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Soil quality — Sampling —

Part 301: Sampling and on site semi-quantitative determinations of volatile organic compounds in field investigations

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Contents

Page

Foreword iv

Introduction v

1 Scope 1

2 Normative references 1

3 Terms and definitions 2

4 General aspects 2

4.1 Using data from VOCs sampling 2

4.2 Behaviour of volatile organic compounds (VOCs) 3

4.3 Sampling strategy 4

4.4 Sampling plan 4

4.5 Sampling station 4

4.6 Health and safety 5

5 Taking soil samples in the field 6

5.1 General 6

5.2 Drilling techniques to take undisturbed soil samples 7

5.2.1 General 7

5.2.2 Windowless core sampler 8

5.2.3 Commentary on sampling from a windowless core sampler 8

5.2.4 Window core sampler 9

5.2.5 Sonic/Rota-sonic drilling 10

5.2.6 Filling of boreholes 11

5.3 Soil sampling techniques 11

5.3.1 General 11

5.3.2 Cutting cylinder filled in-situ and sealed 12

5.3.3 Small coring devices filled ex-situ and sealed (metal coring ring or disposable plastic corer) 13

5.3.4 Vial pre-filled with methanol 17

5.3.5 Glass jar with no field preservation 19

5.3.6 Advantages and limitations of sampling techniques 20

6 On site semi-quantitative measurement of volatile organic compounds 25

6.1 General 25

6.2 Advantages and limitations of portable equipment 26

7 Field storage and transport of samples 28

8 Cleaning of sampling equipment 28

9 Quality assurance and quality control 28

10 Data quality evaluation 29

11 Recording and reporting 29

Annex A (informative) **Procedures for application of soil sampling techniques** 30

Annex B (Informative) **On site semi-quantitative measurement of volatiles organic compounds types of measuring devices** 37

Annex C (informative) **Protocol for using a photo-ionisation detector** 43

Annex D (informative) **Sampling and on site semi-quantitative determinations of non-organic volatile compounds in field investigations** 47

Bibliography 51

Foreword

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This document was prepared by Technical Committee ISO/TC 190, *Soil quality*, Subcommittee SC 7, *Impact assessment*.

A list of all parts in the ISO 18400 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Introduction

Soil samples, especially those containing volatile organic compounds (VOCs), are subject to change as a result of physical, chemical or biological reactions that can take place between the time of sampling and the start of the analysis. The nature and intensity of these reactions is often such that, if the necessary precautions are not taken during sampling, transport, storage and laboratory preparation, the determined concentrations will be different from what they were at the time of sampling.

VOCs are flammable and typically toxic, carcinogenic, narcotic, or otherwise harmful to humans and other biota and terrestrial and aquatic ecosystems, and can cause degradation of certain artificial materials, including plastics. Human exposure can be by inhalation, ingestion (direct and indirect) and dermal contact.

Volatile organic compounds (VOCs) are organic compounds that are volatile under normal environmental/atmospheric conditions, although they can be found in the ground in the solid, liquid and dissolved phase form as well as in the gaseous phase (ISO 11074:2015/Amd.1:2020[1], 6.1.25 modified).

A knowledge of how VOCs can be present in the ground (organic phase, adsorbed phase, dissolved phase and vapour phase), their distribution between soil matrix (i.e. solid, liquid and gaseous), and how they can behave in soil is important. This is necessary in order to reduce uncertainties and to understand how reliable determinations of concentrations in soil are likely to provide a realistic picture of potential risks in any particular situation but also to better design remediation strategies.

Research and field experience have shown that:

a) depending on the management context, some sampling techniques are giving reliable results while others can lead to underestimating results;

b) if soil samples for VOC analysis are incorrectly collected and handled during field sampling, storage and laboratory preparation, a significant proportion of the volatiles compounds can be lost.

Therefore, it is important that the applied sampling techniques, and procedures for conservation, packaging, transport, delivery to the laboratory and laboratory preparation are well chosen, in relation to the degree of accuracy expected.

The decision maker and project leader in charge of investigations are responsible for choice of a soil sampling method that will provide representative soil samples and reduce uncertainties for subsequent interpretation. The selection of appropriate techniques and procedures depends on the objectives of the investigations, the soil characteristics, the nature of the volatiles compounds being targeted and possible organizational constraints in the field. Such attention and care assists in the collection of representative samples so that the analytical results later provide a reliable basis for estimating potential risks. In general, investigations performed on a sample in the laboratory can provide evidence for the sample only. Whether this can be transferred to the soil or site of interest and how far it can be valid should be considered carefully; however this is not within the scope of this document.

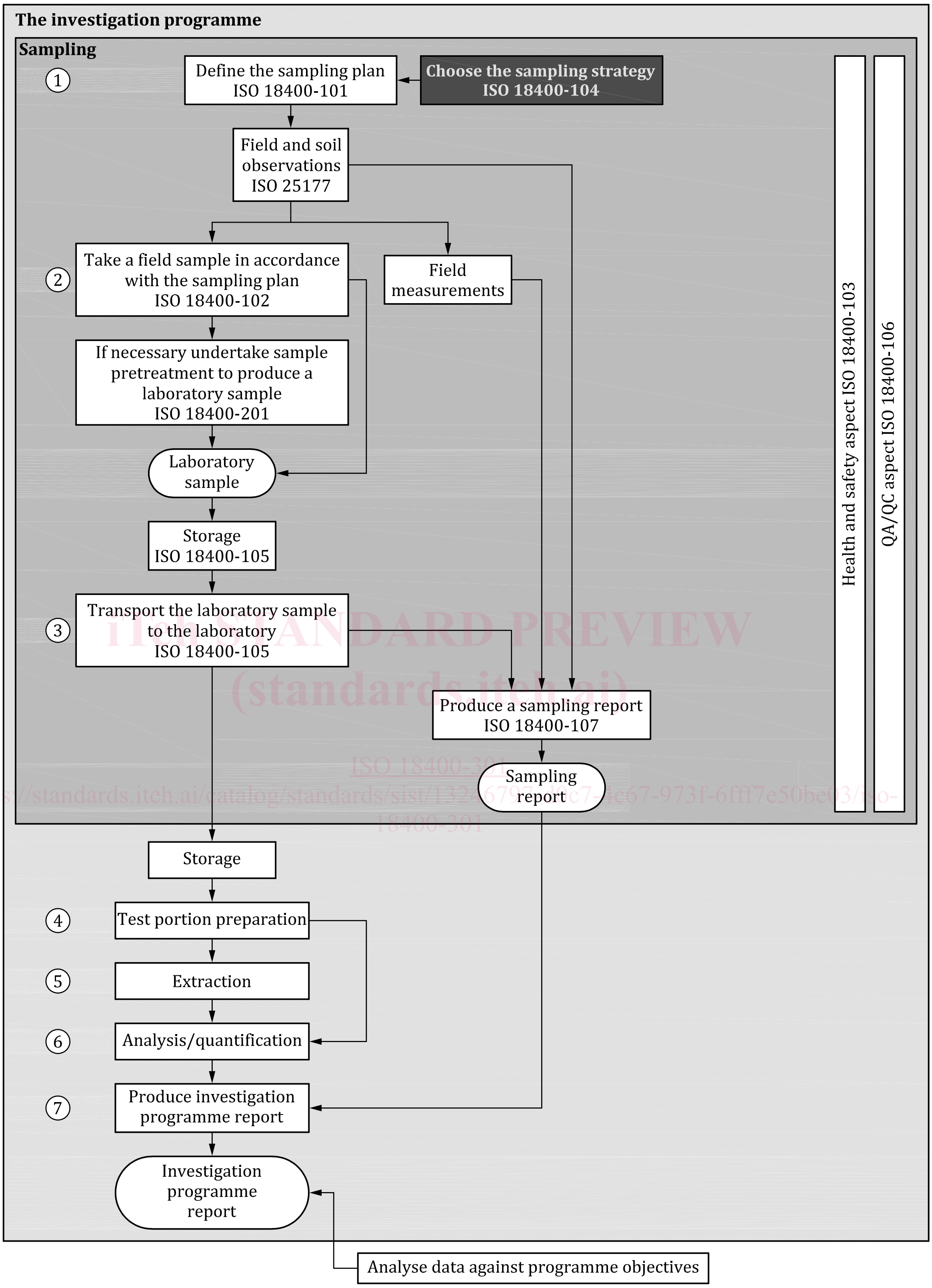
The main objective of this document is to help all stakeholders (technicians, project leaders, owner, authorities and laboratories) carry out adequate determination of VOCs when VOCs are known to be present or suspected in the soil. It provides requirements and guidance on the selection of relevant methods that can be used for taking soil samples, minimizing in the process the possible loss of VOCs before, during and after collection of soil samples. This document distinguishes two main approaches to the collection of soil samples (in-situ sampling methods and ex-situ sub-sampling methods) and clarifies their use, their applicability and limits. The description of each method takes into account the physical, chemical or biological reactions that can occur in soil and how it influences VOCs determination. For example, this document can provide field operators, project leaders and laboratories, an overview of relevant methods for measuring VOCs concentrations in soil, that minimize the possible loss of VOCs before, during and after sample collection.

This document also lists the main measurement instruments for semi-quantitative determination of VOCs during soil sampling (e.g. photoionization detector).

This document can be used when preparing field investigations or to analyse the results of such investigations. In particular, planning the sampling and measurement procedures can require considerable time, resources, competent staff and quality control during their implementation.

This investigation can be part of a broader environmental investigation or can be limited to only VOCs. Laboratories adopt procedures that will yield accurate results for the sample as presented to the laboratory. The sampling methods described are suitable for use in connection with, amongst others, the analytical methods described in ISO 15009,[2] ISO 16558-1[3] and ISO 22155[4].

International Standards within the total investigation program are shown in Figure 1.



NOTE 1 The numbers in circles define the key elements (1 to 7) of the investigation program.

NOTE 2 This figure displays a generic process which can be amended when necessary.

NOTE 3 The step requiring undertaking a sample pretreatment to produce a laboratory sample (see ISO 18400-201 “Physical pretreatment in the field”) is not applicable in the context of VOC sampling.

NOTE 4 When a vial with methanol is used, preservation of sample is done on site, not in the laboratory.

NOTE 5 Step 5 “extraction” consists of agitating the soil sample with the methanol. It is done once the sample is at the laboratory.

NOTE 6 The role of this document is illustrated in Figure 2.

Figure 1 — Links between the essential elements of an investigation programme

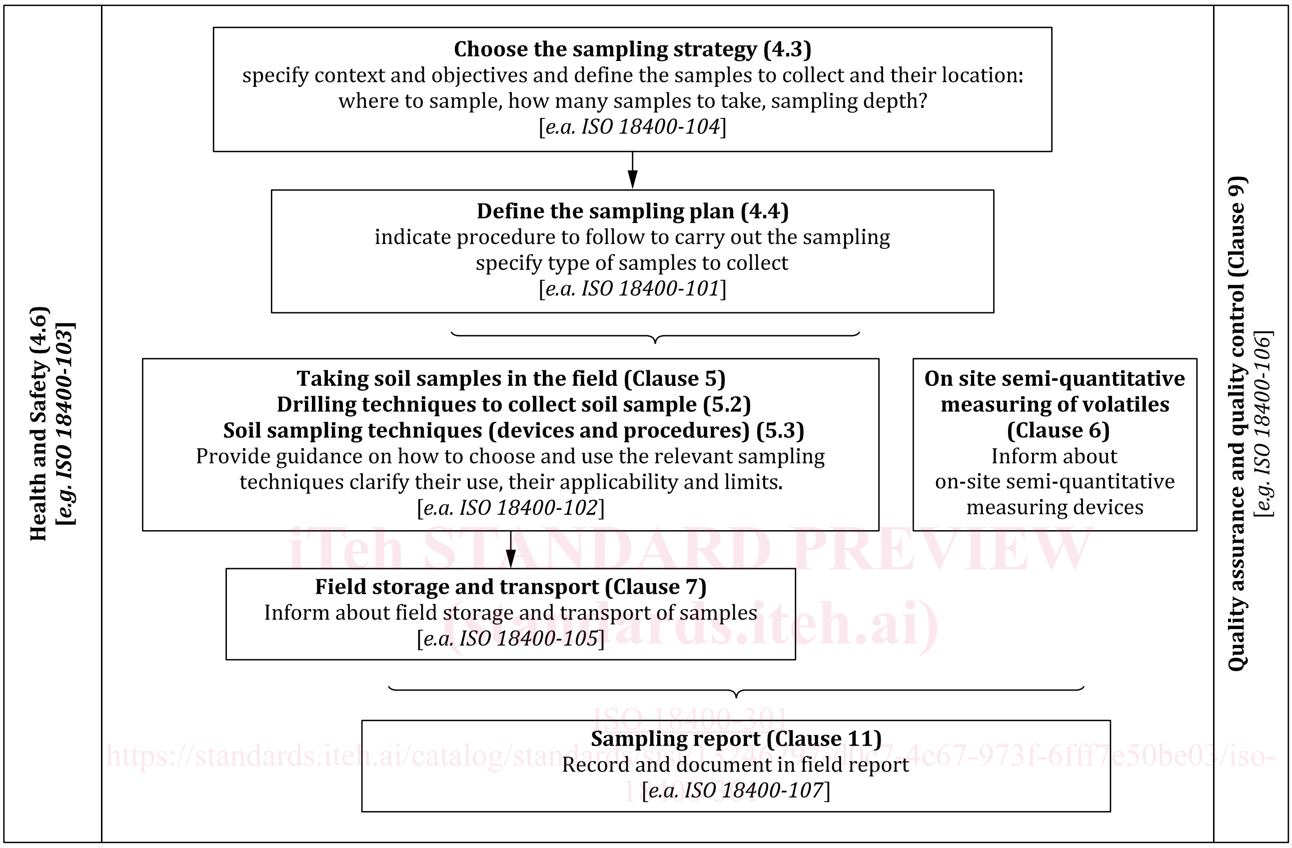


Figure 2 — Soil sampling process described in this standard in the context of VOCs

Soil quality — Sampling —

Part 301: Sampling and on site semi-quantitative determinations of volatile organic compounds in field investigations

1 Scope

This document provides specific requirements and recommendations on soil sampling and semi-quantitative measurements in field investigations for volatile organic compounds (VOCs) that are not explicitly covered in the existing ISO 18400 series. In addition, it provides information on the preparation steps (choosing a sampling strategy, defining a sampling plan); describes sampling techniques (drilling techniques, sampling devices and procedures) and field measurements; and gives advice on conservation, packaging, transport and delivery to the laboratory in the context of VOCs (see soil sampling process described in Figure 2).

VOCs to which this document can be applied include:

— volatile aromatic hydrocarbons such as benzene, toluene, ethylbenzene, naphthalene;

— aliphatic ethers such as methyl tert.-butyl ether(MTBE), ethyl tert.-butyl ether (ETBE) and tert.-amyl methyl ether (TAME);

— volatile halogenated hydrocarbons such as tetrachloroethene and, trichloroethene.

The document does not cover the volatile non-organic compounds. However, some information about these is provided in Annex D.

This document provides requirements and guidance on the selection of drilling and sampling techniques for determining VOCs and how to use them. It clarifies the applicability and limits of the drilling and sampling techniques, taking into account the physical, chemical or biological reactions that can occur in soil.

This document gives requirements and recommendations on the use of instrumental measurement techniques for determination of VOC concentrations in air, firstly in relation to worker safety, and subsequently for semi-quantitative measurements of volatiles during soil sampling.

The following subjects are outside the scope of this document:

— direct quantitative measurement of volatile compounds by field analysis laboratories;

— investigations and evaluation of soil gas quality (these are dealt with ISO 18400 204);

— safety risk assessment; and

— analytical procedures.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements 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 11074, *Soil quality — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 11074 and the following apply:

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
small coring device
instrument used to obtain small cores of soil for analyses

Note 1 to entry: The instrument can either be an apparatus that is used to take metal coring ring (see 5.3.3.2) or a disposable plastic corer (see 5.3.3.3).

3.2
cutting cylinder
cylindrical device with removable top and base forced into the surface of the ground/exposed soil to obtain an undisturbed sample

Note 1 to entry: Cutting cylinders can be reused if the size and shape is standardized between sampling institutes and laboratories. A commonly used specification is a stainless-steel cutting cylinder that has an internal diameter of 38 mm and a length of 200 mm which yields a sample volume of 226 ml.

[SOURCE: ISO 11074:2015/Amd.1:2020, 4.4.7 modified — the brackets have been removed; a note to entry has been added.]

3.3
sampling technique
all appropriate procedures and sampling devices to obtain samples in the field for soil description and laboratory testing and analysis

Note 1 to entry: The manner of selection of the sampling technique is to be described in the sampling plan.

[SOURCE: ISO 11074:2015, 4.4.29 modified — "and describe samples of soil or soil material, either in the field or during transportation and in laboratory" has been replaced by "samples in the field for soil description and laboratory testing and analysis".]

4 General aspects

4.1 Using data from VOCs sampling

Depending on the management context under consideration, the soil sampling strategy shall be chosen to ensure that the samples are representative of the volume of soil concerned and that the resulting data are sufficient in number and quality to meet the intended objective.

Where the aim of the investigation is to assess the health and safety risks from inhalation of vapours, risk assessments are based primarily on concentrations measured in soil gas or in ambient air (e.g. in a confined space), but it is common practice, and sometimes necessary, to also measure VOCs in groundwater and soil.

For soils, the applied sampling technique depends on the objectives of the investigations, the soil characteristics, the nature of the volatiles compounds being targeted and any organisational constraints in the field. This choice should also be based on an understanding and consideration of the factors that can compromise the analytical results by causing loss, or occasionally addition of VOCs.

Research studies have shown that if soil samples for VOC analysis are incorrectly collected and handled during field sampling, storage and laboratory preparation, a significant proportion of the volatile compounds can be lost.

American studies (Hewitt 1996 and 1999) show that loss by volatilisation occurs mostly within minutes to hours, while loss by biodegradation can extend over some days to several weeks. They show losses of 10 % to 15 % in just 5 min of exposure of the soil to air. These losses are greater than 90 % for TCE in less than 40 min.

The application of suitable sampling techniques and procedures for conservation is therefore required to preserve the sample, limit the loss of compounds through volatilisation or biodegradation.

If these aspects are carefully considered in the sampling plan, the collected sample should meet the requirement of representativeness. The analytical results consequently are likely to provide a reliable basis for estimating potential risks.

Results from soil sampling are only valid for the sample taken. They should be transposed to the soil environment or the studied site with caution and with the help of additional information and observations.

The decision maker and project leader in charge of investigations are responsible of the selection of a soil sampling method that will provide representative soil samples and reduce uncertainties for subsequent interpretation.

It is assumed that methanol immersion and use of a small coring device yield equivalent results. Publications of performance studies on the use of these two methods are available. French trials have also made it possible to compare (in order of magnitude) the sampling methods (metal coring ring, glass jar with no field preservation and vial prefilled with methanol).

NOTE For more information, see References [19] to [25].

4.2 Behaviour of volatile organic compounds (VOCs)

Before defining a soil sampling strategy, it is necessary to understand the behaviour of volatile compounds in soil. Particular attention to the following characteristics is needed:

a) VOCs are most likely to be present in soil following incidents such as spillages or leaks;

b) VOCs can be present in solution in water, in the vapour phase, sorbed to soil particles, present between particles as a non-aqueous phase liquid (NAPL);

c) VOCs can be preferentially associated with soil organic matter, including plant remains, or preferentially present in soil pore spaces and finer soil fractions;

d) concentrations of VOCs are likely to vary according to the types of soil (e.g. sand, clays), soil properties (e.g. grain size, moisture, organic matter) and in particular in the transition zone between two soil horizons;

e) concentrations of VOCs can vary by orders of magnitude over very short distances (e.g. a few centimetres).

Soil conditions with the highest potential for vapour intrusion (dry granular soil – high vapour permeability) are also the most difficult in which to accurately measure VOC concentrations. Conversely, moist homogenous fine soil (e.g. clay) are the easiest soil types in which to accurately measure concentrations, but typically represent the lowest potential for vapour intrusion due to their low vapour permeability.

Particular attention should be paid to the likely small-scale variations in concentrations and how VOCs can be present. It should be kept in mind, that the results received from the investigation of a sample are valid for the sample only. Transferring them to the soil or the site under investigation should be done with great care and with the aid of additional information and observations.

4.3 Sampling strategy

The sampling strategy specifies context, objectives and the samples to collect (e.g. number and type) and where to collect them from (location, depth, etc.).

NOTE For general guidance on sampling strategies, see ISO 18400-104[9].

4.4 Sampling plan

Soil samples are subject to modifications as a result of physical, chemical or biological reactions that can take place between the time of sampling and the start of the analysis. Especially when targeting VOCs, these shall be minimised. Therefore, precautions should be taken during the sampling process, transport and storage and laboratory preparation.

The possible observed modifications in the soil sample and losses can be linked mainly to the following factors:

— volatilization during drilling and sampling activities that result in a disturbance of soil structure, or aeration of soil samples and alteration of ambient vapour pressure;

— diffusion through the sample container during storage/shipping;

— biodegradation and chemical degradation during storage/shipping;

— volatilization losses during laboratory operations, for example, sampling methods that involve sample handling or sub-sampling in the laboratory.

These processes can influence sample results by either lowering concentrations or producing detectable biodegradation or chemical degradation products not present in the initial sample.

An important part of the sampling plan is to consider the importance of these changes. The sampling plan should specify, in consultation with the laboratory performing the analysis, procedures for sampling; and for preservation, storage and transport of samples; and any requirements specific to the method (s) of analysis to be employed.

When determining VOCs, single, undisturbed samples are usually collected for laboratory use: these samples are high quality discrete samples that are collected at a specified depth under controlled conditions that limit any physical or chemical disturbance of the sample. Specifically, none of the constituents of the sample should have been altered during the sampling process.

Assessment of a situation usually involves a lot of information about different media. For example, it could involve cross-referencing soil samples with measurements (in situ and/or in the laboratory), soil gas results, visual and field observations (colour, etc.).

All information about type of samples and applied sampling techniques should be described in the sampling plan.

NOTE For general guidance on sampling plans, see ISO 18400-101[6].

4.5 Sampling station

Sampling in accordance with this document usually requires good working conditions, as far as possible shielded from the weather (rain, wind, hot sun, etc.) at a designated location (sampling station). It requires dexterity, careful attention to the detailed application of the procedures and careful recording of everything that is done.

The sampling station should provide, a sheltered environment which allows samples to be collected, field measurements to be made, and soil descriptions to be carried out. It should also minimise the potential for cross-contamination, for example, from exhaust fumes, smoking and perfume.

A sampling station should ordinarily be established so that:

a) the material to be sampled can be accessed;

b) equipment can be laid out;

c) equipment can be cleaned if necessary;

d) samples can be transferred to temporary on-site storage;

e) samples can be prepared for transport off site; and

f) all operations and observations can be recorded (see Clause 11).

If a sampling station is not established, the reason should be recorded, and the potential impact on the reliability of sampling noted. When the sampling is carried out from an in-situ surface or disturbed recovered material, the sampling operation should be completed as close to the sampling location as possible once the sample has been taken into the sampling device.

NOTE The arrangements for sampling from a core obtained with windowless sampler or similar require special attention (see 5.2.2).

4.6 Health and safety

A health and safety risk assessment shall be undertaken prior to investigation which looks into the risks associated with the sampling techniques that are to be used, as well as other site-specific risks associated with intrusive site investigation, when dealing with soil containing VOCs.

Field operators should have appropriate first aid training.

All necessary measures shall be taken when selecting and applying sampling techniques to protect health and safety of those carrying out the work, anyone entering the site (with or without permission), and the general public (e.g. the occupants of neighbouring properties) and to avoid harm to the environment.

Risks associated with sampling soil containing VOCs which can be associated with direct contact and inhalation of toxic and potentially carcinogenic substances, shall be minimized by:

— appropriate design of the sampling techniques (use of drilling and sampling techniques to limit soil exposure to the atmosphere);

— provision of suitable personal protective equipment (PPE), such as chemical resistant gloves, eye protection and respiratory equipment where necessary;

— ceasing drilling and sealing the bored hole (this may be permanently or temporarily whilst advice is sought) if anything untoward is encountered (e.g. unexpectedly high concentrations of VOCs or positive gas flows) during drilling.

Before carrying out any intrusive sampling, checks for services should be made.

Appropriate training shall be given to ensure that personnel understand the precautions required when sampling soil containing VOCs and when using specific sampling methods, such as sampling into vials containing methanol or jars with no field preservation.

Methanol (toxic and flammable liquid) can present risks for the environment, health and safety. Vials containing methanol should thus be used according to a standard protocol in order to prevent exposure.

When immersion in methanol (toxic and flammable liquid) is chosen as the sample preservation method, then it is the responsibility of the user to establish appropriate safety and health practices and to ensure compliance with national regulatory conditions. These include undertaking sampling in a well-ventilated area, and access to washing and first aid facilities, including the provision of an eye wash. Field operators should have appropriate first aid training.

NOTE 1 For general guidance on safety, see ISO 18400-103[8].

NOTE 2 More information on the potential effects of contaminated soil on human exposure can be found in ISO 15800[5].

NOTE 3 A French trial has also made it possible to assess operator exposure in the field during soil sampling. See Reference [29].

5 Taking soil samples in the field

5.1 General

The drilling and sampling technique should be chosen taking into account:

— the objectives of the investigation;

— the required analytical data quality objectives which includes detection limits;

— the concentration range of interest if known;

— the soil's characteristics : type of soil (made ground, gravels, compact soil, dry sand, bedrock,...);

— the access conditions;

— the presence of asbestos and other hazardous substances;

— what VOCs are likely to be present based on the conceptual site model and the preliminary investigation.

As highlighted in Figure 3, implementing soil sampling techniques usually consists of two steps:

a) gaining access to the chosen depth at the sampling point using the relevant drilling equipment;

b) taking soil samples with an in-situ sampling method or an ex-situ sub-sampling method.

The following soil sampling techniques can be used in the context of VOCs - soil sample is taken and preserved in:

— a cutting cylinder filled in-situ that is immediately gas-tight sealed and sent to a laboratory;

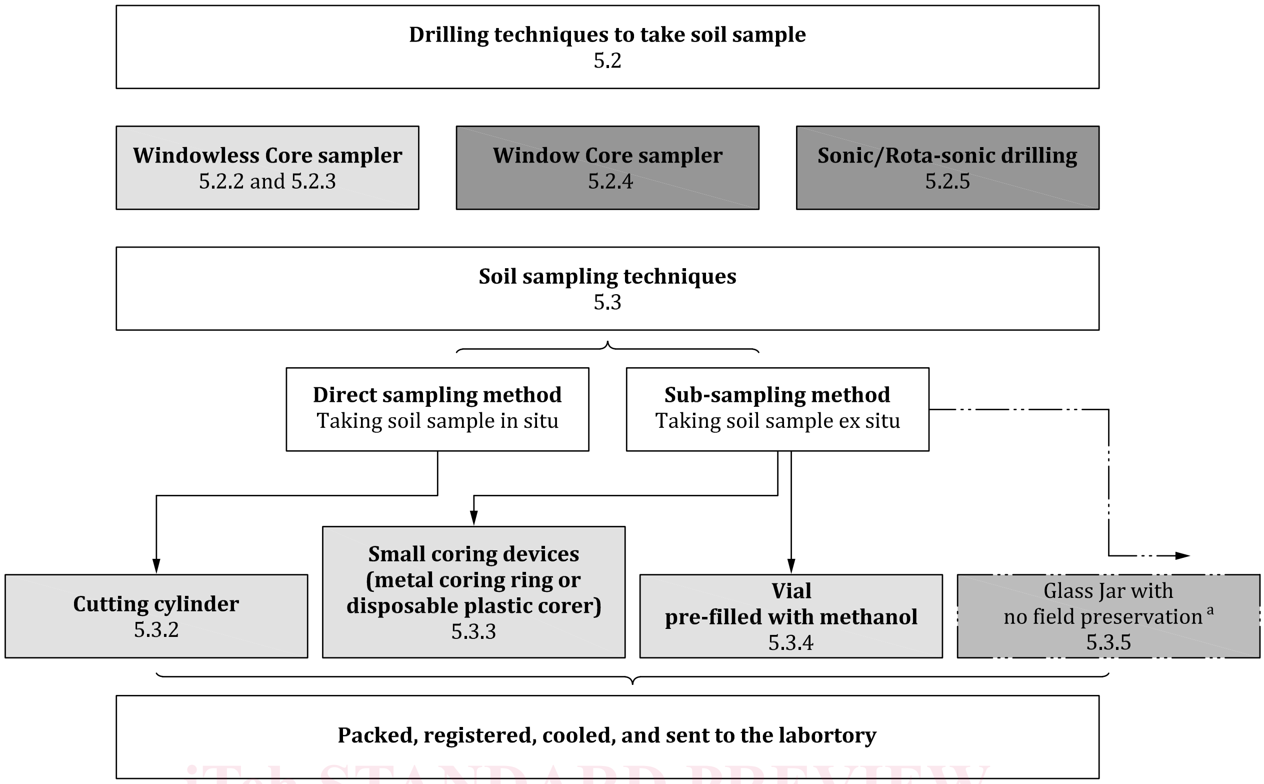
— a small coring device (metal coring ring or disposable plastic corer), filled ex-situ that is immediately gas-tight sealed and sent to a laboratory;

— a vial pre-filled with methanol (soil extruded ex-situ from a syringe or an appropriate coring tool) sent to a laboratory.

Publications of performance studies on the use of these methods are available (see References [21] to [26]).

Sampling into a glass jar with no preservation is not recommended to determine VOCs but where such a method is necessary, due to the specifics of the soil type or design of the investigation, every effort should be made to minimise as far as practical the loss of volatiles to atmosphere prior to sampling.

NOTE Sampling into a glass jar can lead to a recurrent underestimation of the results (i.e. VOC content in soils). This phenomenon is of varying magnitude according to the nature of the soils, the compounds present such as halogenated VOCs, etc. However, in certain special cases, a glass jar without field preservation can be used, provided that this is justified and the reasons recorded. The conditions of application and limitations of this method are presented in 5.3.1 and 5.3.5.



Key

More suitable for VOCs

a Sampling technique used in certain special cases.

Figure 3 — Drilling and sampling techniques

5.2 Drilling techniques to take undisturbed soil samples

5.2.1 General

This subclause provides specific information on possible drilling techniques to preserve the soil structure and collect undisturbed soil samples in the context of VOCs.

It provides information on how to select the appropriate drilling and sampling equipment when sampling and measuring VOCs. In this context, special attention shall be paid to the preservation of the sample to minimize VOCs losses and ensure the safety and health of the operator and the protection of the environment.

NOTE For more information about drilling techniques, see ISO 18400-102[7].

A key consideration for choosing a drilling technique is the ability to take soil samples representative of in-situ conditions. Samples submitted for laboratory analysis shall be capable of being tested for physical and chemical properties and for this reason the sample shall not be physically altered by the drilling technique.

The drilling techniques recommended in this subclause allow minimal soil disturbance and limit the loss of VOCs. Drilling techniques such as the windowless core sampler are effective for volatiles, as they allow for:

— collection of an undisturbed sample from the extruded core;

— preservation of the integrity of the samples and minimization of losses of VOCs;

