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Soil quality — Sampling —
Part 8:
Guidance on sampling of stockpiles

Qualité du sol — Échantillonnage —

Partie 8: Lignes directrices pour l'échantillonnage des stocks de réserve



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Contents

Page

Foreword.....	vii
Introduction	ix
1 Scope	1
2 Normative references	1
3 Terms and definitions.....	2
4 Principle.....	5
5 Sampling plan	6
5.1 General.....	6
5.2 Sampling design	6
5.2.1 Involved parties.....	6
5.2.2 Purpose of sampling	7
5.2.3 Primary sampling goal	8
5.2.4 Determination of target components.....	8
5.2.5 Background information on the soil stockpile	9
5.2.6 Consideration of statistical methods.....	10
5.2.7 Sampling technique.....	10
5.2.8 Sample division in the field	10
5.2.9 Packing, preservation, storage, transport and delivery	11
5.3 Specifying information in the sampling plan	11
5.3.1 General information.....	11
5.3.2 Stockpile data.....	11
5.3.3 Sampling.....	11
5.3.4 Sample pretreatment	12
5.3.5 Packaging, preservation, storage, transport and delivery	12
5.3.6 Actual sampling	12
5.3.7 Sampling record.....	12
5.4 Health and safety	12
5.5 In-field alterations	12
6 Sampling strategy.....	13
6.1 General.....	13
6.2 Statistical principles	14
6.3 Purpose of sampling	14
6.3.1 General.....	14
6.3.2 Primary goals	15
6.3.3 Secondary goals	16
6.4 Types of sampling	16
6.4.1 Probabilistic sampling.....	16
6.4.2 Judgemental sampling	16
6.4.3 Informative judgemental sampling	17
6.4.4 Non-informative judgemental sampling	17
6.5 Sampling locations	17
6.5.1 General.....	17
6.5.2 Simple random sampling	18
6.5.3 Stratified random sampling	18
6.5.4 Systematic sampling	19
6.5.5 Judgemental sampling	20
6.6 Determining the size and number of samples and increments	20
6.6.1 General.....	20
6.6.2 Definition of the type of samples	20

6.6.3	Estimation of increment and sample size	21
6.6.4	Definition of the number of increments and/or samples	22
6.6.5	Calculation of the actual increment and/or sample size	22
6.7	Incorporation in the sampling plan	22
7	Sampling equipment and techniques	22
7.1	General	22
7.2	Sampling techniques	23
7.2.1	Determination of the sampling method	23
7.2.2	Sampling techniques for probabilistic sampling	23
7.2.3	Sampling techniques for judgemental sampling	24
7.3	Sampling equipment	24
7.4	Incorporation in the sampling plan	25
7.5	Sampling	25
8	Sample pretreatment	26
8.1	General	26
8.2	Requirements	27
8.2.1	General	27
8.2.2	Minimum size of the subsample	27
8.2.3	Notes to Table 3 and practical considerations	28
8.3	Equipment for sample pretreatment	29
8.4	Pretreatment methods	30
8.4.1	Making composite samples	30
8.4.2	Procedure for macro-aggregate reduction by hand	30
8.4.3	Subsampling methods	31
8.5	Incorporation in the sampling plan	31
8.6	Pretreatment	31
9	Packing, preservation, storing, transport and delivery	32
9.1	General	32
9.2	Packing the sample	33
9.2.1	Selecting an appropriate sample container	33
9.2.2	Labelling	34
9.3	Preserving the sample	35
9.3.1	General	35
9.3.2	Necessary preservation	36
9.3.3	Preservation methods	36
9.4	Storing the sample prior to transport	37
9.5	Transporting the sample	38
9.6	Delivering the sample	38
9.7	Incorporation in the sampling plan	38
9.8	Actual packing, preservation, storing, transport and delivery	38
10	Report	39
Annex A	(informative) Forms	41
A.1	Example of a sampling plan	41
A.2	Example of a chain of custody form	42
Annex B	(informative) Estimation of minimum increment and sample size	43
B.1	General	43
B.2	Background of the estimation of the minimum increment size	43
B.3	Background of the estimation of the minimum sample size	45
B.4	Use of the equation for the minimum sample size	47
B.4.1	General	47
B.4.2	Spherical particles	48
B.4.3	Particle size distribution, factors D_{95} and c	48
B.4.4	Density of the particle	48
B.4.5	Fraction of the particles with the characteristic to be determined, factor w_{particle}	48
B.4.6	Coefficient of variation from the fundamental error, factor $CV_{\text{fund. error}}$	49
B.5	Determination of the maximum particle size	49

B.5.1	Step 1: Sampling.....	49
B.5.2	Step 2: Weighing the sample.....	50
B.5.3	Step 3: Sieving the sample	50
B.5.4	Step 4: Weighing the sample part(s).....	50
B.5.5	Step 5: Determination of the maximum particle size	50
B.6	Commonly used assumptions.....	52
B.7	Tables for the minimum sample size	52
B.8	Calculation of the actual increment and sample size	56
Annex C	(informative) Scale of sampling.....	58
C.1	Spatial variability and scale	58
C.1.1	General.....	58
C.1.2	Three specific situations for which the scale is defined	58
C.1.3	Effects of different definitions of the scale on sampling.....	60
C.1.4	Choices on the scale of sampling.....	61
C.2	Fundamental variability.....	63
Annex D	(informative) Statistical principles	64
D.1	General.....	64
D.2	Population and subpopulation	64
D.2.1	Population	64
D.2.2	Subpopulation	64
D.3	Types of variability	65
D.3.1	General.....	65
D.3.2	Fundamental variability.....	65
D.3.3	Variability within stockpile.....	66
D.3.4	Variability between stockpiles.....	66
D.4	Error	66
D.4.1	Sampling error	66
D.4.2	Sampling error due to pretreatment	67
D.4.3	Analytical error.....	67
D.4.4	Total error	67
D.5	Population parameters	67
D.6	Reliability	68
D.6.1	Bias.....	68
D.6.2	Precision and confidence	68
Annex E	(informative) Statistical methods for characterizing a population	69
E.1	Probability distributions.....	69
E.1.1	General.....	69
E.1.2	Normal distribution.....	69
E.1.3	LogNormal distribution	69
E.1.4	Binomial distribution	71
E.2	Statistical parameter.....	71
E.2.1	General.....	71
E.2.2	Symbols and abbreviated terms	72
E.2.3	Mean.....	72
E.2.4	Standard deviation.....	72
E.2.5	Coefficient of variation	73
E.2.6	Percentiles	73
E.2.7	Maximum	76
E.2.8	Percentage compliance with a given limit	76
Annex F	(informative) Calculating the required number of samples	78
F.1	Symbols and abbreviated terms	78
F.2	Estimating a mean concentration	78
F.2.1	Using composite sampling	78
F.2.2	Using individual samples.....	81
F.3	Estimating a standard deviation	81
F.4	Estimating a percentile.....	82
F.4.1	Assuming normality	82
F.4.2	Non-parametric approach	83

F.5	Estimating a percentage compliance with a given limit	84
Annex G	(informative) Examples of types of sampling suitable for the goal	86
G.1	General	86
G.2	Example of the basic characterization of a soil stockpile	86
G.2.1	Purpose of sampling	86
G.2.2	Primary sampling goal	86
G.2.3	Definition of secondary sampling goals	87
G.3	Example of the compliance of a soil stockpile with national limit values for re-usability	88
G.3.1	Purpose of sampling	88
G.3.2	Primary sampling goal	88
G.3.3	Definition of secondary sampling goals	88
G.4	Example of on-site verification	89
G.4.1	Purpose of sampling	89
G.4.2	Primary sampling goal	89
G.4.3	Definition of secondary sampling goals	89
Annex H	(informative) Sampling techniques	91
H.1	Sampling techniques for probabilistic sampling	91
H.1.1	General	91
H.1.2	Simple random sampling	91
H.1.3	Stratified random sampling	93
H.1.4	Systematic sampling	94
H.2	Sampling techniques for judgemental sampling	97
H.2.1	General	97
H.2.2	Spot sampling	97
H.2.3	Directional sampling	98
Annex I	(informative) Description of sampling equipment	99
I.1	Augers	99
I.1.1	Soil auger	99
I.1.2	Drill auger	99
I.1.3	Mechanical drill	99
I.2	Sampling tubes	99
I.2.1	Open sampling tube	99
I.2.2	Half cut sampling tube	99
I.2.3	Plunger sampling tube	100
I.3	Scoops	100
I.4	Mechanical shovel	100
Annex J	(informative) Subsampling methods	101
J.1	Long pile and alternate shovel method	101
J.2	Coning and quartering	102
J.3	Riffling	103
J.4	Application of Tyler divider	104
J.5	Application of mechanized turntable (rotating divider)	104
Bibliography		106

Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 10381-8 was prepared by Technical Committee ISO/TC 190, *Soil quality*, Subcommittee SC 2, *Sampling*.

ISO 10381 consists of the following parts, under the general title *Soil quality — Sampling*:

- *Part 1: Guidance on the design of sampling programmes*
- *Part 2: Guidance on sampling techniques*
- *Part 3: Guidance on safety*
- *Part 4: Guidance on the procedure for investigation of natural, near-natural and cultivated sites*
- *Part 5: Guidance on the procedure for the investigation of urban and industrial sites with regard to soil contamination*
- *Part 6: Guidance on the collection, handling and storage of soil for the assessment of aerobic microbial processes in the laboratory*
- *Part 7: Guidance on sampling of soil gas*
- *Part 8: Guidance on sampling of stockpiles*

This corrected version of ISO 10381-2:2006 incorporates the following corrections.

Clause 3

[ISO 11074-2:1995] was changed to [ISO 11074:2005].

In 3.26, Note 3 was deleted.

Subclause 5.5, Table 1

In the third column following “Sampling technique”, “other” was replaced by “different”.

Subclause 6.5.5

In the second sentence of the second paragraph “shaded region” was replaced by “central region”.

Subclause 8.2.3

In the last line of g), “Note 3” was replaced by “item c) 3”.

Subclause D.4.4

In Equation D.1, the horizontal line of the square-root sign was extended to the right to include “+ *CV* analysis”.

Subclause H.1.4.4

In the line before Equation (H.5), “(H.4)” was replaced by “(H.5)”.

Subclause H.2.1

In the first line, “less” was replaced by “little”.

In addition, minor editorial changes were made. These changes do not alter the meaning of the text.

Introduction

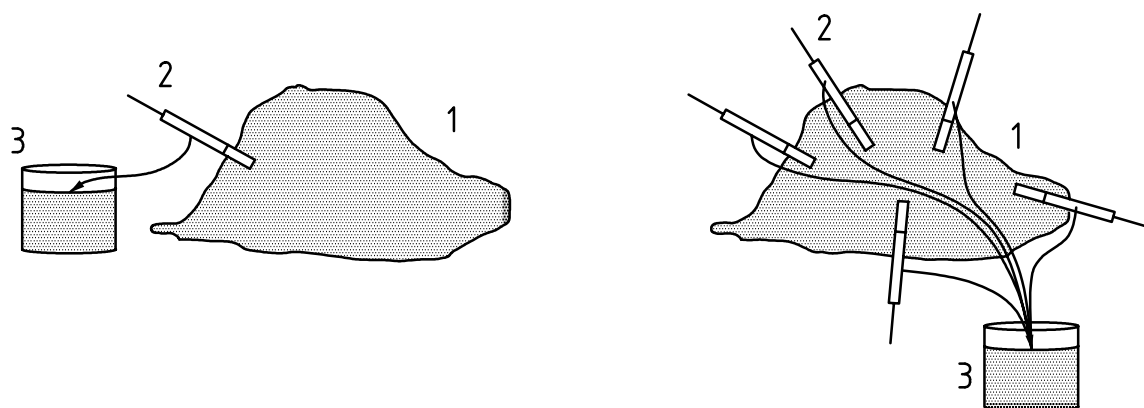
This part of ISO 10381 describes the methods to be applied when sampling soil from stockpiles. The general character of this part of ISO 10381 is a guideline. Nevertheless, many aspects of the sampling of stockpiles are based on well established methods and consequently are described in a prescriptive manner.

This part of ISO 10381 only includes the sampling of the soil material itself, i.e. the solid phase. It defines the different steps in sampling soil from a stockpile and gives instructions on how these steps should be carried out for specific situations.

This part of ISO 10381 is basically a code of practice. It describes what activities, circumstances and requirements should be addressed when sampling soil from stockpiles. As the circumstances can vary enormously, no detailed instructions on how samples should be taken in a specific situation can be given.

For a good understanding of this part of ISO 10381, the distinction between the terms “increment” (3.5), “sample” (3.16) and “composite sample” (3.4) is essential. Figure 1 illustrates this point.

An increment is obtained by a single operation of a sampling device and is per definition put together with other increments in a composite sample. A sample can also be obtained by a single operation of a sampling device, but the obtained material is packed and analysed as an entity.



- a) Only material of one sampling action in sample container: sample
- b) Two or more sampling actions: gathered material in one sample container: composite sample
Material of each individual action: increment

Key

- 1 stockpile
- 2 sampling device
- 3 sample container

Figure 1 — Sample, composite sample and increment

Soil quality — Sampling —

Part 8: Guidance on sampling of stockpiles

1 Scope

This part of ISO 10381 defines the methods that should be applied when sampling soil from stockpiles. This part of ISO 10381 only includes the sampling of the soil material itself, i.e. the solid phase. It applies to the sampling of soil material that is present in a stockpile, generally a heap of soil material that is lying above the surface of the location.

The underlying reason for sampling the soil can differ widely as can the subsequent analysis on the obtained samples. This part of ISO 10381 therefore gives guidance on the various aspects that, together, describe the sampling activity:

- the definition of a sampling plan;
- the choice of an adequate sampling strategy;
- the sampling technique to be applied;
- the sample pretreatment directly after sampling (when necessary);
- the packing, preservation, storing, transport and delivery of the sample.

Given the wide differences in circumstances for all of the above-mentioned sampling steps, this part of ISO 10381 provides information on how to obtain clear and simple instructions for the sampling personnel.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 10381-1:2002, *Soil quality — Sampling — Part 1: Guidance on the design of sampling programmes*

ISO 10381-3:2001, *Soil quality — Sampling — Part 3: Guidance on safety*

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 11464, *Soil quality — Pretreatment of samples for physico-chemical analysis*

ISO 14507, *Soil quality — Pretreatment of samples for determination of organic contaminants*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

3.1

analytical sample

portion of material, resulting from the original sample or composite sample by means of an appropriate method of sample pretreatment, and having the size (volume/mass) necessary for the desired testing or analysis

3.2

actual increment size

amount of material that is present in an increment

NOTE The actual increment size is determined by the minimum increment size, the amount of material needed for the tests or analysis and the number of increments in a composite sample.

3.3

actual sample size

amount of material that is present in the sample

NOTE The actual sample size is determined by the minimum sample size, the amount of material needed for the tests or analysis, the size of the sampling equipment and, for composite samples, the number of increments and the actual size of the increments.

3.4

composite sample

two or more increments/subsamples mixed together in appropriate proportions, either discretely or continuously (blended composite sample), from which the average value of a desired characteristic may be obtained

[ISO 11074:2005]

3.5

increment

sampling unit collected by a single operation of a sampling device and used in a composite sample

[ISO 11074:2005]

NOTE When an individual portion of material is collected in a single operation of a sampling device and this portion is analysed as an individual unit, it is per definition a sample.

3.6

involved parties

individuals involved in the (iterative) process of defining and executing the sampling programme

3.7

judgemental sampling

sampling using methods identified by prior agreement with all involved parties, without sampling in accordance with probabilistic sampling

NOTE Although in general agreement of all parties should be sought, in specific situations some parties are to be considered as more important than others. Whenever there is a hierarchical relation between the different parties, this should be taken into account when no general agreement can be established.

3.8

maximum particle size

D_{95}

particle size that concurs with the mesh width of a sieve on which a maximum of 5 % (mass fraction) of the material remains

3.9**minimum increment size**

minimum amount of material in an increment obtained with a sampling device for which the conditions of probabilistic sampling apply

NOTE The fact that every particle in the material to be sampled shall have the same probability of being part of a sample results in requirements for the size of the sampling equipment. These requirements determine the amount of material that is obtained with a single sampling operation.

3.10**minimum sample size**

minimum amount of material in a sample for which the variability caused by the individual particles within that material has a negligible effect

NOTE The minimum sample size is calculated based on an equation in which different factors result in an estimation of the minimum sample size. One of these factors is the variability that is accepted to be caused by the differences between individual particles. When a large amount of variability is chosen for this factor, there will no longer be a "negligible effect" as mentioned in the definition. However, in normal circumstances, a low value will be chosen, accepting only a relatively small amount of variability.

3.11**particle size reduction**

procedure to reduce the particle size of the whole (sub)sample through grinding or crushing without reducing the sample size (mass)

3.12**population**

totality of items under consideration

[ISO 11074:2005]

NOTE In the case of a random variable, the probability distribution is considered to define the population of that variable.

3.13**probabilistic sampling**

sampling to ensure that each particle or element in the stockpile (population) has an equal chance of being part of the sample

3.14**project manager**

individual responsible for the development of both the sampling plan and the sampling programme

3.15**primary goal**

definition of the sampling in short, general statements, giving direction towards the type of sampling, but still lacking the necessary detail to define a sampling plan

3.16**sample**

portion of soil material selected from a larger quantity of material

[ISO 11074:2005]

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

3.17**sampler**

person or group of persons carrying out the sampling procedures at the sampling locality

[ISO 11074:2005]

3.18

sample division

procedure through which subsamples of smaller size than the original sample are obtained without reducing the particle size of the individual particles

3.19

sample pretreatment

collective noun for all procedures used for conditioning a soil sample to a defined state which allows subsequent examination or analysis or long-term storage

[ISO 11074:2005]

NOTE Sample pretreatment includes, e.g. mixing, splitting, drying, crushing and stabilization.

3.20

sampling goal

technical description of the purpose of sampling

3.21

sampling plan

all information pertinent to a particular sampling activity

NOTE The sampling plan provides the sampler with a predetermined procedure for the selection, withdrawal, on-site pretreatment, preservation and transportation of the portions to be removed from a stockpile (population) as a sample.

3.22

sampling programme

total sampling operation, from the first step in which the purpose of sampling is defined to the last step in which the analytical results are compared with the relevant test level(s)

3.23

sampling technique

correct appliance of appropriate sampling equipment to obtain samples as specified in the sampling plan

NOTE The manner of selection of the sampling technique should be described in the sampling plan.

3.24

secondary goals

detailed definition of the technical aspects necessary for defining the sampling

NOTE The secondary goals address items such as the population to be sampled, the components to be determined, the statistical parameter to be determined, the scale of sampling and the desired precision and confidence.

3.25

stockpile

temporary heap of material

NOTE 1 Within the scope of this part of ISO 10381, the stockpile contains soil material.

NOTE 2 The soil material can be stored in a loosely dumped heap, can be lying in a pre-defined depot, above or below the surface of the location, etc.

3.26**subsample**

sample obtained by procedures in which the items of interest are randomly distributed in parts of equal or unequal size

[ISO 11074:2005]

NOTE 1 A subsample may be:

- a) a portion of the sample obtained by selection or division;
- b) an individual unit of the lot taken as part of the sample;
- c) the final unit of multistage sampling.

NOTE 2 The term “subsample” is used either in the sense of a “sample of a sample” or as synonym for “unit”. In practice, the meaning is usually apparent from the context or is defined.

4 Principle

A sampling plan shall be defined and this is carried out mainly as a desk operation. However, the designer of the sampling plan shall have sampling experience and be aware of the specific circumstances of the objectives and location of the sampling. Where knowledge of the site is insufficient, a site visit may be necessary before designing the sampling plan.

The sampling plan design shall include the consideration and formulation of the sampling strategy. This is important as the strategy shall ensure that the samples obtained from the stockpile are representative. Thus, there are two points to be considered in formulating the sampling plan: 1) the sampling strategy; 2) the sampling techniques.

The aim of the sampling strategy is to ensure that the requirements of probabilistic sampling are achieved. This means that all the particles in a stockpile have an equal chance of being present in the sample. This truly representative sample can only be achieved when all the requirements of probabilistic sampling are met. In practice, this may not be possible, in which case sampling should be carried out following the most practicable methods to achieve the sampling objectives.

The sampling plan shall include the sampling equipment chosen, and the sampler should have the necessary experience to ensure correct use of that equipment.

The sampling plan, when completed, should be given to the sampler before sampling commences, though some alterations may be necessary due to situations encountered onsite. Small alterations to the sampling plan may be made in the field without consulting the designer of the sampling plan.

In some cases, the sampling will result in samples which are too large to take to the laboratory and sample pretreatment in the field shall be necessary. There are two basic conditions for pretreatment in the field. Firstly, the sample should not be changed in a way that will affect the subsequent examination, i.e. contamination of the sample and/or involuntary loss of material or components should be avoided. Secondly, there should be no reduction in particle size since that process requires well-defined conditions which can not be achieved in the field and particle size reduction is restricted to being a laboratory operation.

When the samples have been taken and, if necessary, pretreated, they should be packaged so that the characteristics are protected. The packaging and any preservation necessary depend on the characteristics which are to be preserved. Preservation of soil samples shall involve two basic methods: 1) cool storage; 2) dark storage.

This part of ISO 10381 gives guidance on the aspects to be considered when storing the samples prior to analysis. This includes storage before and during transport, and storage in the laboratory prior to sample preparation for analysis.

5 Sampling plan

5.1 General

A large number of varying conditions occur where and when soil stockpiles are to be sampled. It is impossible to give detailed instructions on how to sample in all of these possible situations. This part of ISO 10381, therefore, addresses the essential points that should be considered before actual sampling, and does not give detailed instructions for specific sampling situations. Nevertheless, a detailed instruction to the sampler is essential in order to acquire the type and quality of samples which are necessary for the purpose of sampling. This instruction is given by means of a sampling plan.

When taking samples from soil stockpiles in accordance with this part of ISO 10381, a sampling plan should be defined prior to sampling. This part of ISO 10381 gives instructions on the definition of the sampling plan. The elements/aspects that should be part of the sampling plan are given, as well as the (type of) considerations that are relevant when defining the sampling plan.

A simple example of a sampling plan is given in A.1.

The sampling plan is based on the specific purpose of the sampling. It translates the purpose and all the information pertinent to a particular sampling exercise into simple and unambiguous instructions for the sampler. Sampling shall only be carried out when an approved sampling plan is available.

The sampling plan acts as a reference document and provides the means of defining the boundaries and logistics of the sampling. Its formulation requires consideration of a number of key elements/aspects (see Figure 2).

The elements/aspects of the sampling plan may be divided into two groups:

- those which relate to identifying and agreeing the sampling design in consultation with the involved parties;
- those which specify the mechanics of how, when, where and by whom the samples will be collected and precautions that will be taken to protect the sampler and the sample.

5.2 Sampling design

5.2.1 Involved parties

The sampling plan should be prepared under the direction of a project manager in consultation with all appropriate involved parties. Such consultation can involve the owner of the stockpile, the landowner on whose property the stockpile is situated, the final decision-maker, the sampler, the analyst, the customer, the regulator and the material provider.

In cases where the level of complexity is low, a number or all of these roles may be the responsibility of one individual. In certain circumstances, the number of involved parties can be influenced, for example, by legislation. In some cases, the landowner has special (safety) regulations for personnel present on the site. When relevant, the sampler shall be instructed before entering the site.

No further action shall be taken unless or until the purposes and restraints are established.

Key components defined in the sampling plan

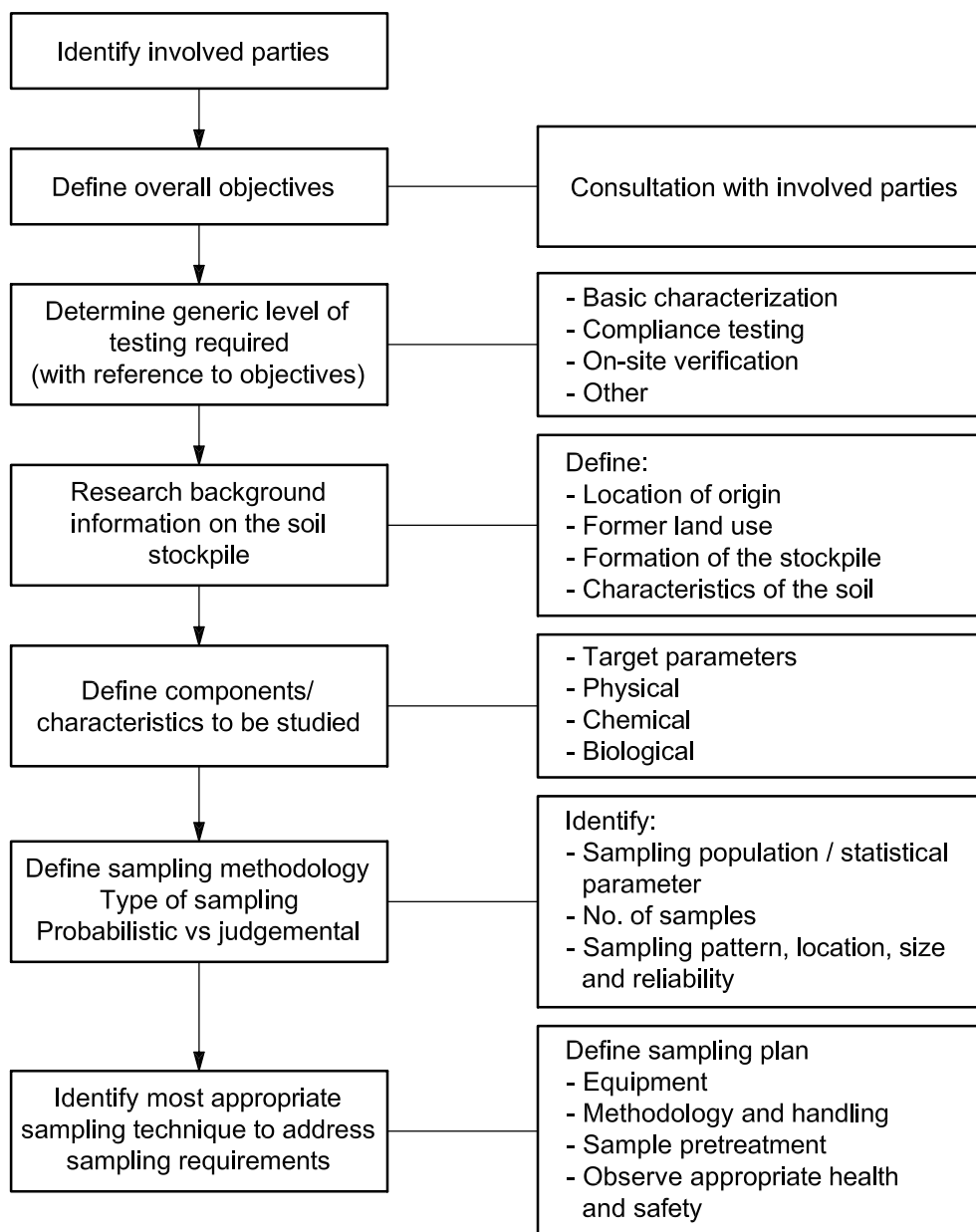


Figure 2 — Key components in the sampling plan

5.2.2 Purpose of sampling

The project manager shall define the purposes of the sampling programme with due consultation of all involved parties. The reasons for sampling can be diverse and can, for example, be to determine the possibilities for re-use, the need for soil clean-up, the assessment of environmental risks.

This diversity of purposes affects the location, number, volume and minimum testing requirements for the sampling exercise. It is therefore important that the ultimate purpose of the sampling programme and any specific goals are clearly identified to ensure that the samples collected meet these purposes. The sampling plan shall identify these primary goals of the sampling programme.

The primary goal(s) shall then be translated within the sampling plan into practical and achievable sampling goals (the secondary goals, see 6.3.3) that take into account the characteristics of the soil stockpile to be determined. Any restrictions or limitations on the reliability of the achieved results shall be detailed in addition to the agreement of interested parties.

5.2.3 Primary sampling goal

The project manager, with regard to the purposes of the sampling programme, shall select the level of testing required. Three generically defined levels of testing are described, but other levels are possible as well as other definitions of the three mentioned levels.

- Level 1: Basic (comprehensive) characterization, consisting of a thorough determination of the behaviour and properties of interest of the material.
- Level 2: Compliance testing, consisting of (periodic) testing to determine compliance with specific conditions or reference conditions (e.g. legislation or contract).
- Level 3: On-site verification, consisting of “quick check” methods to establish consistency with either Level 2 results or other formulated documentation.

For each of these levels, but especially Level 1, different types of investigation shall be specified depending on the specific aims of the sampling. The project manager shall take this into consideration when preparing the sampling plan.

5.2.4 Determination of target components

The project manager shall, within the requirements of the appropriate test level, identify the characteristics or components to be investigated, based on information:

- specified in regulations;
- relating to the intended end-use;
- specified in contract;
- ascertained from knowledge, for instance of the process responsible for contamination of the soil;
- agreed between the involved parties.

The parameter(s) to be determined by analysing the samples shall be listed in the sampling plan. Appropriate methods of sample collection and preservation shall be selected to maintain the integrity of the sample with appropriate reference to the analytical method to be used.

It is recommended that the project manager contacts the laboratory which will carry out the analyses to get adequate advice.

If several target parameters are identified, the sampling operation shall be designed in such manner that the parameters of major importance are determining the sampling. If this is not possible (e.g. the required precision for each parameter can not be achieved), separate sampling programmes shall be set up for each group of parameters.

NOTE This can be relevant for the total sampling programme, as well as for a specific part of the sampling programme (e.g. the conditions for preservation, storage and packaging). Keeping the total sampling programme simple — and thus trying to avoid too many deviations — will avoid in itself the occurrence of human errors.

5.2.5 Background information on the soil stockpile

5.2.5.1 General

Background information on the stockpile will often be essential in order to get (general) information on the material to be sampled. Background information shall be obtained in accordance with 5.4 of this part of ISO 10381, Clause 6 of ISO 10381-1:2002 and Clause 6 of ISO 10381-5:2005.

The effort that should be put into obtaining prior information depends on the purpose for sampling in combination with the sampling strategy that is used to fulfil this purpose.

NOTE When for instance the purpose for sampling asks for high quality information, this need for information can potentially be fulfilled in two ways:

- by obtaining a lot of qualitative and/or quantitative information as prior information and using in addition to this prior information a relatively simple sampling strategy;
- by obtaining only little prior information and using an intensive sampling strategy (many increments and/or samples).

Prior information can also be essential for assessing the safety aspects of sampling the particular stockpile (see 5.4).

5.2.5.2 Site details

The project manager shall establish details of the site location and access, including any perceived hazards relating, for example, to high stockpiles, non-consolidated stockpiles or difficult access.

In some situations, there might be a difference between the owner of the site where the stockpile is situated and the client for whom the stockpile is sampled. If so, the project manager should contact the site owner in order to get access to the stockpile and inform if there are site specific health and safety (see 5.4) regulations to comply with.

5.2.5.3 History of the soil

The project manager shall establish a description of the history of the soil stockpile in order to determine the potential environmental risks involved. The history includes the period before the soil was stored in the stockpile. The history of the soil shall be based on the location(s) where the soil originates from and the processes that occurred on that site. It should also include the process in which the stockpile was formed as this can give prior information on the spatial differentiation of soil quality within the stockpile.

5.2.5.4 Material type and dimensions

The project manager shall establish the soil characteristics (e.g. soil type, water content, particle size distribution) and dimensions of the stockpile to be sampled.

As part of the particle size distribution, an estimate of the maximum particle size D_{95} (see 3.8 and Annex B) in the stockpile is necessary for the definition of the sample and increment size.

5.2.5.5 Preliminary investigation

Where the information established under 5.2.5.2, 5.2.5.3 and 5.2.5.4 is deemed by the project manager to be insufficient, a preliminary investigation should be instigated. This preliminary investigation should either be aimed at gaining the lacking information, or should result in a first identification of the soil, by means of which an appropriate sampling plan can be established.

5.2.6 Consideration of statistical methods

5.2.6.1 General

The selection of an appropriate method of sampling defines how, when and where samples shall be taken to obtain the desired quantity of soil, both to be representative as well as being sufficient to meet the testing requirements.

Probabilistic sampling shall be seen as the preferred option. However, in cases where the project manager has identified that the heterogeneity and the inherent variability of the soil demands sample sizes or numbers of increments that exceed the resources available, the project manager shall outline a process of sample collection on a judgemental basis. The available resources can also be exceeded due to a large particle size of the soil material. In both cases, a thorough evaluation of costs versus representativity shall be made before choosing for a form of judgemental sampling that will or can lead to biased testing results.

Based on the variability within the batch, the degree of precision and reliability required from the results, and the resources available, the project manager should select the appropriate sampling strategy. Guidance on the consideration of statistical issues is given in Clause 6.

5.2.6.2 Probabilistic sampling

The project manager shall establish the quantity of sample material to be collected for testing and analysis. When necessary, this shall include provision for replicate samples. Sampling design is based on statistical principles for

- increment size,
- sample size, and
- sampling locations.

Instructions on the determination of the increment and sample size are given in 6.6.

5.2.6.3 Judgemental sampling

The project manager shall specify the procedure for judgemental sampling for each specific situation, including provisions for replicate samples. The basis of the judgemental sampling procedure is that it will resemble, as much as possible, the probabilistic sampling procedure. Depending on the differences that are necessary to enable (judgemental) sampling, the representativity of the samples can be biased or only representative for a specific part of the soil stockpile. The project manager should be aware of this and consider the consequences of the judgemental approach.

5.2.7 Sampling technique

The technique employed to collect samples will be influenced by the characteristics of the soil to be sampled (e.g. soil type, water content, degree of consolidation, accessibility and particle size). Guidance on the selection of appropriate sampling techniques is given in Clause 7.

5.2.8 Sample division in the field

The project manager should select appropriate pretreatment methods to reduce sample size for presentation to the laboratory. Particle size reduction – often necessary to obtain representative analytical samples of the appropriate size – is only allowed when laboratory conditions are met. Guidance on sample pretreatment in the laboratory is given in ISO 11464 and ISO 14507. A selection of pretreatment techniques suitable for sample division in the field is given in Clause 8.

5.2.9 Packing, preservation, storage, transport and delivery

The project manager should select appropriate methods for packing, preservation and storage, while transport and delivery should comply with conditions and quality considerations. More information is given in Clause 9.

5.3 Specifying information in the sampling plan

5.3.1 General information

In preparing the sampling plan, the project manager shall specify the sampling techniques, the pretreatment (in the field), the quantity of increments and samples, the sampling equipment, the number of samples, the sample containers and methods of storage, preservation and transport between sampling and testing and record that information in the sampling plan. An example of a sampling plan is given in Annex A.

The project manager should prepare a sampling plan incorporating, as a minimum, the following:

- company (body) commissioning the sampling (client);
- name of client representative;
- date of placement of commission;
- company performing the sampling;
- name of the project manager;
- name of personnel performing the sampling (the sampler);
- purpose of sampling and there from derived primary and secondary sampling goals;
- details of sampling location.

5.3.2 Stockpile data

- Identification of the stockpile (e.g. location, boundaries, spatial description);
- description of the soil to be sampled (e.g. soil type, estimated water content, particle size distribution);
- size of stockpile to be sampled;
- way in which the stockpile is available for sampling;
- maximum particle size (D_{95}).

NOTE The commissioning company (client) can supply general information on the soil stockpile.

5.3.3 Sampling

- (Applications of) sampling technique (see Clause 7);
- number of increments or samples to be taken (see Clause 6);
- increment size and/or sample size (see Clause 6);
- instructions on safety precautions;
- sampling date.

5.3.4 Sample pretreatment

- Reduction of the size of the sample in the field directly after sampling (see Clause 8).

5.3.5 Packaging, preservation, storage, transport and delivery

- Packaging and preservation of the increment or sample;
- sample coding to be used (see Clause 9);
- storage and transport of the increment or sample;
- name and location of organisation to receive samples;
- date of delivery of samples;
- name of personnel who accepted the samples at delivery.

5.3.6 Actual sampling

Taking the sample(s) in accordance with all the instructions as provided by the sampling plan.

5.3.7 Sampling record

For recording all procedures and results during sampling, a sampling record is produced. Basically, the sampling record corresponds to the sampling plan, but gives sufficient space to write down observations during sampling or (small) alterations in the original sampling plan.

As a first step of sampling, the sampling plan should be checked in the field (see 6.7). In 5.5, guidelines are given on which types of alterations can be made by the sampler without consulting the person who has made the sampling plan (the project manager).

5.4 Health and safety

For health and safety aspects of sampling, see ISO 10381-3.

In addition to the safety instructions in ISO 10381-3, the following sources can provide relevant safety instructions and regulations:

- (inter)national legislation;
- site specific safety instructions.

At most industrial sites, special safety instructions/regulations are in effect. When relevant, the sampler should be informed about these regulations before entering the site, and shall comply with these regulations during the presence on the site. Where (large) stockpiles are part of the (industrial) activities, heavy mechanical equipment can pose an additional threat to the sampler. Operational personnel should be informed about the presence of the sampler on the site.

When sampling non-consolidated stockpiles, the sampling plan should contain additional safety instructions on how the stockpile shall be sampled safely.

5.5 In-field alterations

It can be necessary to make (small) changes to the sampling plan in order to perform the sampling. Some of these changes will not influence the overall purpose of the sampling; the necessary samples are obtained and

representativity of the samples is maintained at the desired level. Some changes will however have consequences on the resulting quality of the testing.

In general, minor changes that have no effect on the results of sampling may be made in field by the sampler, while major changes should be made or at least be approved by the project manager prior to sampling.

It is not possible to give detailed instructions on the type of changes that are to be considered minor or major. This depends too much on the specific sampling situation and the desired test level. In general terms, the changes listed in Table 1 are to be considered as major changes. However, any change to the sampling plan – with or without consultation of the project manager – shall be noted and motivated in the sampling record.

Table 1 — List of major changes in the sampling plan for which consultation of the project manager is obligatory

Subject	Major change	Examples of possible reasons for the occurrence of a major change
General information	Sample location	The stockpile is no longer at the location where it was supposed to be. The accessibility of the location has changed (negatively).
Stockpile data	Identity of stockpile	The material looks different from what was expected (e.g. colour, particle size). The stockpile is no longer at the location where it was supposed to be. Two or more stockpiles partly overlap. Size is significantly smaller or larger than expected.
Sampling	Sampling technique	The necessity to use a significantly different sampling technique, for example, due to a different estimate of D_{95} .
	Size of increments and/or samples	Different estimate of D_{95} .
	Number of increments and/or samples	No time available to obtain all the necessary increments and/or samples.
	Sampling strategy	Probabilistic sampling is not possible, for example, due to the size of the stockpile.
Pretreatment	Necessity of pretreatment	Pretreatment was not planned, but appears to be necessary due to, for example, a larger estimate of D_{95} . No pretreatment is necessary due to, for example, a smaller estimate of D_{95} .
	Possibility of pretreatment	There is no clean and unused location at the sampling site. The weather conditions do not allow good quality pretreatment.
Packaging, preservation, storage, transport and delivery	Identity of the samples	Breakage of sample containers. Insufficient number of the appropriate sample containers.
	Quality of the samples	Potential contamination of samples due to, for example, the inability to use proper packaging material or preservation/storage conditions.

6 Sampling strategy

6.1 General

Sampling strategy is important due to the fact that soil is a particulate material. It is therefore to be considered heterogeneous. As there are different types of soil particles present, the material has a “fundamental” level of heterogeneity. In addition to this “fundamental” heterogeneity, substances of interest can be heterogeneously distributed in the stockpile. As a consequence, the degree of heterogeneity will directly influence the representativity of the samples. Therefore, statistics play an important role in defining the sampling plan. Basic knowledge of the statistical principles are briefly mentioned in 6.2 and discussed in more detail in Annex D.

Before designing the sampling strategy, the purpose of the sampling should be clear because it will determine which type of sampling strategy is adequate and how reliable the sampling should be. The purpose of sampling shall therefore be translated into more technically defined sampling goals. The purpose of sampling and the therefrom derived sampling goals are considered in 6.3.

The practical translation from sampling goals towards the actual sampling activity will also depend on the question of whether the sampling can fulfil the requirements of probabilistic sampling or not. If not, the sampling shall take place on a judgemental basis. The number and character of the diversions from probabilistic sampling will determine the degree of representativity of the judgemental sampling. To understand the consequences of both probabilistic and judgemental sampling, 6.4 considers the principles of both types of sampling.

The sampling strategy deals also with the “where and when” of sampling. In 6.5, this subject is discussed in more detail.

Having determined the sampling locations, the number and type of samples should be determined. This is discussed in 6.6.

Finally, the choices that have been made should be incorporated in the sampling plan, see in general Clause 5, as well as 6.7 for more specific details.

6.2 Statistical principles

The basic statistical principles of sampling are briefly described in Annex D. The text is not intended to be a statistical textbook, and gives only a basic outline of the statistical elements relevant to this part of ISO 10381. The explanation of the statistical principles is grouped under five headings:

- Population (D.2). This is a statistical term for defining the entirety of material – in general the stockpile – about which information is required. Specification of the population should be the starting point of any sampling exercise.
- Types of variability (D.3). A good awareness of the variability in the material being sampled is a vital element in arriving at an effective sampling programme. Linked with this (for sampling granular material) is the need to decide on the “scale” of the sampling, i.e. the maximum volume of material within which variations in quality are of no concern.
- Error (D.4). Apart from the variability characteristic of the material itself, sampling introduces additional uncertainty, known as “sampling error”. Analysis similarly introduces a further degree of uncertainty, termed “analytical error”.
- Statistical parameters (D.5). A variety of summary measures, or “parameters”, may be used to characterize a population (e.g. the mean, the median or the 90-percentile). It is important to consider the choice of parameter, because this can have a big influence on the size of the sampling error.
- Reliability (D.6). The greater the amount of sampling, the more reliable the results are likely to be. The major benefit of a statistical approach is that it enables this link between sampling effort and reliability to be quantified.

6.3 Purpose of sampling

6.3.1 General

The purpose of sampling should be clear prior to selecting a sampling strategy, as this is an essential step towards defining the type and quality of the information that is to be obtained through sampling. The purpose of sampling can be various, for example:

- the necessity to compare the quality of the stockpile with quality levels defined in (inter)national legislation;

- a change in ownership of the stockpile and the necessity for the buyer to know the (environmental) quality of the soil;
- to determine the (re-)usability of the soil;
- to determine the leachability of the soil;
- to assess the human and/or environmental risks;
- other.

These reasons for sampling by themselves give no information on the type and quality of sampling that is necessary for complying with the purpose. Therefore, it is necessary to define the true sampling goal(s) with which the sampling should comply.

A distinction is made between the primary sampling goal (see 6.3.2) and the secondary sampling goal (see 6.3.3). The primary goal defines the sampling in short, general statements, giving direction towards the type of sampling, but still lacking the necessary detail to define a sampling plan. In general, the sampling will have only one primary goal.

NOTE 1 When more than one primary goal is to be achieved with the same sampling programme, the sampling will often be highly complex, if not practically impossible. Therefore, these situations should be omitted.

The secondary sampling goal gives the detailed information that enables the project manager to define the sampling plan. Aspects like the type, size, scale and number of samples to be taken, the way they are selected from the stockpile, and so on, are addressed by the secondary sampling goal. Usually, there are a number of secondary goals coupled with the primary goal.

It is essential that the involved parties agree on the purpose of sampling, and the therefrom derived primary goal and secondary goals, prior to the actual sampling.

When the purpose of sampling or the primary goal does not explicitly define the quality and type of sampling, the project manager has to define these according to his own judgement. Especially in these cases, the acceptance of the sampling plan by the involved parties prior to sampling is essential.

NOTE 2 In some cases, the translation from the purpose of sampling towards a sampling plan is fairly simple, due to the fact that the number of samples, the type of samples and the sampling strategy are already defined in a (inter)national standard or in (inter)national legislation.

EXAMPLE In the Netherlands, a standardized sampling strategy is used for the sampling of soil stockpiles in order to determine if the soil is clean. The primary goal is to determine if the soil is clean in accordance with the Dutch Building Materials Act. In the Dutch Building Materials Act, the sampling of a soil stockpile is described in detail, and the project manager only has to copy this information into the sampling plan.

6.3.2 Primary goals

Three generically defined levels of testing are described in 5.2.3, but, as mentioned there, other levels are also possible, as well as other definitions of the three mentioned levels. These three levels are:

- Level 1: Basic (comprehensive) characterization, consisting of a thorough determination of the behaviour and properties of interest of the material.
- Level 2: Compliance testing, consisting of (periodic) testing to determine compliance with specific conditions or reference conditions (e.g. legislation or contract).
- Level 3: On-site verification, consisting of “quick check” methods to establish consistency with either Level 2 results or other formulated documentation.

These are examples of primary goals. In short, still general terms, the primary goal defines which type of sampling should be carried out.

Depending on the primary goal and the (inter)national legislation, rules, standards, and accepted methods, the primary goal does imply, directly or indirectly, the quality and type of sampling needed. When there is only an indirect relation, the programme manager has to define the quality and type of sampling explicitly.

6.3.3 Secondary goals

The secondary goals coincide with the elements of the sampling plan:

- definition of the stockpile to be sampled (the population);
- definition of the components to be determined and/or tests to be carried out on the samples;
- definition of the statistical parameter to be determined (e.g. mean concentration, degree of heterogeneity, percentile);
- definition of the type of sampling (probabilistic or judgemental);
- definition of the scale of sampling (the use of increments and composite samples or individual samples and the scale on which the soil should be tested);
- definition of the desired precision and confidence.

By defining the secondary goals, part of the information necessary in the sampling plan is generated.

Annex G gives some examples of the definition of types of sampling based on the purpose of sampling and the therefrom derived primary and secondary sampling goals.

6.4 Types of sampling

6.4.1 Probabilistic sampling

The basis of probabilistic sampling is that each soil particle within the population – that is the whole stockpile to be assessed (see D.1) – has an equal chance of being selected by the sampling process. In probabilistic sampling, the sampling design is based on statistical principles for:

- sampling locations (see 6.5);
- increment size (see 6.6);
- sample size (see 6.6).

6.4.2 Judgemental sampling

In contrast, judgemental sampling is where samples are taken in accordance with a non-probabilistic procedure. The most common reason for falling back on judgemental sampling is that representative sampling from the whole population is practically impossible, given the available resources in time and/or money. However, because judgemental sampling may take any form that is convenient it can result in highly biased samples, and so have severe financial and/or environmental consequences. It is therefore preferable for judgemental sampling to depart from probabilistic sampling as little as possible.

Judgemental sampling can be preferred as a sampling methodology over probabilistic sampling when specific parts of a stockpile are to be sampled. This will often be the case when a subpopulation is to be investigated, as the occurrence of that specific subpopulation is often not obvious from “the outside” of the stockpile. Probabilistic sampling of the subpopulation will then be practically impossible.

EXAMPLE 1 In a soil stockpile, specific particles appear to have an unexpected colour. It is decided that these particles should be investigated. It is however impossible to sample these particles according to the conditions of probabilistic sampling. Therefore, only part of these particles – the ones that are present on the outside of the stockpile – will be sampled.

EXAMPLE 2 In a soil stockpile, a small portion of old bricks and building materials is present. There is reason to believe that the concentrations of e.g. heavy metals in the soil are significantly different from the concentrations in the stones and bricks. Therefore, the soil material and the stones and bricks will be sampled individually. The soil will be sampled according to the conditions of probabilistic sampling, whilst the stones and bricks will be sampled as far as they are visible on the outside of the stockpile.

Accordingly, two types of judgemental sampling can usefully be distinguished:

- informative judgemental sampling;
- non-informative judgemental sampling.

6.4.3 Informative judgemental sampling

The use of judgemental sampling will nearly always result in samples being taken from a subpopulation which is substantially more restrictive than the population. Within that subpopulation, however, it may be feasible for the sampling to be probabilistic – in which case, it can be termed “informative” judgemental sampling. This means that the results will still be representative for the part of the population sampled (within which the conditions for probabilistic sampling are met), though it still runs the risk of being biased for the population.

EXAMPLE 1 Samples might be taken at random from the top 50 cm of a stockpile. The advantage of doing this is that it allows statistically sound information to be generated for at least the subpopulation sampled. This makes it easier to assess the possible errors involved in extrapolating to the whole population (i.e. the stockpile), whilst also making explicit the way in which the sampling is unrepresentative.

EXAMPLE 2 Another example is where sampling is restricted to a maximum particle size. For example, samples might be taken using a 3 cm auger for sampling soil with a maximum particle size of 5 cm. The larger particles will not be part of the sample. When the auger size is the only derivation of probabilistic sampling, the samples will be representative for the part of the population. Which part is now more difficult to define as particles of, for example 2,5 cm diameter, will already have only a small probability to enter the auger.

6.4.4 Non-informative judgemental sampling

With non-informative judgemental sampling, in contrast, no attempt is made to achieve even partial representativeness (or perhaps previous attempts have been abandoned). In this situation, there is no way of judging how useful or representative the resulting samples may be.

6.5 Sampling locations

6.5.1 General

The location where the samples or increments shall be taken is determined by the sampling pattern. The sampling pattern defines the way in which the samples are selected from the population. Three probabilistic sampling patterns and two options for judgemental sampling are illustrated in Figure 3.

NOTE 1 Figure 3 only provides a conceptual definition of the sampling locations, for simple understanding displayed in a two dimensional sampling situation. A more realistic example of the three-dimensional definition of sampling locations in a soil stockpile is provided in Figure 4. The systematic sampling pattern displayed in Figure 4 is explained in H.1.3.

This Subclause only gives the concepts of the definition of the sampling locations. In Clause 7, methods are given for the sampling of a stockpile according to probabilistic sampling (simple random sampling, stratified random sampling and systematic sampling) as well as judgemental sampling (spot sampling and directional sampling).

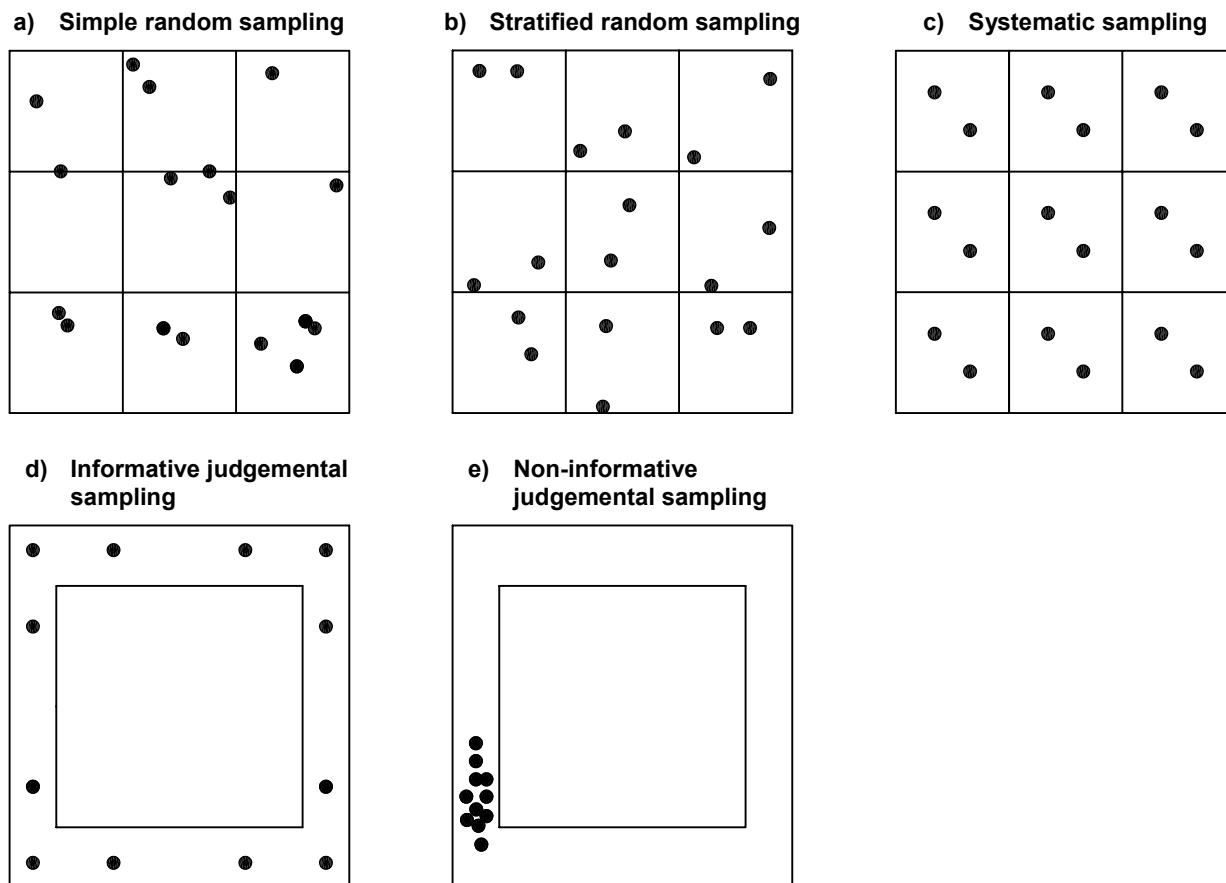


Figure 3 — Different types of sampling patterns for probabilistic and judgemental sampling

NOTE 2 The figure illustrates the patterns for the context of a two-dimensional spatial area. However, the concepts equally apply to a three-dimensional spatial area, as well as temporal variability.

6.5.2 Simple random sampling

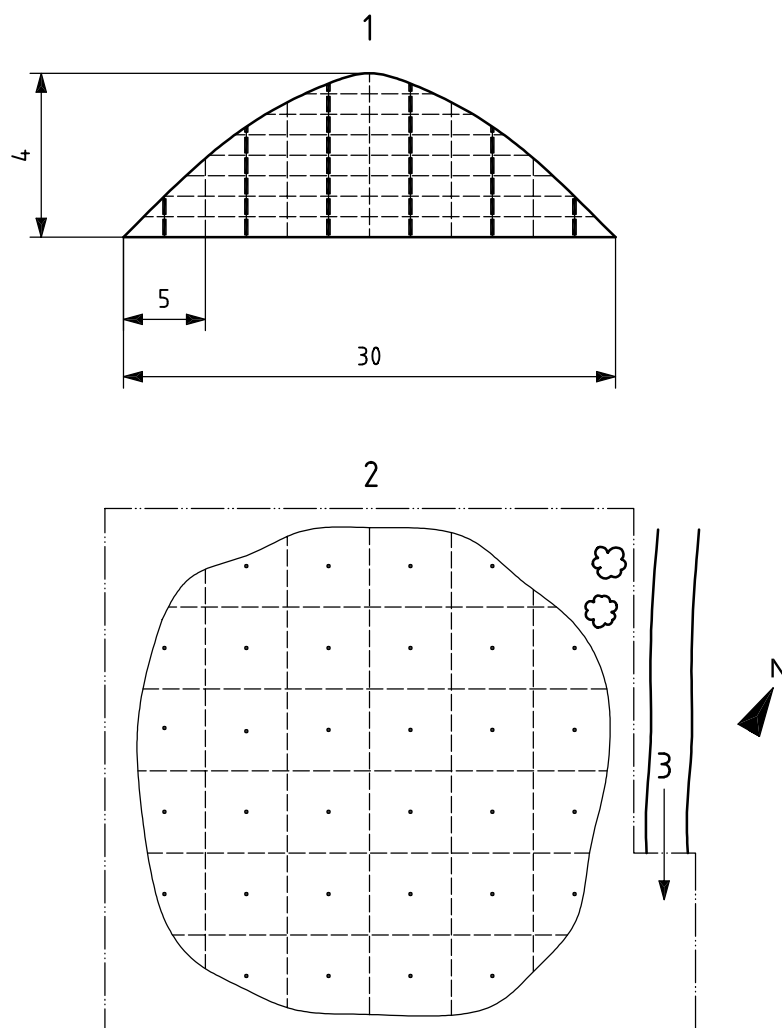
With simple random sampling, every portion of the population has the same (small) chance of being selected as a sample. However, the resulting pattern will not necessarily be very evenly spread across the population. Consequently, other more structured forms of sampling are often preferred to simple random sampling.

6.5.3 Stratified random sampling

With stratified random sampling, specified numbers of samples are spread randomly over each of a number of strata that are predefined in the population. This preserves the advantages of random sampling, whilst ensuring that each stratum is represented by a predetermined number of samples. Where the number of samples in each stratum is proportional to the proportion of the population falling into that stratum, the sampling is termed “self-weighting”. Often, however, there are advantages in having equal numbers of samples in each stratum and, subsequently, weighting the results by the estimated stratum sizes in the population. This is the easiest when all strata are of the same size.

NOTE Potentially, it is possible to define the strata based on, for example, the process that resulted in the material to be sampled or knowledge of a spatial differentiation within the material. However, this is not advisable for sampling soil stockpiles, as, in general, the spatial differentiation within the stockpile is unknown or at least uncertain.

Dimensions in metres

**Key**

1 cross section

2 top view

3 entrance

I increment

· sampling location

The dotted lines indicate the volume represented by each individual sample.

Figure 4 — Example of the definition of a systematic sampling pattern on a soil stockpile**6.5.4 Systematic sampling**

With systematic sampling the samples are evenly spaced across the population. Preferably, the systematic pattern is starting from a randomly chosen point.

Systematic sampling has obvious operational advantages. For the benefits of probabilistic sampling still to apply, however, the approach does rely on the assumption that there are no systematic components of variation within the population which “run in step with” the chosen sampling frequency. Systematic sampling should therefore be applied with care when it is used in place of a random or stratified random approach.

NOTE Distinct spatial patterns that might interfere with the representativity of samples taken from a systematic sampling pattern are difficult to define in a stockpile. Therefore, in most cases, systematic sampling will result in samples that comply with probabilistic sampling.

6.5.5 Judgemental sampling

Judgemental sampling can embrace a wide variety of sampling patterns, but these can be broadly categorized as informative and non-informative.

Figure 3 d) shows an informative judgemental programme. The subpopulation is the narrow strip around the central region. Within this, however, there is a systematic sampling pattern (chosen such that there is no risk of the samples running in step with any systematic pattern that may be present within the subpopulation). As this is a form of probabilistic sampling, the statistical benefits associated with this approach may be exploited. That is, the methodology of Annex D can be used both to estimate the parameter of interest and also to calculate a confidence interval to quantify the uncertainty surrounding that estimate.

In contrast, the pattern in Figure 3 e) is typical of non-informative judgemental sampling. From this, nothing can reliably be inferred about mean quality except in the immediate vicinity of the sampling. There is, however, one situation in which this type of sampling can be preferable: that is when the purpose of sampling is simply to estimate the characteristics of an atypical material that is unexpectedly present in the population.

6.6 Determining the size and number of samples and increments

6.6.1 General

The sampling plan shall contain specific instructions on the number of increments and/or samples to be taken, the size of the increments and/or samples and, when relevant, the number of increments that should be put together in a composite sample.

NOTE For a good understanding of this clause, the definitions of increment (3.5), sample (3.16) and composite sample (3.4) are essential. Furthermore, the background principle for the estimation of minimum increment size (3.9), the minimum sample size (3.10) and the actual increment size (3.2) and actual sample size (3.3), as given in Annex B, are important.

In order to define the specific instructions needed for the sampling plan, the following activities should be performed in subsequent manner:

- a) definition of the type of samples to be taken (see 6.6.2);
- b) estimation of the minimum increment and/or sample size (see 6.6.3);
- c) definition of the number of increments and/or samples to be taken (see 6.6.4);
- d) calculation of the actual increment and/or sample sizes (see 6.6.5).

6.6.2 Definition of the type of samples

Depending on the purpose of sampling (see 6.3), different types of samples shall be taken from the stockpile. A distinction is made between two types of "samples": increments (3.5) and samples (3.16). For each sampling situation, the type of samples which provide the desired information shall be chosen.

In general:

- One (or only a few) sample(s) will be taken when an indication of the quality of the stockpile is sufficient. Costs of sampling and analysis will be low (spot sampling).
- A (large) number of increments will be taken when a good estimate of the mean quality of the stockpile is desired. The resulting composite sample(s) in which the increments are put together prior to analysis will

result in a reliable estimate of the mean quality. Costs of sampling will be relatively high, but costs of analysis will be low (composite sampling).

- A (large) number of samples will be taken when a good estimate of the quality of the stockpile is desired. In addition to a reliable estimation of the mean quality information on the heterogeneity within the stockpile will also be obtained. Costs of sampling and analyses will be high (spot sampling).

When the purpose of sampling does not directly specify the type of samples, the project manager shall consult the involved parties prior to the definition of the sampling plan (and sampling).

6.6.3 Estimation of increment and sample size

6.6.3.1 General

As mentioned in 6.4.1, one of the requirements of probabilistic sampling is that all particles in the soil stockpile could be part of the sample. This has effect on the scale (volume) of both increments and samples. In this clause and subsequent subclauses, the increment and sample size will be determined. Increment and sample size are estimated in accordance with the following subsequent steps:

Determination of the minimum increment size see 6.6.3.2;

Determination of the minimum sample size see 6.6.3.3.

Subsequent steps are the definition of the number of increments and/or samples and the calculation of the actual increment and sample size, see 6.6.

If the sampling is carried out on the basis of a number of increments or samples, the individual increments or samples shall be equal size ($\pm 25\%$, mass fraction).

NOTE By using sampling equipment tailored to the material, the increment size is generally laid down much more precisely than the value of $\pm 25\%$ indicated for guidance purposes.

6.6.3.2 Estimation of the minimum increment size

The minimum increment size when sampling from a soil stockpile shall, under the different conditions under which the sampling shall be carried out, meet the following requirements:

- The actual width, height and length of the sampling equipment shall be at least equal to three times the maximum particle size (D_{95}) of the material to be sampled in the case of materials with a maximum particle size (D_{95}) of at least 3 mm.
- The actual width, height and length of the sampling equipment shall be at least equal to 10 mm in the case of materials with a maximum particle size (D_{95}) of less than 3 mm.

Annex B provides more detailed information on the estimation of the minimum increment size.

6.6.3.3 Estimation of the minimum sample size

Irrespective of whether composite sampling is to be used, it is important that each sample is sufficiently large for the effect of fundamental variability (see Annex B) to be negligible and meets the quantity requirements for testing and analyses. This is particularly important when the contaminant or characteristic of interest constitutes only a small proportion of the material. Annex B provides an equation for estimating the minimum sample size (by mass).

At the sampling stage, samples shall be taken of at least the size determined on the basis of the formula for the minimum sample size, see Annex B. However, when the actual sample's size is larger than the minimum sample size (see 6.6.5), samples should (at least) comply with the actual sample size.

6.6.4 Definition of the number of increments and/or samples

Irrespective of whether composite sampling is to be used, the next step is to determine the required number of increments and/or samples. E.2.7.1 provides a methodology for determining the required number of increments (m) and samples (n).

The number of increments and/or samples is directly related to the purpose of sampling (see 6.3) and the desired precision and confidence (see D.5.2).

The variability of the soil to be sampled also influences the precision and confidence realized in a sampling programme. It is therefore impossible to fulfil exact requirements for precision and confidence with a one-stage sampling programme.

When sampling consists of taking increments and putting these increments together into one or more composite samples, the number of increments in each composite sample shall be quantified in the sampling plan. In most cases, the number of increments will be equal for all composite samples within the sampling programme, which simplifies statistical analysis.

6.6.5 Calculation of the actual increment and/or sample size

Where composite sampling is not being considered, the question of increment size is irrelevant and the actual sample size is simply set to the minimum sample size as calculated in 6.6.3.3. Additionally, the resulting sample size shall be compared to the amount of material necessary for the desired testing and analysis. If insufficient material is sampled, the actual sample size is enlarged to accommodate all testing and analysis.

Where composite sampling is to be undertaken, there is a possible conflict between the previously calculated minimum values for increment size (see 6.6.3.2) and sample size (see 6.6.3.3), and the planned number of increments (see 6.6.4). Such conflict can be resolved by increasing either the number of increments, the increment size or the sample size, resulting in the actual increment size and/or sample size, as described in B.8. Additionally, the resulting sample size shall be compared to the amount of material necessary for the desired testing and analysis. If insufficient material is sampled, either the number of increments or the increment size is enlarged; resulting in a composite sample sufficiently large to accommodate all testing and analysis.

6.7 Incorporation in the sampling plan

The resulting sampling strategy derived on the basis of the earlier subclauses in Clause 6 shall be incorporated in the sampling plan (see Clause 5). Prior to the actual sampling, the right type of sampling equipment and appropriate sampling technique shall be selected (see Clause 7).

When the circumstances in the field deviate too much from the assumed situation in the sampling plan, the sampling plan should be altered. Depending on the type of alterations, the project manager who made the sampling plan should be consulted prior to actual sampling. Subclause 5.5 gives instructions on the type of alterations that can be made by the sampler, and the alterations for which the project manager should be consulted.

7 Sampling equipment and techniques

7.1 General

This clause describes suitable techniques for the sampling of soil stockpiles found in a variety of locations and consisting of a variety of soil types. This clause of ISO 10381 also gives guidance on the selection and appliance of equipment used in the sampling programme.

Prior to the selection of the sampling equipment and technique, the method of sampling has to be chosen. This involves combining the desired sampling strategy as chosen based on 6.5 and the local situation encountered.

The sampling equipment and sampling technique are closely related. Specific techniques can only be used adequately with specific types of sampling equipment. In 7.2, different sampling techniques suitable for sampling soil stockpiles are described. The sampling equipment to be used for these techniques is mentioned in 7.3, but a more detailed description is given in Annex I.

Finally, having chosen the correct sampling technique and equipment, the results should be incorporated in the sampling plan (see 7.4 and Clause 5). When the sampling plan is defined, sampling can be carried out according to the directions given in Clause 6 and this clause.

For simplicity reasons, in this clause, the material sampled will be referred to as “sample”, irrespective of the fact that it can be either an increment (3.5) or a sample (3.16).

7.2 Sampling techniques

A number of different sampling techniques are defined in this subclause and discussed in more detail in the subsequent subclauses. A distinction is made between sampling techniques that are potentially suitable for probabilistic sampling (see 6.4.1) and sampling techniques that will basically result in non-probabilistic samples and are therefore (in principle) only suitable for judgemental sampling (see 6.4.2). Under specific conditions, the “non-probabilistic” sampling techniques can also result in probabilistic samples, as well as vice versa, and therefore the distinction made in this subclause should only be considered as a rough outline.

7.2.1 Determination of the sampling method

As part of the sampling plan, determine the way in which the sampling shall be carried out.

NOTE 1 The prevailed sampling strategy is based on a random, stratified random, or, under specific conditions, systematic selection of the sampling location(s) by means of which probabilistic samples can be obtained.

The method of sampling is determined by the conditions under which the sampling shall be carried out. These conditions are determined by both the (type of) soil to be sampled, the size of the stockpile and the accessibility of the stockpile, as well as the time and financial possibilities for sampling.

NOTE 2 Sampling during transportation of the soil, by means of sampling from a conveyor belt or sampling from a mechanical shovel used to transfer the soil, is often to be preferred above sampling from a static stockpile. During transport probabilistic sampling is often much easier to accomplish than from the stockpile itself. However, in daily practice, it is most often not possible to sample the soil during transportation and thus sampling will be carried out from the static stockpile.

The sampling shall be carried out in accordance with probabilistic sampling as defined in 7.2.2 and H.1. Only if probabilistic sampling is not feasible shall the sampling be carried out in accordance with judgemental sampling, as defined in 7.2.3 and H.2. In view of the difference in quality between the samples obtained by probabilistic sampling and judgemental sampling, priority is given to probabilistic sampling.

7.2.2 Sampling techniques for probabilistic sampling

The following sampling techniques will, when applied correctly, result in probabilistic samples:

- simple random sampling;
- stratified random sampling;
- systematic sampling.

See also 6.5.

In the case of a stockpile which, due to the way it is available for sampling, cannot be satisfactorily differentiated from adjoining stockpiles, a “safety margin” shall be applied in connection with the spatial definition of the stockpile such that adjoining stockpiles do not partially overlap.

NOTE The size of the sampled stockpile is actually reduced by this safety margin. The material in the safety margin (the area where the adjoining stockpiles possibly overlap each other partially) can therefore not be assessed.

See Annex H for more details on the different sampling techniques.

7.2.3 Sampling techniques for judgemental sampling

When applying judgemental sampling, it can be preferred to deviate as little as possible from the probabilistic sampling. In those situations, the sampling techniques as mentioned in 7.2.2 and H.1 shall be used. In other situations, these sampling techniques are not applicable, or other types of sampling are preferential given the purpose of sampling. The following sampling techniques will normally not result in probabilistic samples, but are applicable for judgemental sampling:

- spot sampling;
- directional sampling.

See Annex H for more details on the different sampling techniques.

7.3 Sampling equipment

Selecting suitable sampling equipment is important for obtaining good quality samples. Advice should be sought on:

- a) the risk assessment of the sampling activities and the safety procedures to be implemented during sampling and transport;
- b) the moisture content of the soil;
- c) the maximum size and size distribution of the soil particles;
- d) the accessibility of sampling points;
- e) the quantity of soil necessary for the tests and analyses.

In the case of soil stockpiles, augers, drill sampling tubes, scoops and shovels are used. Sampling equipment, ancillary apparatus (and sampling containers) should be made of materials that do not interact physically or chemically with the sample.

Basic requirements common to all sampling equipment and ancillary apparatus are

- suitability for purpose,
- safety in operation,
- ability to take a representative sample from the required sampling point,
- capability of preserving the integrity of the sample until it can be transferred to a sample container,
- ability to be cleaned,
- simplicity in use,
- practicality of use, and
- ability to withstand rough usage.

Suggested applications for generic types of equipment are detailed in Table 2.

Table 2 — Suggested applications for generic types of sampling equipment suitable for sampling soil stockpiles

Generic sampling apparatus	Dry fine grained soil	Moist fine grained soil	Dry coarse grained soil	Moist coarse grained soil	Very coarse soils ^a
Soil auger	+/-	+	+	+	—
Drill auger	—	+	+	+	—
Mechanical drill	—	—	—	—	+ ^b
Open sampling tube	—	+	—	—	—
Half cut sampling tube	+	+ ^c	—	—	—
Plunger sampling tube	+/-	+	—	—	—
Scoop	+/- ^d	+	+	+	+
Mechanical shovel	—	—	—	+	+
^a Soils consisting of particles larger than 50 mm diameter. ^b Suitable for taking part of the individual particle. ^c Only suitable for a sludge. ^d Suitability depending on wind velocity.					

Detailed descriptions of the equipment identified in Table 2 are given in Annex I.

The size of the sampling equipment depends on the (maximum) particle size of the soil and the quantity of sample required. Depending on whether increments (3.5) or samples (3.16) are taken, the size of the sampling equipment should at least be equal to the actual increment or sample size respectively (see 6.6.5). In general, the opening used for sampling should at least be three times the diameter of the maximum particle size (D_{95}) in all directions that are relevant for the sampling process.

7.4 Incorporation in the sampling plan

Before actual sampling, the selected sampling equipment shall be prescribed in the sampling plan, see Clause 5.

When the circumstances in the field deviate too much from the assumed situation in the sampling plan, the sampling plan should be altered. Depending on the type of alterations, the project manager who made the sampling plan should be consulted prior to actual sampling. Subclause 5.5 gives instructions on the type of alterations that can be made by the sampler, and the alterations for which the project manager should be consulted.

7.5 Sampling

Prior to sampling, all elements of the sampling plan should be checked (see also 7.4). As a second step, the identity of the soil stockpile should be checked and recorded in such manner that it can be checked again on a later date. The most appropriate method is to photograph the stockpile.

NOTE Verification of the identity of the stockpile is often essential, specifically when the stockpile is publicly accessible or on a production site. Changes to the identity of the soil stockpile, either due to adding or removing (part of) the soil, will result in loss of validity of the sampling results.

For further identification of the stockpile, a number of visual characteristics can also be useful (e.g. colour, particle size, soil type). These characteristics should be noted by the sampler and be checked against the sampling plan when these kinds of characteristics are already mentioned there.

When the sampling plan is fully checked, the sampling locations shall be defined on the actual stockpile. This can be done either for all sampling locations at once or on individual bases prior to the sampling at that specific point.

After defining the sampling location, the sample is taken using the defined type of sampling equipment and applying the correct sampling technique.

Having obtained the sample, it is either directly stored in a suitable sample container (see Clause 9), or stored after appropriate sample pretreatment in the field, in accordance with Clause 8.

8 Sample pretreatment

8.1 General

Sample pretreatment is the process of subsampling, necessary to obtain a representative subsample for packaging and transport to the laboratory.

In sample pretreatment, two types of sample manipulation can be recognized:

- sample division: obtaining subsamples of smaller size than the original sample without reducing the particle size of the individual particles;
- particle size reduction: grinding the sample in order to reduce the particle size of the whole (sub)sample without reducing the sample size (mass).

Sample pretreatment is almost always necessary, as the amount of material sampled is larger than the amount of material necessary for the test or analysis.

When possible, the sample pretreatment shall take place in the laboratory, as sample integrity can be best guaranteed under laboratory conditions. However, the sampling of coarse material and the necessity to use large sampling equipment (e.g. a shovel) can result in (very) large samples. Sample pretreatment “in the field” can then be advisable in order to prohibit that these large samples have to be transported to the laboratory. In these situations, sample pretreatment “in the field”, directly after sampling, is advisable.

The requirements for sample pretreatment in the field are the same as for sample pretreatment in the laboratory. As the circumstances are in most situations not at all comparable to laboratory conditions, the type of sample pretreatment that is allowed in the field is limited to sample division. Only when laboratory conditions are available on site (there is a sample pretreatment laboratory/facility present), can the full range of sample pretreatment activities – thus also including particle size reduction – be carried out directly after sampling. As these conditions are only met in exceptional cases, sample pretreatment in this part of ISO 10381 only provides directions for the sample division that is possible in the field.

Whenever volatile components are to be determined, the process of sample pretreatment can result in a substantial loss of these components. Sample pretreatment shall be omitted in these cases by taking specific samples for the determination of volatile components. These samples shall be sealed directly after sampling, cooled and analysed as soon as possible after sampling.

In the case of very coarse soils, it can be necessary to reduce the particle size of the larger particles in the field in order to be able to send a representative sample of an acceptable size to the laboratory. When grinding or crushing “in the field” is truly necessary, measures have to be taken in order to prevent contamination and/or loss of both components and soil material. This part of ISO 10381 does not give instructions for these situations. In general, the basic International Standards for sample pretreatment are ISO 11464 and ISO 14507.

One should realise that the quality of subsampling in the field is less than the quality of subsampling in the laboratory, due both to the (environmental) circumstances for subsampling and to the inability to use the best possible subsampling method. When transfer of the individual sample(s) or composite sample(s) to the laboratory is possible, this should be considered as a preferable option.