•s) is considered. The particulate matter concentration in the liquid should not exceed 1000 mg SS/l and the maximum size of the individual particles must not exceed 5-6 mm in diameter. The flow pattern in a channel or in a pipe can be constant or variable.

2.1 Delimitation of the sampling target

Typical examples of sampling targets are:

- Volume of wastewater discharged from a municipal or industrial wastewater treatment plant per day, flowing in a channel or pipe (e.g. discharge control)

- Volume of liquid entering or leaving a processing reactor in a given period of time

- Random flows in a municipal sewerage system in a given period of time

Normally, these sampling situations require withdrawal of composite samples or several sub composite samples during a predetermined time interval (sampling period). However, sampling for analysis of fat or oil and volatile components, where only grab samples shall be used, or liquids that could stratify, are not included in the scope of this document.

3 REVIEWED STANDARDS/DOCUMENTS

The following standards/documents have been reviewed

- EN ISO 5667-2: Water quality – Sampling – Part 2: Guidance on sampling techniques
- EN ISO 5667-3: Water quality – Sampling – Part 3: Guidance on the preservation and handling of water samples
- EN ISO 5667-6: Water quality – Sampling – Part 6: Guidance on sampling of rivers and streams
- EN ISO 5667-10: Water quality – Sampling – Part 10: Guidance on sampling of waste waters
- EN ISO 5667-14: Water quality – Sampling – Part 14: Guidance on quality assurance of environmental water sampling and handling
- EN ISO 3171 Petroleum liquids – Automatic pipeline sampling

4 SAMPLING EQUIPMENT

The sampling equipment suitable for sampling in dynamic flow situation are automatic systems controlled by a liquid flow-meter (flow proportional sampling) or a timer (time proportional sampling). A further description of automatic sampling equipment can be found in the report “Wastewater and sludge sampling” (Storhaug et al., 2005)

4.1 Sampling from open channels and non pressurized pipes

4.1.1 Automatic vacuum sampler, composite sampling

An automatic vacuum sampler system (composite sampling) is designed for composite sampling e.g. a 24h time proportional or flow proportional composite sample, or any composite sample during a given period. The sampler is controlled by a timer or a flow measuring system. The sub samples add up to a composite sample. The composite samples are stored in a sample storage container. Automatic vacuum samplers for composite sampling are suitable:

– When the sampling target is a liquid stream with an open surface and a turbulent mixing pattern in the sampling point.

– If the objective of the sampling is to produce a composite sample (time or flow weighted) to describe the average liquid quality based on given analytical parameters during a given period (sampling period)

4.1.2 Automatic vacuum sampler, sequential sampling

An automatic vacuum sampler system (sequential sampling) is designed for time or flow proportional sampling of individual samples or several sub composite samples during the sampling period. The sampler is controlled by a timer or a flow measuring system. The individual or sub composite samples are stored in separate containers.

Automatic vacuum samplers for sequential sampling are suitable:

- When the sampling target is liquid stream with an open surface and a turbulent mixing pattern in the sampling point.
- When the objective of the sampling is to produce sub samples or sub composite samples (time or flow weighted) to describe the average concentration of given analytical parameters at a given point in time or the average substance concentration during given sub periods of the total sampling period.

4.2 Sampling from pressurized pipes

Sampling from pressurized pipes requires an even distribution of particles and dissolved substances across the flow cross section. The force of gravity tends to promote stratification in horizontal pipelines while distribution of particles tends to be more uniform in vertical pipelines. Several systems are used for automatic sampling from pressurized pipes, e.g.:

- Automatic vacuum sampler in combination with a flow through cell provides a non pressurized sampling point
- A 3-way solenoid valve that draw samples and then drains the samples by purging. During the sample cycle the 3-way solenoid valve opens to allow the sample to leave the pipe

So far, no standards describe in detail how to use automatic samplers on pressurized pipes.

Automatic sampling systems for sampling from pressurized pipes are suitable:

- When the sampling target is a liquid stream in a pressurized pipe with a turbulent mixing pattern at the sampling point (pipe cross section).
- When the object of the sampling is to produce sub samples, sub composite samples or composite samples (time or flow weighted) you want to describe the concentration at a given analytical parameter at:
    - A given time during the sampling period
    - The average substance concentration during given sub periods of the total sampling period
    - The average liquid quality of the sampling period

4.3 Decision rule – sampling equipment

During sampling, all the source characteristics of the sample must be maintained. For example, no change in the composition of the sample must occur after sampling. When selecting a sampling equipment care must be taken to avoid contamination while obtaining and preserving the sample. Example, all particle sizes must be included in the sample. The materials used in the sampling equipment should not cause any cross contamination of the sample, e.g. leakage of organic micro- pollutants from the sample container and into the sample.

Table 4.1: Summarization of decision rules concerning sampling equipment

Element of sampling equipment	***Requirement concerning the equipment***	***Criteria***	***Standard***
Design and materials in the sampling equipment	*Location of the sampling equipment*	*As close as possible to the sampling point*	*EN ISO 3171sec. 8.2*
	Contact time between the sample and the sampler	*The contact time should be minimized*	*EN ISO 5667-2 sec. 6.3.1*
	Materials used	*No sample contamination should occur*	*EN ISO 5667-2 sec. 6.3.1*
	Minimum internal diameter for sampling pipe (from intake point to sample delivery point)	*≥ 9mm*	*EN ISO 5667-10 sec. 4.2.2*
	Minimum intake liquid velocity	*≥ 0,5 m/s*	*EN ISO 5667-10 sec. 4.2.2*
	The precision and accuracy of delivered sub sample volume	*> 5% of the intended volume*	*EN ISO 5667-10 sec. 4.2.2*
Composite sample storage	*Materials in composite sample storage container*	*Decided by determinant of interest*	*EN ISO 5667-3,table 1*
	Temperature during storage of the composite sample	*Decided by determinant of interest* *Usually: dark and* *0-4˚C*	*EN ISO 5667-3,table 1*

5 SAMPLING METHOD/TECHNIQUES

In a dynamic flow situation, several general flow-concentration combinations can occur. The flow-concentration combination is decisive for the sampling method/technique that can be used.

5.1 Sampling from open channels

Due to the heterogeneity (liquid and particles) the mixing conditions in the sampling point are crucial when the sampling is performed from a flowing liquid stream. Consequently, good mixing and no stratification in the sampling point are of fundamental importance related to the final result of the sampling process in open channels.

Good mixing conditions will normally be found:

- Immediately downstream of water flow measurement devices (for example Parshall flumes), overflow weir)
- Downstream of artificial mixing devices

For a constant liquid flow, time weighted composite sampling can be used. For varying liquid flow and varying concentration of substances, flow weighted composite sampling should be used.

The sub sampling frequency have to be based on variogram (Smith, 2001) studies of the liquid flow and practical considerations of sampling cycle time and the maximum anticipated flow.

5.2 Sampling from pressurized pipes

The mixing conditions in the pipe cross section are very important for retrieval of a representative sample. Preferably, the sampling point should be located on a vertical pipe, based on the assumption that the flow velocity in the pipe is significantly higher than the particle settling rate.

5.3 Decision rules – Sampling methods/techniques

Good mixing conditions at the sampling point are a basic requirement for correct sampling of liquids in a dynamic situation. Consequently the mixing conditions in the sampling point are of fundamental importance for the final result of the sampling process.

Based on the flow, the following situations have been considered:

- In situations where there is insufficient mixing in the pipeline, the use of static mixer or powered mixers can be used. The sampling point should be located from 3 to 8 pipe diameters from the mixer. To avoid wall effects in the sampling point, the sample should be drawn from the central part of the pipe cross section, which provides efficient mixing.
- For a constant liquid flow, time weighted composite sampling can be used. For varying liquid flow, flow weighted composite sampling should be used. The sub sampling fre-

quency has to be based on variogram studies of the liquid flow and practical considerations of sampling cycle time and the maximum anticipated flow.

Table5.1: Summarization of decision rules concerning sampling methods

Element of sampling system	***Critical parameter***	***Criteria***			***Standard***
Flow pattern	*Variation of flow and concentration of the determinant of interest*	***Liquid flow***	***Concentration of determinant of interest***	***Sampling method***	
		Constant	*Constant*	*Grab samples*	
		Constant	*Variable*	*Time proportional*	
		Variable	*Constant*	*Time proportional*	
		Variable	*Variable*	*Flow proportional*	
Sampling point	*Mixing in the sampling point*	*All particles in the liquid passing the sampling point(channel or pipe cross section) , shall have the same probability to be included in the sample*			<u>*Open channels*</u> *EN ISO 5667-10 sec. 5.1.2* <u>*Pressurized pipes*</u> *EN ISO 3171sec. 5*
	Sample intake point	<u>*Open channels*</u> *1/3 of the water depth below the water surface, preferably 10-15 cm from the channel side wall* <u>*Pressurized pipe*</u> *> 0,25 D from the inner wall of the pipe (vertical pipe)*			*EN ISO 5667-10 sec. 5.1.2* *EN ISO 3171sec. 5.4.3*

Element of sampling system	***Critical parameter***	***Criteria***	***Standard***
		D= pipe diameter	
Composite sample	*Volume of a sub sample*	*>50 ml*	*EN ISO 5667-10 sec. 5.3.1.2*
	Number of sub-samples in the composite sample	*Depending on the variation in the concentration of the determinant of interest. Variogram studies should be performed* *The time interval between the sub samples have to be calculated based on the sampling cycle time for the automatic sampler and the maximum flow in the channel/pipe*	

6 BIBLIOGRAPHY

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A P P E N D I C E S

Appendix A: Sampling equipment

Sampling scenario: Sampling of liquid from open channels or non pressurized pipes
Material: Liquid (water) and suspended particles with maximum diameter less than 5-6 mm

Sampling Equipment	Sampling method	Standard – Equipment	Critical Parameters and Recommendations
Vacuum wastewater sampler or peristaltic wastewater sampler	Time or flow proportional sampling of sub composite samples or composite samples from channels or non pressurized pipes	EN ISO 5667-10 sec. 4.2.2	Criteria for selection of a Vacuum or peristaltic wastewater sampler is described in section 4.1 and 4.2

Sampling scenario: Sampling of liquid from pressurized pipes

Material: Liquid (water) and suspended particles with maximum diameter less than 5-6 mm

Sampling Equipment	Sampling method	Standard – Equipment	Critical Parameters and Recommendations
Vacuum wastewater sampler and a flow-through cell	Time or flow proportional sampling of sub composite samples or composite samples from pressurized pipes	EN ISO 5667-10 sec. 4.2.2	Criteria for selection of a Vacuum wastewater sampler and a flow-through cell is described in section 4.3
3-way solenoid valve	Time or flow proportional sampling of sub composite samples or composite samples from pressurized pipes	EN ISO 3171	Criteria for selection of a Vacuum wastewater sampler and a flow-through cell is described in section 4.3

Appendix B: Sampling methods/ techniques

Sampling scenario: Sampling of liquid from open channels and pressurized pipes
Material: Liquid (water) and suspended particles with maximum diameter less than 5-6 mm

Sampling Method	Sampling equipment	Standard – Equipment	Critical Parameters and Recommendations
Time weighted composite sampling Flow weighted composite sampling	Vacuum wastewater sampler Vacuum wastewater sampler and a flow-through cell 3-way solenoid valve	EN ISO 5667-10 sec. 5 EN ISO 3171 sec 5 - 8	Criteria for sampling from an open channel or pressurized pipe are described in section 5.1 and 5.2

APPENDIX D

Tables containing reviewed standards

Table D.0.1 List of identified documents – sampling design.

Document number, year and title
CEN/TS 14778-1:2005 Solid biofuels – Sampling – part 1: Methods for sampling
CEN/TS 14778-2:2005 Solid biofuels – Sampling – part 2: Methods for sampling particulate material transported in lorries
D346-04 Standard practice for collection and preparation of coke samples for laboratory analysis
D2234/D2234M-03 Standard practice for collection of a gross sample of coal
D6009-96 (reapproved 2006) Standard guide for sampling waste piles
DS/EN 1482:1996 (plus corrigendum DS/EN 1482/AC) Sampling of solid fertilizers and liming materials
DS/EN 12274-1:2002 Slurry surfacing – test methods – part 1: sampling for binder extraction
DS/EN 23954:1993 Powders for powder metallurgical purposes – sampling
DS/EN ISO 542:1995 Oilseeds – sampling
DS/EN ISO 1015-2:1999 Methods of test for mortar for masonry – part 2: bulk sampling of mortars and preparation of test mortars
DS/EN ISO 6497:2005 Animal feeding stuffs – sampling
DS/EN ISO 8130-9:1999 Coating powders – part 9: sampling
DS/EN ISO 15528:2000 Paints, varnished and raw materials for paints and varnishes – sampling
DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling
EN 12350-1:1999 Testing fresh concrete – Part 1: sampling
EN 14999:2006
ISO 1124:1988 Rubber compounding ingredients – carbon black shipment sampling procedures
ISO 1839:1980 Tea – sampling
ISO 1988:1975 Hard coal – sampling
ISO 2067:1998 Granulated cork — sampling
ISO 3082:2000 Iron ores – Sampling and sample preparation procedures
ISO 3085:2002 Iron ores – experimental methods for checking the precision of sampling. Sample preparation and measurement
ISO 5667-12:1995 Water quality – sampling – part 12: Guidance on sampling of bottom sediments
ISO 6644:2002 Flowing cereals and milled cereal products – automatic sampling by mechanical means
ISO 8213:1986 Chemical products for industrial use – sampling techniques – solid chemical products in the form of particles varying from powders to coarse lumps
ISO 8633:1992 Solid fertilizers – simple sampling method for small lots
ISO 8868:1989 Fluorspar – sampling and sample preparation
ISO 9138:1993 Abrasive grains – sampling and splitting
ISO 9411-1:1994 Solid mineral fuels – Mechanical sampling from moving streams – Part 1: coal
ISO 10381-2:2003 Soil quality – sampling – Part 2: Guidance on sampling techniques
ISO 10381-4:2003 Soil quality – sampling – Part 4: Guidance on the procedures for investigation of natural, near-natural and cultivated sites
ISO 10381-5:2005 Soil quality – sampling – Part 5: Guidance on the procedure for the investigation of urban and industrial sites with regard to soil contamination
ISO 13909-2:2001 Hard coal and coke – Mechanical sampling – part 2: Coal – sampling from moving streams
ISO 13909-3:2001 Hard coal and coke – Mechanical sampling – part 3: Coal – sampling from stationary lots

ISO 13909-6:2001 Hard coal and coke – Mechanical sampling – part 6: Coal ─ preparation of test samples ISO/DIS 10381-8:2003 Soil quality – sampling – Part 8: Guidance on sampling of stockpiles ISO/FDIS 18283:2006 Hard coal and coke – manual sampling ISO/FDIS 20904:2006 Hard coal – sampling of slurries NT ENVIR 001:1995 Solid waste, municipal: sampling and characterisation NT ENVIR 004:1996 Solid waste, particulate materials: sampling prCEN/TR 15310-1:2005 Characterisation of waste – sampling of waste materials – part 1: Guidance on selection and application of criteria for sampling under various conditions prCEN/TR 15310-2:2005 Characterisation of waste – sampling of waste materials – part 2: Guidance on sampling techniques prCEN/TS 15442:2006 Solid recovered fuels – Methods for sampling prEN/ISO 13690:2006 Cereals, pulses and milled products – sampling of static batches SOP 2009 (11/16/94) Drum sampling SOP 2010 (11/16/94) Tank sampling SOP 2017 (11/17/94) Waste pile sampling TC 151 WI 151 (2004) D2.1 Sampling of sewage sludge, treated biowastes and soils in the landscape – Framework for the preparation and application of a sampling plan: Introductory element – sampling of sewage sludge, treated biowastes and soils in the landscape – framework for the preparation and application of a sampling plan TC 151 WI 151 (2004) D2.2
DS 2214:1990 Water analysis – Sampling of natural waters for analysis of trace metals DS 2250:1983 Sampling, transportation and storage of samples for microbiological analysis DS/EN 58:2004 Bitumen and bituminous binders – sampling bituminous binders DS/EN 25667-2:1994 Water quality – sampling – Part 2: Guidance on sampling techniques DS/EN ISO 707:1997 Milk and milk products – guidance on sampling DS/EN ISO 3170:2004 Petroleum liquids – Manual sampling DS/EN ISO 3171:1999 Petroleum liquids – Automatic pipeline sampling DS/EN ISO 5667-13:1998 Water quality – sampling – Part 13: Guidance on sampling of sludges from sewage and water treatment works DS/ISO 5667-10:2004 ISO 5555:2001 Animal and vegetable fats and oils – sampling ISO 5667-4:1987 Water quality – sampling – Part 4: Guidance on sampling from lakes, natural and man-made ISO 5667-5:1991 Water quality – sampling – Part 5: Guidance on sampling of drinking water and water used for food and beverage processing ISO 5667-6:1990 Water quality – sampling – Part 6: Guidance on sampling of rivers and streams ISO 5667-9:1992 Water quality – sampling – Part 9: Guidance on sampling from marine waters ISO 5667-11:1993 Water quality – sampling – Part 11: Guidance on sampling of groundwaters ISO 5667-18:2001 Water quality – sampling – Part 18: Guidance on sampling of groundwater at contaminated sites

Table D.0.2 List of identified documents – sampling plan and sampling scheme.

Document number, year and title
CEN BTTF 151:2007 (CSS99031) Sludge, treated biowastes, and soils in the landscape – Sampling – Framework for the preparation and application of a sampling plan
CEN BTTF 151:2007 (CSS99058) Sludge, treated biowastes, and soils in the landscape – Sampling – Part 1: Guidance on selection and application of criteria for sampling under various conditions
CEN BTTF 151:2007 (CSS99060) Sludge, treated biowastes, and soils in the landscape – Sampling – Part 5: Guidance on the process of defining the sampling plan
CEN/TS 14778-1:2005 Solid biofuels – Sampling – part 1: Methods for sampling
CEN/TS 14778-2:2005 Solid biofuels – Sampling – part 2: Methods for sampling particulate material transported in lorries
DS/CEN/TS 14779:2005 Solid biofuels – sampling – methods for preparing sampling plans and sampling certificates
DS/EN 932-1:2000 Test for general properties of aggregates – part 1: methods for sampling
DS/EN 1482:1996 (plus corrigendum DS/EN 1482/AC) Sampling of solid fertilizers and liming materials
DS/EN 14899:2006 Characterisation of waste – sampling of waste materials — framework for the preparation and application of a sampling plan
DS/EN/ISO 5667-1:2007 Water quality – sampling – part 1: guidance on the design of sampling programmes and sampling techniques
DS/ISO 10381-1:2003 Soil quality – sampling – part 1: Guidance on the design of sampling programmes
DS/ISO 11648-2:2002 Statistical aspects of sampling from bulk materials – part 2: Sampling particulate materials
ISO 3082:2000 Iron ores – sampling and sample preparation procedures
ISO 8685:1992 Aluminium ores – sampling procedures
ISO 9411-1:1994 Solid mineral fuels – mechanical sampling from moving streams, Part 1: coal
ISO 9411-2:1994 Solid mineral fuels – mechanical sampling from moving streams, Part 1: coke
ISO 13909-2:2001 Hard coal and coke – mechanical sampling – part 2: Coal – sampling from moving streams
ISO 13909-3:2001 Hard coal and coke – mechanical sampling – part 3: Coal – sampling from stationary lots
ISO 13909-5:2001 Hard coal and coke – mechanical sampling – part 5: Coke – sampling from moving streams
ISO/DIS 10381-8:2003 Soil quality – sampling – Part 8: Guidance on sampling of stockpiles
ISO/FDIS 18283:2006 Hard coal and coke – manual sampling
ISO/FDIS 20904:2006 Hard coal – Sampling of slurries
prCEN/TR 15310-1:2005 Characterisation of waste – sampling of waste materials – part 1: Guidance on selection and application of criteria for sampling under various conditions
prCEN/TR 15310-5:2005 Characterisation of waste – sampling of waste materials – part 5: guidance on the process of defining the sampling plan
prCEN/TS 15442:2006 Solid recovered fuels – Methods for sampling
S 2123-1:2001 Waste sampling plans – sampling from heaps

Table D.0.3 List of identified documents – sampling procedure.

Document number, year and title
CEN/TS 14778-1:2005 Solid biofuels – Sampling – part 1: Methods for sampling
CEN/TS 14778-2:2005 Solid biofuels – Sampling – part 2: Methods for sampling particulate materials transported in lorries
prCEN/TR 15310-2:2005 Characterisation of waste – sampling of waste materials – part 2: Guidance on sampling techniques
prCEN/TR 15310-3:2005 Characterisation of waste – sampling of waste materials – part 3: Guidance on procedures for sub-sampling in the field
prCEN/TS 15442:2006 Solid recovered fuels – Methods for sampling
D346-04 Standard practice for collection and preparation of coke samples for laboratory analysis
D2234/D2234M-03 Standard practice for collection of a gross sample of coal
D 5956-96 (reapproved 2001) Standard guide for sampling strategies for heterogeneous waste
DS/EN 196-7:1994 Methods of testing cement – Part 7: methods of taking and preparing samples of cement
DS/EN ISO 542:1995 Oilseeds – sampling
DS/EN 1015-2:1999 Methods of test for mortar for masonry – part 2: bulk sampling of mortars and preparation of test mortars
DS/EN 1482:1996 (plus corrigendum DS/EN 1482/AC) Sampling of solid fertilizers and liming materials
DS/EN ISO 6497:2005 Animal feeding stuffs – sampling
DS/EN ISO 8130-9:1999 Coating powders – part 9: sampling
DS/EN 12274-1:2002 Slurry surfacing – test methods – part 1: sampling for binder extraction
DS/EN 12697-27:2001 Bituminous mixtures – test methods for hot mix asphalt – part 27: sampling
DS/EN ISO 15528:2000 Paints, varnished and raw materials for paints and varnishes – sampling
DS/EN ISO 15605:2004 Adhesives – sampling
DS/EN 23954:1993 Powders for powder metallurgical purposes – sampling
DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling
EN 12350-1:1999 Testing fresh concrete – Part 1: sampling
prEN ISO 13690:2006 Cereals, pulses and milled products – sampling of static batches
prEN ISO 21568:2003 Foodstuffs – Methods of analysis for the detection of genetically modified organisms and derived products — sampling
ISO 1124:1988 Rubber compounding ingredients – carbon black shipment sampling procedures
ISO 1839:1980 Tea – sampling
ISO 1988:1975 Hard coal – sampling
ISO 2067:1998 Granulated cork — sampling
ISO 3082:2000 Iron ores – Sampling and sample preparation procedures
ISO 3085:2002 Iron ores – experimental methods for checking the precision of sampling. Sample preparation and measurement
ISO 3963:1977 Fertilizers – sampling from a conveyor by stopping the belt
ISO 5667-12:1995 Water quality – sampling – part 12: Guidance on sampling of bottom sediments
ISO 6644:2002 Flowing cereals and milled cereal products – automatic sampling by mechanical means
ISO 8213:1986 Chemical products for industrial use – sampling techniques – solid chemical products in the form of particles varying from powders to coarse lumps
ISO 8633:1992 Solid fertilizers – simple sampling method for small lots
ISO 8868:1989 Fluorspar – sampling and sample preparation

ISO 9138:1993 Abrasive grains – sampling and splitting

ISO 9411-1:1994 Solid mineral fuels – Mechanical sampling from moving streams – Part 1: coal

ISO 10381-2:2003 Soil quality – sampling – Part 2: Guidance on sampling techniques

ISO 10381-4:2003 Soil quality – sampling – Part 4: Guidance on the procedures for investigation of natural, near-natural and cultivated sites

ISO 10381-5:2005 Soil quality – sampling – Part 5: Guidance on the procedure for the investigation of urban and industrial sites with regard to soil contamination

ISO 13909-1:2001 Hard coal and coke – Mechanical sampling – part 2: General introduction

ISO 13909-2:2001 Hard coal and coke – Mechanical sampling – part 2: Coal – sampling from moving streams

ISO 13909-3:2001 Hard coal and coke – Mechanical sampling – part 3: Coal – sampling from stationary lots

ISO/FDIS 18283:2006 Hard coal and coke – manual sampling

ISO/FDIS 20904:2006 Hard coal – sampling of slurries

NT ENVIR 001:1995 Solid waste, municipal: sampling and characterisation

NT ENVIR 004:1996 Solid waste, particulate materials: sampling

SOP 2006 (08/11/94) Sampling equipment decontamination

SOP 2009 (11/16/94) Drum sampling

SOP 2010 (11/16/94) Tank sampling

SOP 2012 (02/18/00) Soil sampling

SOP 2016 (11/17/94) Sediment sampling

SOP 2017 (11/17/94) Waste pile sampling

TC 151 WI 151 (2004) D2.1 (part 1) Sampling of sewage sludge, treated biowastes and soils in the landscape – Framework for the preparation and application of a sampling plan: Introductory element – sampling of sewage sludge, treated biowastes and soils in the landscape – framework for the preparation and application of a sampling plan

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DS/EN 58:2004 Bitumen and bituminous binders – sampling bituminous binders

DS/EN ISO 707:1997 Milk and milk products – guidance on sampling

DS 2214:1990 Water analysis – Sampling of natural waters for analysis of trace metals

DS 2250:1983 Sampling, transportation and storage of samples for microbiological analysis

DS 2398:1998 Ship's and marine technology – Sampling from lubricating oil and hydraulic systems – Guidance for sampling of representative samples for determination of degree of cleanliness and for solid particle contamination

DS/EN ISO 3170:2004 Petroleum liquids – Manual sampling

DS/EN ISO 3171:1999 Petroleum liquids – Automatic pipeline sampling

DS/EN 25667-1:1994 Water quality – sampling – Part 1: Guidance on the design of sampling programmes

ISO 5555:2001 Animal and vegetable fats and oils – sampling

ISO 5667-4:1987 Water quality – sampling – Part 4: Guidance on sampling from lakes, natural and man-made

ISO 5667-5:1991 Water quality – sampling – Part 5: Guidance on sampling of drinking water and water used for food and beverage processing

ISO 5667-6:1990 Water quality – sampling – Part 6: Guidance on sampling of rivers and streams

ISO 5667-7:1993 Water quality – sampling – Part 7: Guidance on sampling of water and steams in boiler plants

ISO 5667-9:1992 Water quality – sampling – Part 9: Guidance on sampling from marine waters

ISO 5667-10:2004 Water quality – sampling – Part 10: Guidance on sampling of waste waters

ISO 5667-11:1993 Water quality – sampling – Part 11: Guidance on sampling of groundwaters
DS/EN ISO 5667-13:1998 Water quality – sampling – Part 13: Guidance on sampling of sludges from sewage and water treatment works
ISO 5667-17:2000 Water quality – sampling – Part 17: Guidance on sampling of suspended sediments
ISO 5667-18:2001 Water quality – sampling – Part 18: Guidance on sampling of groundwater at contaminated sites

Table D.0.4 List of identified documents – sampling equipment.

Document number, year and title
CEN/TS 14778-1:2005 Solid biofuels – Sampling – part 1: Methods for sampling
CEN/TS 14778-2:2005 Solid biofuels – Sampling – part 2: Methods for sampling particulate materials transported in lorries
prCEN/TR 15310-2:2005 Characterisation of waste – sampling of waste materials – part 2: Guidance on sampling techniques
prCEN/TS 15442:2006 Solid recovered fuels – Methods for sampling
D2234/D2234M-03 Standard practice for collection of a gross sample of coal
D6009-96 (reapproved 2006) Standard guide for sampling waste piles
D6232-03 Standard guide for selection of sampling equipment for waste and contaminated media data collection activities
DS/EN 196-7:1994 Methods of testing cement – Part 7: methods of taking and preparing samples of cement
DS/EN ISO 542:1995 Oilseeds – sampling
DS/EN 1015-2:1999 Methods of test for mortar for masonry – part 2: bulk sampling of mortars and preparation of test mortars
DS/EN 1482:1996 (plus corrigendum DS/EN 1482/AC) Sampling of solid fertilizers and liming materials
DS/EN ISO 6497:2005 Animal feeding stuffs – sampling
DS/EN ISO 8130-9:1999 Coating powders – part 9: sampling
DS/EN 12274-1:2002 Slurry surfacing – test methods – part 1: sampling for binder extraction
DS/EN 12697-27:2001 Bituminous mixtures – test methods for hot mix asphalt – part 27: sampling
DS/EN ISO 15528:2000 Paints, varnished and raw materials for paints and varnishes – sampling
DS/EN ISO 15605:2004 Adhesives – sampling
DS/EN 23954:1993 Powders for powder metallurgical purposes – sampling
DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling
EN 12350-1:1999 Testing fresh concrete – Part 1: sampling
prEN ISO 13690:2006 Cereals, pulses and milled products – sampling of static batches
ISO 1124:1988 Rubber compounding ingredients – carbon black shipment sampling procedures
ISO 1839:1980 Tea – sampling
ISO 1988:1975 Hard coal – sampling
ISO 3082:2000 Iron ores – Sampling and sample preparation procedures
ISO 3963:1977 Fertilizers – sampling from a conveyor by stopping the belt
ISO 5667-12:1995 Water quality – sampling – part 12: Guidance on sampling of bottom sediments
ISO 6644:2002 Flowing cereals and milled cereal products – automatic sampling by mechanical means
ISO 8213:1986 Chemical products for industrial use – sampling techniques – solid chemical products in the form of particles varying from powders to coarse lumps

ISO 8633:1992 Solid fertilizers – simple sapling method for small lots ISO 8868:1989 Fluorspar – sampling and sample preparation ISO 9138:1993 Abrasive grains – sampling and splitting ISO 9411-1:1994 Solid mineral fuels – Mechanical sampling from moving streams – Part 1: coal ISO 10381-2:2003 Soil quality – sampling – Part 2: Guidance on sampling techniques ISO 10381-4:2003 Soil quality – sampling – Part 4: Guidance on the procedures for investigation of natural, near-natural and cultivated sites ISO/DIS 10381-8:2003 Soil quality – sampling – Part 8: Guidance on sampling of stockpiles ISO 13909-2:2001 Hard coal and coke – Mechanical sampling – part 2: Coal – sampling from moving streams ISO 13909-3:2001 Hard coal and coke – Mechanical sampling – part 3: Coal – sampling from stationary lots ISO 13909-6:2001 Hard coal and coke – Mechanical sampling – part 6: Coal ─ preparation of test samples ISO/FDIS 18283:2006 Hard coal and coke – manual sampling ISO/FDIS 20904:2006 Hard coal – sampling of slurries NT ENVIR 004:1996 Solid waste, particulate materials: sampling SOP 2006 (08/11/94) Sampling equipment decontamination SOP 2009 (11/16/94) Drum sampling SOP 2010 (11/16/94) Tank sampling SOP 2012 (02/18/00) Soil sampling SOP 2016 (11/17/94) Sediment sampling SOP 2017 (11/17/94) Waste pile sampling
DS/EN 58:2004 Bitumen and bituminous binders – sampling bituminous binders DS/EN ISO 707:1997 Milk and milk products – guidance on sampling DS 2214:1990 Water analysis – Sampling of natural waters for analysis of trace metals DS 2250:1983 Sampling, transportation and storage of samples for microbiological analysis DS 2398:1998 Ship's and marine technology – Sampling from lubricating oil and hydraulic systems – Guidance for sampling of representative samples for determination of degree of cleanliness and for solid particle contamination DS/EN ISO 3170:2004 Petroleum liquids – Manual sampling DS/EN ISO 3171:1999 Petroleum liquids – Automatic pipeline sampling DS/EN 25667-2:1994 Water quality – sampling – Part 2: Guidance on sampling techniques ISO 5555:2001 Animal and vegetable fats and oils – sampling ISO 5667-4:1987 Water quality – sampling – Part 4: Guidance on sampling from lakes, natural and man-made ISO 5667-6:1990 Water quality – sampling – Part 6: Guidance on sampling of rivers and streams ISO 5667-7:1993 Water quality – sampling – Part 7: Guidance on sampling of water and steams in boiler plants ISO 5667-9:1992 Water quality – sampling – Part 9: Guidance on sampling from marine waters ISO 5667-10:2004 Water quality – sampling – Part 10: Guidance on sampling of waste waters ISO 5667-11:1993 Water quality – sampling – Part 11: Guidance on sampling of groundwaters DS/EN ISO 5667-13:1998 Water quality – sampling – Part 13: Guidance on sampling of sludges from sewage and water treatment works ISO 5667-17:2000 Water quality – sampling – Part 17: Guidance on sampling of suspended sediments ISO 5667-18:2001 Water quality – sampling – Part 18: Guidance on sampling of groundwater at contami-

nated sites

Table D.0.5 List of identified documents – competence requirements.

Document number, year and title
DS/EN ISO 6497:2005 Animal feeding stuff – sampling
ISO 10381-4:2003 Soil quality – sampling – part 4: Guidance on the procedure for investigation of natural, near-natural and cultivated sites
ISO/FDIS 18283:2006 Hard coal and coke – manual sampling
ISO/IEC 17025:1999 General requirements for the competence of testing and calibration laboratories
ISO 17024: 2003 Conformity assessment - General requirements for bodies operating certification of persons
DS/EN ISO 707:1997 Milk and milk products – guidance on sampling
DS/EN ISO 3170:2004 Petroleum liquids – Manual sampling
ISO 667-5:1991 Water quality – sampling – part 5: Guidance on sampling of drinking water and water used for food and beverage processing

Table D.0.6 List of identified documents – quality control.

Document number, year and title
prCEN/TR 15310-4:2005 Characterisation of waste – sampling of waste materials – part 4: Guidance on procedures for sample packaging, storage, preservation, transport and delivery
ISO 1988:1975 Hard coal – sampling
ISO 9411-1:1994 Solid mineral fuels – mechanical sampling from moving streams – part 1: Coal
ISO 10381-4:2003 Soil quality – sampling – Part 4: Guidance on the procedures for investigation of natural, near-natural and cultivated sites
NT ENVIR 001:1995 Solid waste , municipal: sampling and characterisation
SOP 2006 (08/11/94) Sampling equipment decontamination
SOP 2009 (11/16/94) Drum sampling
SOP 2010 (11/16/94) Tank sampling
SOP 2012 (02/18/00) Soil sampling
SOP 2016 (11/17/94) Sediment sampling
SOP 2017 (11/17/94) Waste pile sampling
DS/EN ISO 707:1997 Milk and milk products – guidance on sampling
ISO 5667-5:1991 Water quality – sampling – Part 5: Guidance on sampling of drinking water and water used for food and beverage processing
ISO 5667-6:1990 Water quality – sampling – Part 6: Guidance on sampling of rivers and streams
ISO 5667-14:1998 Water quality – sampling – Part 14: Guidance on quality assurance of environmental water sampling and handling
ISO 5667-17:2000 Water quality – sampling – Part 17: Guidance on sampling of suspended sediments
ISO 5667-18:2001 Water quality – sampling – Part 18: Guidance on sampling of groundwater at contaminated sites

Table D.0.7 List of identified documents – reporting.

Document number, year and title
prCEN/TS 15442:2006 Solid recovered fuels – Methods for sampling
DS/EN 196-7:1994 Methods of testing cement – Part 7: methods of taking and preparing samples of cement
DS/EN ISO 542:1995 Oilseeds – sampling
DS/EN 1482:1996 (plus corrigendum DS/EN 1482/AC) Sampling of solid fertilizers and liming materials
DS/EN ISO 6497:2005 Animal feeding stuffs – sampling
DS/EN 12274-1:2002 Slurry surfacing – test methods – part 1: sampling for binder extraction
DS/EN 12697-27:2001 Bituminous mixtures – test methods for hot mix asphalt – part 27: sampling
DS/EN ISO 15528:2000 Paints, varnished and raw materials for paints and varnishes – sampling
DS/EN ISO 15605:2004 Adhesives – sampling
DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling
EN 12350-1:1999 Testing fresh concrete – Part 1: sampling
EN 14899:2006 Characterisation of waste – sampling of waste materials – framework for the preparation and application of a sampling plan
prEN ISO 13690:2006 Cereals, pulses and milled products – sampling of static batches
prEN ISO 21568:2003 Foodstuffs – Methods of analysis for the detection of genetically modified organisms and derived products – sampling
ISO 1124:1988 Rubber compounding ingredients – carbon black shipment sampling procedures
ISO 1839:1980 Tea – sampling
ISO 2067:1998 Granulated cork – sampling
ISO 3085:2002 Iron ores – experimental methods for checking the precision of sampling. Sample preparation and measurement
ISO 3963:1977 Fertilizers – sampling from a conveyor by stopping the belt
ISO 5667-12:1995 Water quality – sampling – part 12: Guidance on sampling of bottom sediments
ISO 6644:2002 Flowing cereals and milled cereal products – automatic sampling by mechanical means
ISO 8213:1986 Chemical products for industrial use – sampling techniques – solid chemical products in the form of particles varying from powders to coarse lumps
ISO 8633:1992 Solid fertilizers – simple sapling method for small lots
ISO 10381-2:2003 Soil quality – sampling – Part 2: Guidance on sampling techniques
ISO 10381-4:2003 Soil quality – sampling – Part 4: Guidance on the procedures for investigation of natural, near-natural and cultivated sites
ISO 10381-5:2005 Soil quality – sampling – Part 5: Guidance on the procedure for the investigation of urban and industrial sites with regard to soil contamination
ISO 13909-1:2001 Hard coal and coke – mechanical sampling – part 1: General introduction
ISO/FDIS 18283:2006 Hard coal and coke – manual sampling
NT ENVIR 001:1995 Solid waste, municipal: sampling and characterisation
NT ENVIR 004:1996 Solid waste, particulate materials: sampling
TC 151 WI 151 (2004) D2.1 (part 1) Sampling of sewage sludge, treated biowastes and soils in the landscape – Framework for the preparation and application of a sampling plan: Introductory element – sampling of sewage sludge, treated biowastes and soils in the landscape – framework for the preparation and application of a sampling plan
DS/EN 58:2004 Bitumen and bituminous binders – sampling bituminous binders

DS/EN ISO 707:1997 Milk and milk products – guidance on sampling
DS 2250:1983 Sampling, transportation and storage of samples for microbiological analysis
DS/EN 25667-2:1994 Water quality – sampling – Part 2: Guidance on sampling techniques
ISO 5555:2001 Animal and vegetable fats and oils – sampling
ISO 5667-4:1987 Water quality – sampling – Part 4: Guidance on sampling from lakes, natural and man-made
ISO 5667-5:1991 Water quality – sampling – Part 5: Guidance on sampling of drinking water and water used for food and beverage processing
ISO 5667-6:1990 Water quality – sampling – Part 6: Guidance on sampling of rivers and streams
ISO 5667-7:1993 Water quality – sampling – Part 7: Guidance on sampling of water and steams in boiler plants
ISO 5667-9:1992 Water quality – sampling – Part 9: Guidance on sampling from marine waters
ISO 5667-10:2004 Water quality – sampling – Part 10: Guidance on sampling of waste waters
ISO 5667-11:1993 Water quality – sampling – Part 11: Guidance on sampling of groundwaters
DS/EN ISO 5667-13:1998 Water quality – sampling – Part 13: Guidance on sampling of sludges from sewage and water treatment works
ISO 5667-14:1998 Water quality – sampling – Part 14: Guidance on quality assurance of environmental water sampling and handling
ISO 5667-18:2001 Water quality – sampling – Part 18: Guidance on sampling of groundwater at contaminated sites

Table D.0.8 List of identified documents – health and safety.

Document number, year and title
DS/EN ISO 15605:2004 Adhesives – sampling
DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling
EN 14899:2006 Characterisation of waste – sampling of waste materials – framework for the preparation and application of a sampling plan
prEN ISO 13690:2006 Cereals, pulses and milled products – sampling of static batches
prEN ISO 21568:2003 Foodstuffs – Methods of analysis for the detection of genetically modified organisms and derived products – sampling
ISO 3082:2000 Iron ores – Sampling and sample preparation procedures
ISO 3165:1976 Sampling of chemical products for industrial use – safety in sampling
ISO 3963:1997 Fertilizers – sampling from a conveyor by stopping the belt
ISO 5667-12:1995 Water quality – sampling – part 12: Guidance on sampling of bottom sediments
ISO 8213:1986 Chemical products for industrial use – sampling techniques – solid chemical products in the form of particles varying from powders to coarse lumps
ISO 9411-1:1994 Solid mineral fuels – Mechanical sampling from moving streams – Part 1: Coal
ISO 10381-2:2003 Soil quality – sampling – Part 2: Guidance on sampling techniques
ISO 10381-3:2002 Soil quality – sampling – Part 3: Guidance on safety
ISO/DIS 10381-8:2003 Soil quality – sampling – Part 8: Guidance on sampling of stockpiles
ISO 13909-2:2001 Hard coal and coke – Mechanical sampling – Part 2: Coal- sampling from moving streams
NT ENVIR 001:1995 Solid waste, municipal: sampling and characterisation
SOP 2006 (08/11/94) Sampling equipment decontamination
SOP 2009 (11/16/94) Drum sampling

SOP 2010 (11/16/94) Tank sampling
SOP 2012 (02/18/00) Soil sampling
SOP 2016 (11/17/94) Sediment sampling
TC 151 WI 151 (2004) D2.1 (part 1) Sampling of sewage sludge, treated biowastes and soils in the landscape – Framework for the preparation and application of a sampling plan: Introductory element – sampling of sewage sludge, treated biowastes and soils in the landscape – framework for the preparation and application of a sampling plan
DS/EN 58:2004 Bitumen and bituminous binders – sampling bituminous binders
DS 2250:1983 Sampling, transportation and storage of samples for microbiological analysis
DS/EN ISO 3170:2004 Petroleum liquids – Manual sampling
DS/EN ISO 3171:1999 Petroleum liquids – Automatic pipeline sampling
DS/EN 25667-1:1994 Water quality – sampling – Part 1: Guidance on the design of sampling programmes
ISO 5667-4:1987 Water quality – sampling – Part 4: Guidance on sampling from lakes, natural and man-made
ISO 5667-5:1991 Water quality – sampling – Part 5: Guidance on sampling of drinking water and water used for food and beverage processing
ISO 5667-6:1990 Water quality – sampling – Part 6: Guidance on sampling of rivers and streams
ISO 5667-9:1992 Water quality – sampling – Part 9: Guidance on sampling from marine waters
ISO 5667-10:2004 Water quality – sampling – Part 10: Guidance on sampling of waste waters
ISO 5667-11:1993 Water quality – sampling – Part 11: Guidance on sampling of groundwaters
DS/EN ISO 5667-13:1998 Water quality – sampling – Part 13: Guidance on sampling of sludges from sewage and water treatment works
ISO 5667-17:2000 Water quality – sampling – Part 17: Guidance on sampling of suspended sediments
ISO 5667-18:2001 Water quality – sampling – Part 18: Guidance on sampling of groundwater at contaminated sites

Table D.0.9 List of identified documents – sample treatment on site.

Document number, year and title
CEN/TS 14778-1:2005 Solid biofuels – Sampling – part 1: Methods for sampling
CEN/TS 14778-2:2005 Solid biofuels – Sampling – part 2: Methods for sampling particulate materials transported in lorries
prCEN/TR 15310-3:2005 Characterisation of waste – sampling of waste materials – part 3: Guidance on procedures for sub-sampling in the field
D 346-04 Standard practice for collection and preparation of coke samples for laboratory analysis
D2234/D2234M-03 Standard practice for collection of a gross sample of coal
DS/EN 196-7:1994 Methods of testing cement – Part 7: methods of taking and preparing samples of cement
DS/EN ISO 542:1995 Oilseeds – sampling
DS/EN 1015-2:1999 Methods of test for mortar for masonry – part 2: bulk sampling of mortars and preparation of test mortars
DS/EN 1482:1996 (plus corrigendum DS/EN 1482/AC) Sampling of solid fertilizers and liming materials
DS/EN ISO 6497:2005 Animal feeding stuffs – sampling
DS/EN ISO 15528:2000 Paints, varnished and raw materials for paints and varnishes – sampling
DS/EN 23954:1993 Powders for powder metallurgical purposes – sampling
DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling

ISO 1124:1988 Rubber compounding ingredients – carbon black shipment sampling procedures
ISO 1839:1980 Tea – sampling
ISO 1988:1975 Hard coal – sampling
ISO 2067:1998 Granulated cork ─ sampling
ISO 3082:2000 Iron ores – Sampling and sample preparation procedures
ISO 3085:2002 Iron ores – experimental methods for checking the precision of sampling. Sample preparation and measurement
ISO 4296-2:983 Manganese ores – sampling – Part 2: preparation of samples
ISO 7742:1988 Solid fertilizers – reduction of samples
ISO 8213:1986 Chemical products for industrial use – sampling techniques – solid chemical products in the form of particles varying from powders to coarse lumps
ISO 8633:1992 Solid fertilizers – simple sapling method for small lots
ISO 8868:1989 Fluorspar – sampling and sample preparation
ISO 9138:1993 Abrasive grains – sampling and splitting
ISO 9411-1:1994 Solid mineral fuels – Mechanical sampling from moving streams – Part 1: Coal
ISO 10381-4:2003 Soil quality – sampling – Part 4: Guidance on the procedures for investigation of natural, near-natural and cultivated sites
ISO/DIS 10381-8:2003 Soil quality – sampling – Part 8: Guidance on sampling of stockpiles
ISO 13909-6:2001 Hard coal and coke – Mechanical sampling – part 6: Coal ─ preparation of test samples
ISO/FDIS 18283:2006 Hard coal and coke – manual sampling
ISO/FDIS 20904:2006 Hard coal – sampling of slurries
NT ENVIR 001:1995 Solid waste, municipal: sampling and characterisation
SOP 2012 (02/18/00) Soil sampling
SOP 2017 (11/17/94) Waste pile sampling
TC 151 WI 151 (2004) D2.1 (part 1) Sampling of sewage sludge, treated biowastes and soils in the landscape – Framework for the preparation and application of a sampling plan: Introductory element – sampling of sewage sludge, treated biowastes and soils in the landscape – framework for the preparation and application of a sampling plan
DS/EN 58:2004 Bitumen and bituminous binders – sampling bituminous binders
DS 2214:1990 Water analysis – Sampling of natural waters for analysis of trace metals
DS/EN ISO 3170:2004 Petroleum liquids – Manual sampling
DS/EN ISO 3171:1999 Petroleum liquids – Automatic pipeline sampling
ISO 5555:2001 Animal and vegetable fats and oils – sampling
ISO/WD 5667-3 Water quality – sampling – Part 3: Guidance on the preservation and handling of samples
ISO 5667-5:1991 Water quality – sampling – Part 5: Guidance on sampling of drinking water and water used for food and beverage processing
ISO 5667-11:1993 Water quality – sampling – Part 11: Guidance on sampling of groundwaters
DS/EN ISO 5667-13:1998 Water quality – sampling – Part 13: Guidance on sampling of sludges from sewage and water treatment works

Table D.0.10 List of identified documents – sample handling.

Document number, year and title
CEN/TS 14778-1:2005 Solid biofuels – Sampling – part 1: Methods for sampling
CEN/TS 14778-2:2005 Solid biofuels – Sampling – part 2: Methods for sampling particulate materials

transported in lorries
prCEN/TR XXXX-4:2007 Sludge, treated biowastes, and soils in the landscape - Sampling - Part 4: Guidance on procedures for sample packaging, storage, preservation, transport and delivery (CEN BTTF 151, CSS99059)
prCEN/TR 15310-4:2005 Characterisation of waste – sampling of waste materials – part 4: Guidance on procedures for sample packaging, storage, preservation, transport and delivery
prCEN/TS 15442:2006 Solid recovered fuels – Methods for sampling
D6009-96 (reapproved 2006) Standard guide for sampling waste piles
DS/EN 196-7:1994 Methods of testing cement – Part 7: methods of taking and preparing samples of cement
DS/EN ISO 542:1995 Oilseeds – sampling
DS/EN 1015-2:1999 Methods of test for mortar for masonry – part 2: bulk sampling of mortars and preparation of test mortars
DS/EN 1482:1996 (plus corrigendum DS/EN 1482/AC) Sampling of solid fertilizers and liming materials
DS/EN ISO 6497:2005 Animal feeding stuffs – sampling
DS/EN ISO 8130-9:1999 Coating powders – part 9: sampling
DS/EN ISO 15528:2000 Paints, varnished and raw materials for paints and varnishes – sampling
DS/EN ISO 15605:2004 Adhesives – sampling
DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling
EN 12350-1:1999 Testing fresh concrete – Part 1: sampling
prEN ISO 13690:2006 Cereals, pulses and milled products – sampling of static batches
prEN ISO 21568:2003 Foodstuffs – Methods of analysis for the detection of genetically modified organisms and derived products ─ sampling
ISO 1124:1988 Rubber compounding ingredients – carbon black shipment sampling procedures
ISO 1839:1980 Tea – sampling
ISO 2067:1998 Granulated cork ─ sampling
ISO 3082:2000 Iron ores – Sampling and sample preparation procedures
ISO 4296-2:1983 Manganese ores – sampling – Part 2: preparation of samples
ISO 5667-12:1995 Water quality – sampling – part 12: Guidance on sampling of bottom sediments
ISO 6644:2002 Flowing cereals and milled cereal products – automatic sampling by mechanical means
ISO 8868:1989 Fluorspar – sampling and sample preparation
ISO 9411-1:1994 Solid mineral fuels – Mechanical sampling from moving streams – part 1: Coal
ISO 10381-2:2003 Soil quality – sampling – Part 2: Guidance on sampling techniques
ISO 10381-4:2003 Soil quality – sampling – Part 4: Guidance on the procedures for investigation of natural, near-natural and cultivated sites
ISO/DIS 10381-8:2003 Soil quality – sampling – Part 8: Guidance on sampling of stockpiles
ISO 13909-1:2001 Hard coal and coke – Mechanical sampling – part 2: General introduction
ISO 13909-2:2001 Hard coal and coke – Mechanical sampling – part 2: Coal – sampling from moving streams
ISO 13909-3:2001 Hard coal and coke – Mechanical sampling – part 3: Coal – sampling from stationary lots
ISO/FDIS 18283:2006 Hard coal and coke – manual sampling
ISO/FDIS 20904:2006 Hard coal – sampling of slurries
NT ENVIR 004:1996 Solid waste, particulate materials: sampling
SOP 2009 (11/16/94) Drum sampling

SOP 2010 (11/16/94) Tank sampling SOP 2012 (02/18/00) Soil sampling SOP 2016 (11/17/94) Sediment sampling SOP 2017 (11/17/94) Waste pile sampling TC 151 WI 151 (2004) D2.1 (part 1) Sampling of sewage sludge, treated biowastes and soils in the landscape – Framework for the preparation and application of a sampling plan: Introductory element – sampling of sewage sludge, treated biowastes and soils in the landscape – framework for the preparation and application of a sampling plan
DS/EN 58:2004 Bitumen and bituminous binders – sampling bituminous binders DS/EN ISO 707:1997 Milk and milk products – guidance on sampling DS 2214:1990 Water analysis – Sampling of natural waters for analysis of trace metals DS 2250:1983 Sampling, transportation and storage of samples for microbiological analysis DS 2398:1998 Ship's and marine technology – Sampling from lubricating oil and hydraulic systems – Guidance for sampling of representative samples for determination of degree of cleanliness and for solid particle contamination DS/EN ISO 3170:2004 Petroleum liquids – Manual sampling DS/EN ISO 3171:1999 Petroleum liquids – Automatic pipeline sampling DS/EN 25667-2:1994 Water quality – sampling – Part 2: Guidance on sampling techniques ISO 5555:2001 Animal and vegetable fats and oils – sampling ISO/WD 5667-3 Water quality – sampling – Part 4: Guidance on the preservation and handling of samples ISO 5667-4:1987 Water quality – sampling – Part 4: Guidance on sampling from lakes, natural and man-made ISO 5667-5:1991 Water quality – sampling – Part 5: Guidance on sampling of drinking water and water used for food and beverage processing ISO 5667-6:1990 Water quality – sampling – Part 6: Guidance on sampling of rivers and streams ISO 5667-7:1993 Water quality – sampling – Part 7: Guidance on sampling of water and steams in boiler plants ISO 5667-9:1992 Water quality – sampling – Part 9: Guidance on sampling from marine waters ISO 5667-10:2004 Water quality – sampling – Part 10: Guidance on sampling of waste waters ISO 5667-11:1993 Water quality – sampling – Part 11: Guidance on sampling of groundwaters DS/EN ISO 5667-13:1998 Water quality – sampling – Part 13: Guidance on sampling of sludges from sewage and water treatment works ISO 5667-14:1998 Water quality – sampling – Part 14: Guidance on quality assurance of environmental water sampling and handling ISO 5667-18:2001 Water quality – sampling – Part 18: Guidance on sampling of groundwater at contaminated sites

APPENDIX E

Selection of operational standards – equipment

Table E.1 Selection of best operational standard regarding equipment for 1-D sampling of solids from stationary systems.

Material	**Solid**		
Situation	**Stationary**		
	Equipment type	**Selection of standard and relevant section**	**Remarks**
Dimension	**One-dimensional**		
	Sampling frame	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling, sections 5.5, 5.6.1, 6.2.7 and 6.1	
	Sampling frame	DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling, sections 7 and A.3	Frame width of 3*d, min. 10 mm
	Sampling frame	ISO 3082:2000 Iron ores – Sampling and sample preparation procedures, section 9	Frame width 3*d or 30 mm
	Sampling frame	ISO 1988:1975 Hard coal – sampling, sections 4.3.2, 4.4 and A.4.5	Frame width 2.5*d
	Parallel boards or metals sheets (similar to sam-pling frame)	ISO 3963:1977 Fertilizers – Sampling from a conveyor by stopping the belt, sections 4 and 5	
	Parallel boards or metals sheets (similar to sam-pling frame)	DS/EN 1482:1996 (plus corrigendum DS/EN 1482/AC) Sampling of solid fertilizers and liming materials, section 5.2	
	Shovel	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling, sections 5.5, 6.1 and 6.2.2	
	Shovel	DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling, sections 7 and A.2	Width of 3*d, min. 10 mm
	Scoops	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling, sections 5.5, 6.1 and 6.2.3	
	Scoops	DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling, sections 7 and A.1	Width of 3*d, min. 10 mm
	Scoops	ISO 1988:1975 Hard coal – sampling, section A.4.3	Size: 2.5*d, not suitable for particles larger than 80 mm

Table E.2 Selection of best operational standard regarding equipment for 1-D sampling of solids from dynamic systems.

Material	**Solid**		
Situation	**Dynamic**		
	Equipment type	**Selection of standard and relevant section**	**Remarks**
Dimension	**One-dimensional**		
	Sampling box (manual sampling from falling stream)	CEN/TS 14778-1:2005 Solid biofuels – Sampling – part 1: Methods for sampling, section 13.1	Width: 2.5 * d; Stream velocity: max. 1.5 m/s or 0.3+ 0.1(b/d) m/s
	Sampling box (manual sampling from falling stream)	CEN/TS 14778-2:2005 Solid biofuels – Sampling – part 2: Methods for sampling particulate material trans-ported in lorries, section 7.1	Width of 2.5*d
	Sampling box (manual sampling from falling stream)	DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling, section 7 and A.4	Width of 3*d, min. 10 mm
	Sampling box (cup) (manual sampling from falling stream)	DS/EN 1482:1996 (plus corrigendum DS/EN 1482/AC) Sampling of solid fertilizers and liming materials, section 5.4.2	
	Cutters for falling stream dividers	ISO 13909-6:2001 Hard coal and coke – Mechanical sampling – part 6: Coal ─ preparation of test samples, section 8.2	Max. Velocity 0.3*(1+b/3*d)
	Cutters for falling stream	ISO 3082:2000 Iron ores – sampling and sample preparation procedure, section 7.1 (paragraph 2), section 7.5.2 to 7.5.5	Velocity: max. 1.5 m/s or 0.3*(1+ b/3*d) m/s
	Cutters for falling stream	ISO 13909-2:2001, section 5.1 (para-graph 4), sections 6.7 and 6.8	Velocity max. 1.5 m/s
	Cutters for cross-belt sampling	ISO 13909-2:2001, section 5.1 (para-graph 4), section 6.7	
	Cutters (falling stream)	ISO/FDIS 20904:2006, section 4.2.3 (mentioning delimitation and extrac-tion error), sections 6.1, 12.1 and 12.3	
	Ladles (manual sampling from falling stream	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling, sections 5.5 and 5.6.2, figure 2i, sections 6.1 and 6.2.1	Not to be used for systems with a capacity of approx. 100 t/h; Velocity: less than 0.6 m/s
	Ladles (manual sampling from falling stream)	ISO 1988:1975 Hard coal – sampling, section A.4.2	Width 2.5*d, not suitable for particles larger than 80 mm
	Manual cutter (manual sampling from falling stream)	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling, sections 5.5, 5.6.6, 6.1 and 6.2.6	Not to be used for systems with a capacity of approx. 100 t/h; Velocity: less than 0.6 m/s

Table E.3 Selection of best operational standard regarding equipment for 2-D sampling of solids from stationary systems.

Material	**Solid**		
Situation	**Stationary**		
	Equipment type	**Selection of standard and relevant section**	**Remarks**
Dimension	**Two-dimensional**		
	Sampling thief (manual sampling)	ISO 9138:1993 Abrasive grains – sampling and splitting, section 3.1	Geometry: tube, size of holes are determined by particle Size: defined length, approx. 25 mm in diameter Note: tube has a pointed end
	Mechanical auger	ISO 13909-3:2001 Hard coal and coke – Mechanical sampling – part 3: Coal – sampling from stationary lots, section 7	Pitch 3*d, annular gap: 3*d, capable of taking full-depth samples
	Probes	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling, sections 5.5, 6.1 and 6.2.4, figure 2e (best type), figure 2f	Note: only to be used for nominal top sizes of up to 15 mm Note: avoid probe type in figure 2 g — triangular cross-section
	Probes	ISO 1988:1975 Hard coal – sampling, sections 5.4.1 and A.4.6	Only for nominal size up to 25 mm, opening 2.5*d, minimum 30 mm, penetrates full depth, full column extracted
	Auger	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling, sections 5.5, 6.1 and 6.2.5, figure 2h	Note: only to be used for nominal top sizes of up to 25 mm
	Augers (sampling tubes)	prCEN/TR 15310-2:2005 Characterisation of waste – sampling of waste materials – part 2: Guidance on sampling techniques, section A.3.3	Geometry, but not size relative to particles size and length
	Auger	ISO 1988:1975 Hard coal – sampling, section A.4.1	
	Spear sampler or auger	ISO 3082:2000 Iron ores – Sampling and sample preparation procedures, sections 8.2.1 and 8.2.2	Full depth shall be sampled Diameter of 30 mm
	Scoops	ISO 3082:2000 Iron ores – Sampling and sample preparation procedures, section 10.4.2.1, table 7	Note: scoops for increment division — correlation between nominal top size, thickness of spread sample and scoop dimension

Table E.4 Selection of best operational standard regarding equipment for 3-D sampling of solids from stationary systems.

Material	**Solid**		
Situation	**Stationary**		
	Equipment type	**Selection of standard and relevant section**	**Remarks**
Dimension	**Three-dimensional**		
	Thief (manual sampling)	ISO 9138:1993 Abrasive grains – sampling and splitting, section 3.1	Notice that the tube has a pointed end
	Thief	prCEN/TR 15310-2:2005 Characterisation of waste – sampling of waste materials – part 2: Guidance on sampling techniques, section A.3.5	Width of slots 3*d
	Tube (Thief)	DS/EN 932-1:2000 Test for general properties of aggregates – Part 1: Methods for sampling, sections 7 and A.5	Width of 3*d, min. 10 mm
	Shovel (manual sampling)	ISO 8868:1989 Fluorspar – sampling and sample preparation, section 5.1	Table with correlation of nominal top size (0.25 mm to 150 mm) to be sampled and shovel dimensions
	Shovel	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling, sections 5.5, 6.1 and 6.2.2	
	Shovel	CEN/TS 14778-2:2005 Solid biofuels – Sampling – part 2: Methods for sampling particulate material transported in lorries, section 7.3	Width 2.5*d, length 5*d,
	Scoops	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling, sections 5.5, 6.1 and 6.2.3	
	Scoops	CEN/TS 14778-2:2005 Solid biofuels – Sampling – part 2: Methods for sampling particulate material transported in lorries, section 7.2	Width 2.5*d, length 5*d, height 2.5*d
	Scoops	prCEN/TS 15442:2006 Solid recovered fuels – Methods for sampling, sections C.3 and C.6	Width, length and height 3*d
	Mechanical auger	I ISO 13909-3:2001 Hard coal and coke – Mechanical sampling – part 3: Coal – sampling from stationary lots, section 7	Pitch 3*d, annular gap: 3*d, capable of taking full-depth samples
	Manual probe/-auger	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling, section 5.6.4 paragraph 3; section 5.6.5 paragraph 3, section 5.6.6 paragraph 4; section 6.1	Size: 3*d, large enough to hold the sample
	Mechanical probe	prCEN/TS 15442:2006 Solid recovered fuels – Methods for sam-	Diameter 3*d, usable for nominal top size of up to 25

		pling, sections C.3 and C.7	mm
	Probes	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling, sections 5.5, 6.1 and 6.2.4, figure 2e (best type), figure 2f	Note: only to be used for nominal top sizes of up to 15 mm; avoid probe type in figure 2 g ─ triangular cross-section
	Auger	ISO/FDIS 18283:2006 Hard coal and coke – manual sampling, sections 5.5, 6.1 and 6.2.5, figure 2h	Note: only for nominal top sizes of up to 25 mm
	Augers (sampling tubes)	prCEN/TR 15310-2:2005 Characterisation of waste – sampling of waste materials – part 2: Guidance on sampling techniques, section A.3.3	
	Augers, ladles, scoops	ISO 1988:1975 Hard coal – sampling, sections A.4.1-A.4.3	
	Probes	ISO 1988:1975 Hard coal – sampling, sections 5.4.1 and A.4.6	Only for nominal size up to 25 mm, opening 2.5*d, minimum 30 mm, penetrates full depth, full column of coal extracted