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Soil quality — Sampling —

Part 102:
Selection and application of sampling techniques

Qualité du sol — Échantillonnage —

Partie 102: Choix et application des techniques d'échantillonnage

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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.

The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation on the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT) see the following URL: www.iso.org/iso/foreword.html

This document was prepared by Technical Committee ISO/TC 190, *Soil quality*, Subcommittee SC 2, *Sampling*.

This first edition of ISO 18400-102, together with ISO 18400-104, ISO 18400-105 and ISO 18400-206, cancels and replaces ISO 10381-2:2002 and ISO 10381-6:2009, which have been technically and structurally revised. The new ISO 18400 series is based on a modular structure and cannot be compared to ISO 10381-2 and ISO 10381-6 clause by clause.

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

Introduction

This document is one of a group of International Standards intended to be used in conjunction with each other where necessary. It deals with various aspects of sampling for the purposes of soil investigation including agricultural, forestry, and contamination investigations, but is not applicable to investigations for geotechnical purposes. These are dealt with in the ISO 22475 series.

ISO 22475-1 specifies the technical principles for the execution of sampling and groundwater measurements for geotechnical purposes. It describes and provides guidance on the application of many of the sampling techniques included in this document albeit in a different context. Many contractors engaged to carry out work in connection with environmental studies will be familiar with its often prescriptive requirements. It includes detailed design information for some equipment. It is to be noted that the nomenclature used in this document may differ in places from that used in ISO 22475-1 because of the different contexts and traditions in the fields of geotechnical and geo-environmental investigation.

General principles to be applied in the design of sampling programmes for the purpose of characterization of soil and identification of sources and effects of contamination of soil and related material are given in ISO 18400-104[1)]. ISO 18400-104[1)] provides information about where to sample, the tests to be conducted, the type of sample, the depth of sampling and the required representativeness of the sampling system for sampling in respect of specific purposes.

This document is part of a series on sampling standards for soil. The role/position of the International Standards within the total investigation programme is shown in Figure 1.

1) Under preparation.

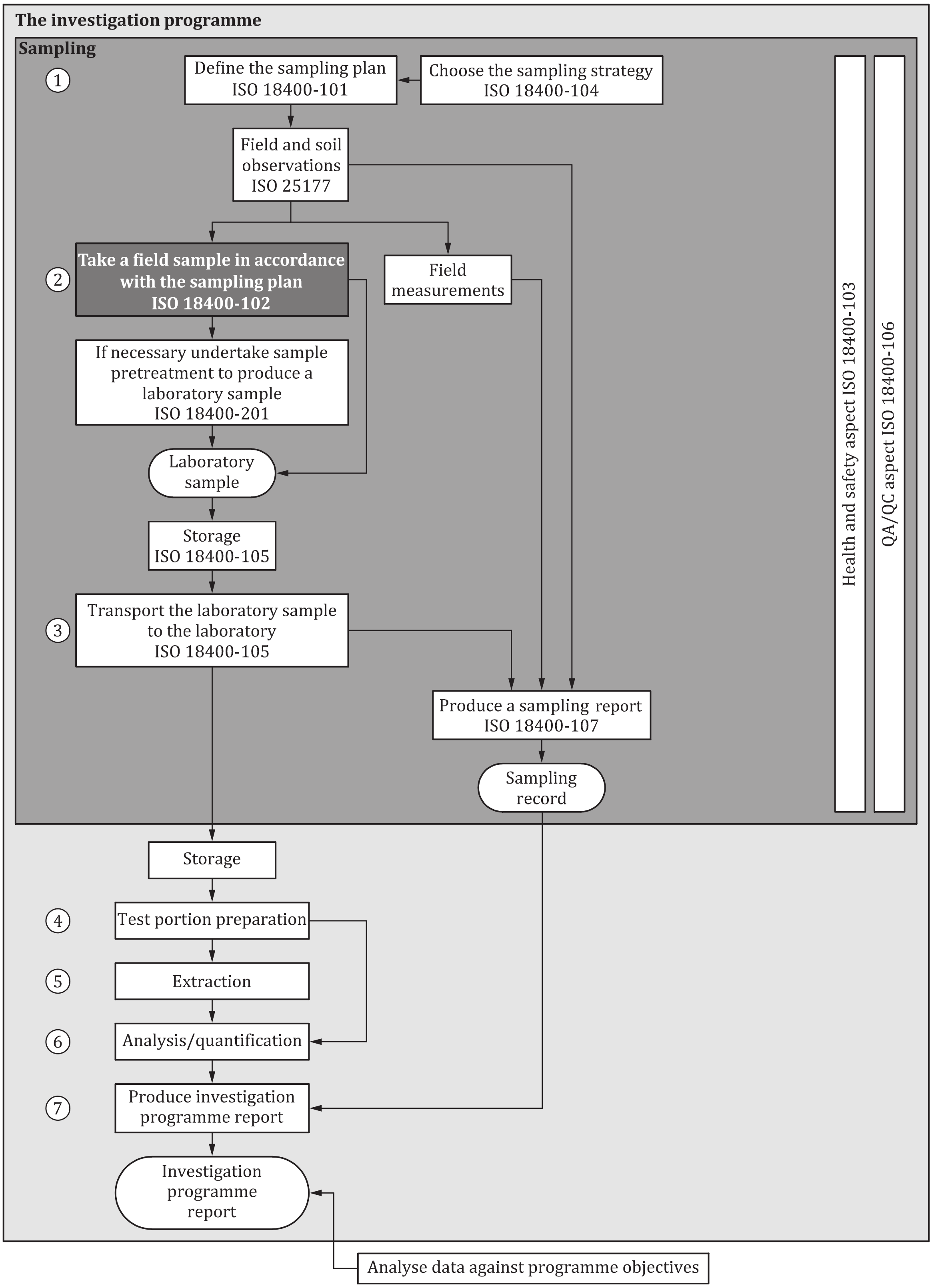


Figure 1 — Links between the essential elements of an investigation programme

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

NOTE 2 Figure 1 displays a generic process which can be amended when necessary.

Soil quality — Sampling —

Part 102:
Selection and application of sampling techniques

1 Scope

This document gives guidelines for techniques for taking samples so that these can subsequently be examined for the purpose of providing information on soil quality. It gives information on equipment that is typically applicable in particular sampling situations to enable correct sampling procedures to be carried out and representative samples to be collected. Guidance is given on the selection of the equipment and the techniques to use to enable both disturbed and undisturbed samples to be correctly taken at different depths.

This document does not cover:

— investigations for geotechnical purposes, though where redevelopment of a site is envisaged, the soil quality investigation and the geotechnical investigation may sometimes be beneficially combined;

— sampling of hard strata such as bedrock;

— methods for the collection of information on soil quality without taking samples such as geophysical methods;

— collection of water samples (these are to be collected in accordance with appropriate International Standards on ground or surface water sampling; for further information, see the ISO 5667 series);

— investigations of soil gas about which guidance is provided in ISO 18400-204;

— investigation of radioactively contaminated sites.

NOTE 1 "Sampling technique" is defined in ISO 11074.

NOTE 2 Guidance on the investigation and assessment of radioactivity in soils is provided in the ISO 18589 series.

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 3551-1, *Rotary core diamond drilling equipment — System A — Part 1: Metric units*

ISO 3552-1, *Rotary core diamond drilling equipment — System B — Part 1: Metric units*

ISO 10097-1, *Wireline diamond core drilling equipment — System A — Part 1: Metric units*

ISO 11074, *Soil quality — Vocabulary*

ISO 18400-101, *Soil quality — Sampling — Part 101: Framework for the preparation and application of a sampling plan*

ISO 18400-103, *Soil quality — Sampling — Part 103: Safety*

ISO 18400-104[2)], *Soil quality — Sampling — Part 104: Strategies and statistical evaluations*

ISO 18400-105, *Soil quality — Sampling — Part 105: Packaging, transport, storage and preservation of samples*

ISO 18400-201, *Soil quality — Sampling — Part 201: Physical pretreatment in the field*

ISO 18400-202[3)], *Soil quality — Sampling — Part 202: Preliminary investigations*

ISO 25177, *Soil quality — Field soil description*

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 terminological databases for use in standardization at the following addresses:

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

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

3.1
cluster sample
composite sample for which the increments are taken over a small area around a predefined sampling point

Note 1 to entry: Sampled area is typically about 0,5 m^2 to 1,0 m^2.

Note 2 to entry: Material sampled is taken from within the same stratum or from material with the same characteristics.

3.2
cutting cylinder
cylindrical device with removable top and base forced into the surface of exposed soil to obtain an *undisturbed sample* (3.7)

3.3
disturbed sample
sample obtained from the ground without any attempt to preserve the soil structure

EXAMPLE Sample obtained by using a hand auger.

[SOURCE: ISO 11074:2015, 4.4.8, modified — changed to read: ...from the ground...]

3.4
Kubiëna tin
metal box with removable top and base which can be forced into the surface of exposed soil to obtain an *undisturbed sample* (3.7)

Note 1 to entry: Usually made to desired size from aluminium, galvanized steel, or stainless steel sheet. Size varies, but a typical example might have an area of about 55 mm × 75 mm with a depth of 40 mm. The sample, once obtained, can be used to determine bulk density or may be impregnated with resin prior to the production of thin sections for microscopic examination.

2) Under preparation. Stage at the time of publication: ISO/DIS 18400-104:2016.

3) Under preparation. Stage at the time of publication: ISO/DIS 18400-202:2016.

3.5
spatial sample
composite sample formed from evenly spaced increments of the same size taken over a predetermined area which are then bulked together

Note 1 to entry: The increments may be located according to a regular grid, random, or other pattern. In agricultural/horticultural land investigations, “N”, “S”, “W”, and “X” sampling patterns are commonly used.

Note 2 to entry: The general premise is that the distribution of soil constituents is relatively homogeneous. Along the outline of such a pattern, a number of samples or increments are taken which are bulked and mixed to provide one (composite) sample for analysis.

3.6
spot sample
sample from a discrete location made up of one or more contiguous increments

Note 1 to entry: May be a *disturbed* (3.3) or *undisturbed sample* (3.7).

3.7
undisturbed sample
sample obtained from the ground with soil structure unaltered during sampling procedure

Note 1 to entry: Special sampling equipment is used so that the soil particles and voids cannot change from the distribution which exists in the ground before sampling (these can provide volume-proportional or mass-proportional results).

4 Principle

Sampling technique should be chosen taking into account all the needs of the investigation including planned distribution of sampling locations, the depth(s) from which samples are to be taken, the size and type of sample(s) required, the nature of any potential contaminants, and the nature of the site including any problems the site poses to carrying out the investigation.

The sampling technique(s) should be selected to enable:

— the collection of samples of soil and soil materials that can be presented to the laboratory for examination or analysis to establish basic information on the pedology and distribution of naturally occurring or man-made soils, their chemical, mineralogical and biological composition, and their physical properties at selected locations, as appropriate, to meet the objectives of the investigation;

— examination and recording of *in situ* materials exposed by the investigation.

NOTE 1 Detailed guidance on general aspects of sampling relevant to the selection and application of sampling techniques are given in 5.1 to 5.4 and about available techniques in 5.5. Detailed guidance on the selection of sampling techniques is provided in Clause 6 and on their application in Clause 7.

Among the decisions to be made is whether to use manual methods or machinery. Sampling may be required at or near the ground surface at some depth below the ground surface, or from locations deep below the ground surface. Methods of achieving the desired depth for sampling include formation of excavations (e.g. trial pits), by driven probes, or by drilling (e.g. boreholes).

Depending on the purpose for which sampling is being carried out, either disturbed or undisturbed, samples may be taken (5.3). Undisturbed samples could be required, for example, for soil physical testing or for determination of volatile organic compounds (VOCs).

NOTE 2 What constitutes a sufficiently undisturbed sample depends on the purpose for which the sample is required and can be a matter of judgement. For example, some compression of the sample might be acceptable when VOCs are to be determined, but would not be acceptable when the bulk density is to be determined. The ISO 22475 series defines classes of sample suitable for geotechnical testing.

Soil sampling techniques usually consists of the following two steps:

a) gaining access to the point of sampling (avoiding services, as well as removing any hard cover, etc., digging, or drilling a hole to reach the desired depth of sampling);

b) taking the soil sample.

These steps are interdependent and should both meet the requirements of the sampling principles.

NOTE 3 A distinction can also be made between:

— sampling by drilling (continuous sampling);

— sampling using samplers (sampling devices) to obtain disturbed or undisturbed samples as required once a borehole or excavation has been formed;

— block sampling (in which a large undisturbed sample is obtained).

Combinations of these sampling methods are possible and sometimes required due to the geological conditions and the purpose of the investigation.

5 General aspects

5.1 Health and safety

All necessary measures shall be taken when selecting and applying sampling techniques to protect the 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.

The guidance in ISO 18400-103 shall be followed.

ISO 18400-103 should be read in conjunction with relevant national and international legislation and regulations regarding health and safety at work and associated guidance produced by statutory bodies and trade associations.

5.2 Preliminary information

A preliminary investigation comprising a desk study and site reconnaissance (walk-over survey, site inspection) should be carried out as specified in ISO 18400-202 prior to undertaking any sampling.

The selection of the sampling technique, the sampling equipment to be used, and the method of taking soil samples depend upon the objectives of the sampling, the strata to be sampled, the nature of possible contamination, and the examination or analysis to be carried out on the samples.

Information should be compiled and assessed about the following:

a) the objectives of the sampling;

b) required accuracy of measurements;

c) planned locations for boreholes and excavations;

d) the anticipated depths from which samples are to be taken taking into consideration the future use of the site including depth of excavations or foundations (see ISO 18400-104);

e) potential risks to the health and safety of the site personnel;

f) potential risks to the environment from the investigation including the potential to pollute groundwater and to spread infective agents;

g) emergency arrangements;

h) the size and topography of the area to be sampled;

i) accessibility for different types and sizes of equipment and factors such as the likely bearing capacity of the ground, see Reference [1];

j) the nature of the ground to be sampled;

k) possible lateral and vertical variations of soil type or strata;

l) the geology of the site and surrounding area;

m) the assumed depth to groundwater;

n) previous usage or treatment of the site;

o) the presence of buildings and obstructions such as foundations, buried tanks, and underground services (e.g. electricity, sewers, mains, cables, gas);

p) the presence of concrete or tarmac pathways, roadways, or hard-standings;

q) the growth of vegetation leading to extensive root development;

r) the presence of unexpected surface-water pools or water-saturated ground;

s) the presence of fences, walls, or earthworks designed to prevent access to the site;

t) the presence of tipped material above the general level of the site or material from the demolition of buildings;

u) the presence of artefacts of archaeological or heritage value;

v) possible presence of unexploded ordinance, see Reference [2];

w) the presence of protected species, ecosystems, and other features of scientific value;

x) the presence of invasive or noxious plant species (e.g. Japanese Knotweed – *Fallopia japonica*, Giant Hogweed – *Heracleum mantegazzianum*) or infective agents (these may affect humans, animals, or plants) (see also 7.2, last paragraph);

y) location of water bodies at risk from contamination including surface and ground water;

z) the planned flow of information.

NOTE For guidance on accessibility for light percussion drilling rigs, see Reference [1].

5.3 Sample types

The samples taken should be of appropriate type(s) to enable the objectives of the investigation to be achieved in accordance with the guidance provided in ISO 18400-104. Special consideration is required regarding the following:

— whether to take disturbed or undisturbed samples;

— whether to take spot samples or cluster samples or to employ a form of spatial composite sampling (see Table 1);

— how to comply with any statutory or authoritative guidance relating to judging whether guideline values (assessment criteria) have been exceeded;

— whether statistical analysis of the data obtained will be required;

— the expected distribution of contaminants or other substances of interest;

— how to reduce uncertainty in the results of the investigation.

Composite samples should not be used when soil characteristics that may suffer changes during the composition process, such as concentrations of volatile compounds, are to be determined. They also should not be used if peak concentrations of any substance or variations of soil characteristics are to be determined.

The use of cluster samples can reduce sampling uncertainties. This method of sampling is particularly appropriate when using trial pits when surface samples (e.g. 0,0 mbgl to 0,10 mbgl) are being taken and when carrying out validation sampling of imported topsoil.

Where composite sampling is used to determine the characteristics of *in situ* soil, the sample should represent a single stratum.

NOTE Table 1 provides information on different types of sample and their application.

Table 1 — Types of sample

Type of sample[a]	Uses	Means of sampling
Disturbed sample See 3.3	Disturbed samples are suitable for most purposes except, e.g. for determination of volatile organic compounds (VOCs), some physical measurements, profile descriptions, and microbiological examinations for which undisturbed samples are required.	Samples can be collected using one of a variety of sampling techniques. Disturbed samples may be taken as single spot samples or as composite samples where this is appropriate for the objectives of the investigation.
Undisturbed sample See 3.7	Undisturbed samples are inherently spot samples, i.e. taken from a specific material at a specific location and depth.	Samples can be collected using one of a number of techniques designed to preserve the soil structure and/or to prevent the loss of volatiles. The initial undisturbed field sample may sometimes be taken over a depth range or of extended lateral extent (e.g. when a core is taken for later examination) and subsequently subsampled in the laboratory.
Spot sample See 3.6	Suitable for identifying distribution and concentration of particular elements or compounds in geological or contamination investigations.	Samples can be collected using one of a variety of sampling techniques. Where undisturbed samples are required, specific drilling methods or special equipment (see Clause 8) are used to collect the sample while maintaining the original ground structure.

[a] See ISO 18400-104 for detailed guidance.

Table 1 *(continued)*

Type of sample[a]	Uses	Means of sampling
Cluster sample See 3.1	Suitable for identifying distribution and concentration of particular elements or compounds in geological or contamination investigations involving disturbed samples.	Samples are typically collected using hand tools on exposed surfaces, but may also be taken from locations within a bucket of excavated material.
Spatial (composite) sample Spatial sample, see 3.5	Appropriate for assessing the overall quality or nature of the ground in an area, e.g. for agricultural purposes. Not normally recommended for investigations of land potentially affected by contamination However, some jurisdictions specify the use of a form of composite sampling for the assessment of surface and near-surface soils.	Samples normally collected using auger, trowel, or similar implement for speed and repeatability.

[a] See ISO 18400-104 for detailed guidance.

5.4 Sample size

Instructions regarding the size of the samples to be sent to laboratories should be provided in the sampling plan (as specified in ISO 18400-101) in accordance with the guidance in ISO 18400-104 taking into account, among other things:

— the range of pedological, chemical, physical, and/or biological examinations and tests that are to be carried out;

— the particle size distribution of the material be sampled;

— the specific requirements of the laboratory(ies) carrying out the examinations and tests.

Any subsampling from the sample extracted by the equipment or measures to reduce the volume of material to be transported to the laboratory should be carried out in accordance with ISO 18400-201.

When potentially expansive slags are to be sampled for expansion tests, specialist advice should be sought. These tests commonly require samples of about 50 kg or more to be taken, see References [3] and [4].

NOTE Often, laboratories carrying out the chemical analyses will require more than one sample from a location with those for different tests being of an appropriate size and placed in an appropriate container (e.g. plastic tub, glass jar) rather than a single large sample that can be subdivided or subsampled in the laboratory.

5.5 Available techniques

Available techniques for accessing and obtaining samples are listed in Table 2 together with qualitative information about their advantages and disadvantages. Table 3 provides further detail on the applicability and characteristics of the techniques while Table 4 provides further information on practical aspects of their application, such as the operating footprint and access requirements.

The use of other methods which might be suitable in specific locations or other methods which are developed in the future are not precluded by this document (see Clause 7).

Extreme natural circumstances such as permafrost, laterization, calcretion, or other indurations might require techniques other than those listed in Tables 2 and 3, in order to obtain samples.

Other situations where special procedures might be required include, for example:

— sampling water-saturated soil (influenced by groundwater) in order to avoid negative influences on structure and physical properties, as well as loss or displacement of substances of interest;

— sampling when asbestos or asbestos-containing materials are present in the ground (it is essential to comply with national regulations concerning asbestos in relation to protection of workers, preventing spread of the asbestos, and the disposal of asbestos-containing wastes) (see References [5] and [6]).

NOTE 1 ISO 22475-1 specifies the technical principles for the execution of sampling and groundwater measurements for geotechnical purposes. It describes and provides guidance on the application of many of the sampling techniques included in this document, albeit in a different context. Many contractors engaged to carry out work in connection with environmental studies will be familiar with its often prescriptive requirements.

NOTE 2 When sampling from a trial pit, samples may be taken using a trowel, or similar, or samplers with a cutting action may be used (9.1.1), or block samples recovered. In cohesive soils, block samples can be cut by hand.

Continuous sampling (sampling by drilling) allows the following:

— identification and description of the soil at the site penetrated by the borehole;

— the differentiation of distinct soil layers and changes of soil material;

— the sampling, as well as the investigation of samples from all strata and depths.

Sampling using samplers (sampling devices) can be used in conjunction with many drilling methods. The drilling diameter should be chosen so that the sampler can be lowered to the borehole bottom without hindrance.

Table 2 — Principle techniques for taking samples

Methods	Advantages	Disadvantages
Table 2 should be read in conjunction with Table 3 which gives further information on the applicability of ground excavation, drilling, and sampling techniques.		
Thin diagnostic layer scraping Can be formed by scraping off a thin layer (10 mm to 50 mm) from the exposed surface using a small shovel, trowel, spatula, or similar tool. Increments may be taken in this way from a number (e.g. 5 to 10) of squares and combined in a composite sample.	Allows collection of loosely compacted layers, especially organic horizons and a thin A horizon in forest areas.	—
Digging trial pits and trenches Can be formed by hand digging vacuum excavation or using wheeled or tracked excavators depending on the requirements of the investigation. For health and safety reasons, trial pits cannot normally be entered, unless shored, see Reference [7]. A suitably wide bucket is chosen according to the depth to be excavated which allows a good view of the excavation, but minimizes the amount of material excavated.	Allows detailed examination of ground conditions (in three dimensions). Easy to obtain discrete samples (where entry is appropriate) and bulk samples. Rapid and inexpensive if dug by hand or machinery is available. Applicable to a wide range of ground conditions. Can be used for integrated contamination and geotechnical investigations. Excavations (including separate faces) and excavated material can be photographed. It is good practice to use an identifier board giving the trial pit reference and also a scale, e.g. surveyor's staff. Use of a board showing standard colours can also be helpful.	The investigation depth is limited by the size of the machine (generally, approximately 4,5 m) (see Table 3). There can be significant safety issues (see ISO 18400-103, A.1.3 and Reference [7]). Media are exposed to air and there is a risk of changes to contaminants and loss of volatile components. Not suitable for sampling below water and groundwater table. Greater potential for disruption of/damage to the site than boreholes/probe holes. Care is required to ensure that surrounding area is not affected by excavated spoil and that reinstatement does not leave contaminants exposed or result in settlement of trafficked surface. Can generate more waste for disposal than boreholes. There is more potential for escape of contaminants to air/water. Might be necessary to import clean material to site for backfilling (to ensure clean surface).

[a] See A.2.

Table 2 *(continued)*

Methods	Advantages	Disadvantages
Hand augering Many designs available for different soil types, conditions, and sampling requirements. Preferred forms take a core sample.	Allows examination of soil profile and collection of samples at pre-set depths. Easier to use in sandy soils, i.e. where there are no obstructions, such as stones. Portable and useful for locations with poor access. Limited operating expense.	Only limited depths can be achieved if obstructions present, e.g. stones. Ease of use very dependent on soil type. Can lead to cross-contamination from material falling down auger hole. This can be prevented by the use of plastic casing. Only small sample volumes obtainable. Equipment can be physically difficult to operate. Samples are heavily disturbed. Not recommended for sampling for volatiles.[a]
Forming power driven auger boreholes Rotary drilling using solid stem auger	Can achieve greater depths than hand augers. More rapid than hand augering for shallow investigations. Can be used to install water and ground gas monitoring wells if hole remains open after withdrawal of auger.	Greater risk of physical injury to operator due to lack of guards and potential for snagging (due to obstructions). There is a need to avoid cross-contamination of samples and contamination due to fuel/exhaust gases. Sampling is only possible when auger withdrawn and if borehole remains open. Not suitable for sampling for volatiles.

[a] See A.2.

Table 2 *(continued)*

Methods	Advantages	Disadvantages
Forming hollow stem auger boreholes Uses a continuous flight auger with hollow central shaft. Withdrawing centre bit and plug allows access down the stem for sampling.	Forms a fully cased hole avoiding potential problems of cross-contamination arising with cable percussion techniques. Soil samples can be taken through hollow stem allowing accurate estimation of depth. Can be used for installation of water and ground gas monitoring wells. Usually more rapid than cable percussion. Good recovery possible of very coarse samples (e.g. river terrace gravels) compared to cable percussion.	Less amenable to visual inspection of strata than cable percussion boreholes. Less suitable for deeper boreholes than cable percussion, unless large rigs used. Not suitable for sampling for volatiles. Difficulties in measuring water strikes, particularly where water is used during drilling.
Driven tube sampling Consist of a hollow metal tube (possibly with a plastic sleeve) that is driven into the ground with a hydraulic or pneumatic hammer.	Continuous intact samples of the complete soil profile can be recovered. A variety of measuring devices can be installed once hole is formed. Less potential for adverse effects on health and safety and above-ground environment than trial pits and boreholes. Can be used either for shallow sampling or at depths down to 10 m with appropriately sized equipment. Substantially faster than cable percussion. Portable so can be used in poor and limited access areas. Enables groundwater samples to be collected since ground is not disturbed. Enables monitoring well installation by using a driven point slotted well screen.	Limited opportunity to inspect strata. Sample volumes can be relatively small depending upon the diameter of the driven tube. Cannot penetrate obstructions, e.g. brick. Can cause smearing of hole walls in some strata. Poor sample recovery in non-cohesive granular material. Causes compression of some strata, e.g. peat. Holes not cased and could open up migration pathways. Limited possibility of sampling for volatiles. Difficulties in measuring water strikes, particularly where water is used during drilling.

[a] See A.2.

Table 2 *(continued)*

Methods	Advantages	Disadvantages
Dynamic sampling, window sampling, windowless sampling, closed piston sampling Cylindrical steel tubes are driven into the ground by a percussive hammer Steel tubes are often provided with disposable plastic liners. (Some dynamic sampling rigs are capable of rotary drilling also.)	Permits collection of continuous intact samples Can be used for installation of water and ground gas monitoring wells. Very compact rigs are available which can be used inside buildings or where space is limited. Does not require flush to be used minimizing the risk of cross-contamination and waste generated Effective at retaining volatiles, especially in cohesive soils where a plastic liner is used and because a relatively intact sample can be cut from the extruded core. Windowless sampling can be used to obtain samples for testing for volatiles. Casing can be inserted where the rig has adequate power and a removal system.	Generally, poor recovery in dense sands and gravels loose sands below the water table and certain types of made ground. Limited depth of penetration compared to other drilling methods, particularly for the smallest rigs. Where used, a percussive hammer is noisy. Could be unsuitable in certain locations where noise is an issue Cannot penetrate through hard rock or obstructions (except where the drilling rig has a dual percussive and rotary capability). Hammering and rod vibration can lead to compaction of sediments within the plastic liner during sampling. Difficulties in measuring water strikes, particularly where water is used during drilling.

[a] See A.2.

Table 2 *(continued)*

Methods	Advantages	Disadvantages
Forming cable percussion boreholes Consists of a tripod derrick with a winch driven by a diesel engine. The cutting tool which forms the borehole by gravity percussion is attached to the winch via a steel cable. Steel casing can be used to support the borehole	Allows greater sampling depth than trial pits or hand augers. Enables installation of permanent sampling/monitoring wells. Can penetrate most soil types. Less potential for adverse effects on above-ground environment than trial pits (but note, there are potential risks to groundwater). Minimal surface disturbance. Allows the collection of intact samples. Allows integrated sampling for contamination, geotechnical and gas/water sampling, and the installation of groundwater and ground gas monitoring pipes. Allows use of clean drilling techniques for aquifer protection. Not usually suitable for sampling for volatiles, but large diameter cores can be sealed in the field and subsampled in the laboratory under controlled conditions.	More time-consuming than trial pits and hand augers. Less amenable to visual inspection than trial pits. Waste from boreholes requires disposal and can cause surface contamination where groundwater or liquid contamination is present. Limited access for discrete sampling purposes. Smaller sample volumes than for trial pits. Can cause disturbance of samples and therefore, loss of contaminants. Potential for contamination of underlying aquifers and groundwater flow between strata within an aquifer, unless properly cased (see 7.2). Samples from standing water can be subject to cross-contamination and are therefore, not representative of the groundwater (see B.2.7, Application). Difficulties in measuring water strikes, particularly where water is used during drilling.

[a] See A.2.

Table 2 *(continued)*

Methods	Advantages	Disadvantages
Sonic/rota-sonic drilling Involves the use of high-frequency energy which shears and displaces the soil particles. Two types of rig are generally available: sonic and rota-sonic. Rota-sonic combines rotary and sonic drilling capabilities in the same rig	Permits at or near 100 % core recovery in the majority of ground conditions. Fast drilling is possible. Permits recovery of intact samples. The use of drilling flush is not always necessary. Rotary-sonic drilling can penetrate all soil types and also hard rock, concrete, and other obstructions (sonic drilling can be subject to refusal). Might permit sampling for volatiles from core.	Some rigs do not have the ability to insert casing, which could result in the creation of migration pathways. Dry drilling (without flush) can result in heat being generated by the drill rod, which causes loss of volatiles. This can be reduced by changing the drilling process. Sonic drilling in weak rock can result in drilling-induced fracturing of the intact samples, which could be of concern if an integrated investigation (see 7.2) is required. Dry soils can adversely affect progress of probing. Difficulties in measuring water strikes, particularly where water is used during drilling. Drilling flush requires containment and disposal.
[a] See A.2.		

Table 3 — Applicability of ground excavation, drilling, and sampling techniques

Designation	Method	Method of sample extraction	Normal area/ diameter	Soil profile detail	Suitability for ground type		Suitable below water table	Type of sampling possible	Typical depth of sampling[a]	Comments
				mm	Unsuitable for soil type	Suitable for soil type			m	
Manual methods										
Hand auger	Rotary	With auger	50 mm to 100 mm	50	Hard rock Non-cohesive gravel, stones, rubble, lumps of material Likely to be difficult in made ground	Clay, silt, cohesive sand and similar ground Granular-material subject to ground stability, grain size and degree of cohesion	No	Disturbed	0 to 2,0	Sampling to 5,0 m possible in cohesive sandy ground Some types of auger can be used below water table
Hand excavation	Digging	With sampling tool	1 m × 1 m	10	Solid concrete or similar obstruction	All types	No	Disturbed or undisturbed	0 to 1,5	In unstable ground, the sides may need support
Machine excavations										
Trial pit	Digging	With sampling tools	3 m to 4 m × 1 m	10	Hard rock Large solid obstructions	All soils and material including made ground subject to ground stability	No	Disturbed and undisturbed	0 to 6	
Power-driven sampling holes										
Power driven auger	Rotary	With auger	50 mm	50	Non-cohesive gravel, large stones, lumps of material	Clay, silt, cohesive and similar ground	No	Disturbed	0,05 to 2,0	Sampling to 5,0 m possible in cohesive sandy ground

NOTE Table 3 is only indicative.

[a] Where a minimum depth is given, a "starter pit" of the specified depth is usually required.

Table 3 *(continued)*

Designation	Method	Method of sample extraction	Normal area/diameter	Soil profile detail	Suitability for ground type		Suitable below water table	Type of sampling possible	Typical depth of sampling[a]	Comments
				mm	Unsuitable for soil type	Suitable for soil type			m	
Continuous flight auger	Rotary drilling with solid stem auger	Not possible	150 mm to 500 mm	300 to 500	Solid obstructions and hard rock/boulders	All soils	No	None	0 to 20	Suitable for passing through top layers which are of interest
Hollow stem auger	Rotary drilling	With sampling equipment down stem	150 mm to 500 mm	50	Solid obstructions and hard rock/boulders	All soils	Yes	Disturbed and undisturbed	0 to 20	Sampling down centre stem with auger *in situ* possible
Pulse boring/dynamic probe	Ramming	With sample tool on machine	50 mm to 100 mm	25	Hard rock Gravels, large stones, lumps of material Very dense sands and gravels	Clay, silt, cohesive sand and similar ground subject to grain size and cohesiveness	Yes	Disturbed and undisturbed	0,5 to 10	
Light cable	Percussion	With boring tools	150 mm to 300 mm	100	Obstructions, e.g. tyres, wood, concrete, solid obstructions and hard rock/boulders	Clay, silt, cohesive sand and similar ground	Yes	Disturbed and undisturbed	0,5 to 30 (but can be deeper)	

NOTE Table 3 is only indicative.

[a] Where a minimum depth is given, a "starter pit" of the specified depth is usually required.

Table 3 *(continued)*

Designation	Method	Method of sample extraction	Normal area/ diameter	Soil profile detail	Suitability for ground type		Suitable below water table	Type of sampling possible	Typical depth of sampling[a]	Comments
				mm	Unsuitable for soil type	Suitable for soil type			m	
Driven probes	Pressure	Retrieval of core	30 mm to 150 mm	10	Hard rock Solid obstructions Very dense sands and gravels	All soils subject to grain size and cohesiveness	Yes	Disturbed and undisturbed	0 to 30	Core obtained and *in situ* instruments possible in some cases
Sonic	High-frequency energy (HFE)	Retrieval of core	Up to 125 mm	25 to 10	Harder/ compact formations	Soft to medium geology	Yes	Disturbed and undisturbed	0 to 40	Some rigs do not permit use of casings
Rotasonic	High-frequency energy with simultaneous rotation	Retrieval of core	Up to 300 mm	25 to 10	None	All overburden, including boulders, mixed formations and bedrock	Yes	Disturbed and undisturbed	0 to 100	
Multi-function drill	Percussion Rotary Pressure	Various bits	30 mm	150 to 2 500	No natural obstructions	All types including glacial till and bedrock	Yes	Disturbed and undisturbed	0 to 100	Suitable specially in glaciated terrain

NOTE Table 3 is only indicative.

[a] Where a minimum depth is given, a "starter pit" of the specified depth is usually required.

Table 3 *(continued)*

Designation	Method	Method of sample extraction	Normal area/diameter	Soil profile detail	Suitability for ground type		Suitable below water table	Type of sampling possible	Typical depth of sampling[a]	Comments
				mm	Unsuitable for soil type	Suitable for soil type			m	
Rotary drills (open hole)	Rotary	Detailed profile not possible Generally for borehole formation only	150 mm to 500 mm	300 to 500	Solid obstructions	All soils	No	None	1,0 to 40	Suitable for passing through top layers which are not of interest but should avoid creation of migration pathways for contaminants
Rotary drills (core drill)	Rotary	Retrieval of core	150 mm to 500 mm	300 to 500	Solid obstructions	All soils	No	None	1,0 to 20	
Direct push Open piston and closed piston samplers	Percussive See Reference [8]	Liner in open tube or closed piston sample	29 mm to 60 mm	5 to 10	Cemented sediments elastic layers (e.g. brown coal), solid obstructions	Sand, clay, soft gravel	yes	Disturbed and undisturbed	To 20	

NOTE Table 3 is only indicative.

a Where a minimum depth is given, a “starter pit” of the specified depth is usually required.

Table 4 — Physical requirements of different techniques

Physical requirements	Investigation method									
	Excavator	Hand dug pit	Hand auger	Percussive sampler	Driven samplers			Borehole		
					Hand operated	Vehicle mounted	Cable percussion	Rotary	Sonic	Rotary sonic
Footprint required	20 m^2	3,0 m^2	1,0 m^2	5 m^2 to 15 m^2	2,0 m^2	20 m^2	30 m^2[d]	30 m^2	20 m^2	
Ease of surface penetration[a]										
Concrete	Yes	No	No	No	Moderate	Yes	Moderate	Yes	No	Yes
Soil	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Compact aggregate	Yes	Moderate	Moderate	No	Yes	Yes	Yes	Yes	Yes	Yes
Depth restriction	4,5 m[b]	1,2 m[c]	1,0 m to 5,0 m	30 m	3 m	7 m	30 m[b]	None	30 m	None
Restricted by height	Yes	No	No	Yes	No	3 m	Yes	Yes	Yes	Yes
Surface disturbance	Large	Small	Minimal	Minimal	Minimal	Moderate	Moderate to large	Moderate to large	Minimal to moderate	Minimal to moderate
Width restriction	Yes	1,0 m	1,0 m	Yes	1,5 m	Yes	Yes	Yes	Yes	Yes

NOTE Values given under “depth restriction” are general values based on experience which can significantly vary.

a Different techniques are available for breaking out the hardcover and any buried obstructions on a site. The most appropriate technique will depend on the nature of the hardcover/obstruction and the area necessary to breakout for the purpose of the investigation. A careful assessment of the risk to buried services should be made.

— Hand-held power breakers may be used, but these require an experienced operator and a source of compressed air and are not appropriate for penetrating thick concrete (more than 250 mm) or below-ground obstructions. The impact of vibration effects on operators should be considered with this type of equipment.

— In some cases, the equipment selected for the site investigation could be capable of also carrying out the breaking out.

i) Cable percussion equipment can chisel through concrete (less than 100 mm thick) and tarmac. Rotary and rota-sonic drilling can penetrate reinforced concrete and obstructions.

ii) Excavators can be fitted with hydraulic breakers which can break through substantial thickness (up to 500 mm) of concrete.

— A specialist coring drill could be required to drill a suitably sized hole, particularly through thick concrete. This may be used for borehole and probing methods of investigation, but is not suitable for excavations. This method has the advantage of forming a neat hole, which can be easily reinstated to the original surface. With this method, risks to services cannot be reduced by hand excavation

b Deeper with larger machines, but difficult to properly inspect and sample deep pits from the surface. Entry would require shoring and atmosphere verification.

c Deeper with shoring

d See also Reference [1].

6 Selection of sampling techniques

6.1 General

Sampling techniques should be chosen in accordance with the principles set out in Clause 4.

Specialized tools and techniques might be required for collection of samples for physical, geological, and biological purposes. These forms of sampling should be carried out under the guidance of an appropriate expert.

NOTE 1 Tables 2 to 4 give guidance intended to aid the selection of appropriate sampling techniques for the circumstances anticipated in a site investigation.

NOTE 2 Guidance on the application of some commonly used methods of sampling and providing access to the sampling point is provided in normative Annex A, in which schematic examples of trial pits formed for sampling soils are provided.

NOTE 3 Descriptions of a wider range of techniques are provided in informative Annex B.

NOTE 4 Illustrations of a variety of equipment and tools are provided in informative Annex C.

NOTE 5 Some of the main issues to be considered when selecting a sampling technique are listed in Table 5.

NOTE 6 Guidance on taking disturbed and undisturbed samples using various techniques is provided in Clauses 8 and 9.

NOTE 7 It could also be useful to consult ISO 22475-1 for guidance on the application of some techniques.

It is not possible to include all possible circumstances or objectives in such tables as are included in this document and judgement should be used when necessary to determine the most appropriate sampling technique. Many objectives are satisfied by more than one technique. The listings in Tables 2 and 3 do not preclude the use of other techniques which are suited to the problems of a particular location, e.g. areas of permafrost, nor do they preclude the use of other methods which have been developed.

The choice of technique(s) should take into account:

— the characteristics of the soil to be sampled (e.g. soil type, water content, degree of consolidation, and particle size);

— the different materials that may be present in the ground;

— the soil characteristics of interest including the analysis and other testing to be carried out;

— the required precision of the results, which in turn depends on the ranges of concentration of components, the sampling procedures, and the type of analysis;

— the health and safety of those carrying out the work or living or working nearby;

— the need to avoid damage to utilities (e.g. electricity cables) and whether hard cover is to be penetrated;

— protection of the environment (7.2);

— site specific factors such as accessibility, ground stability, and other logistical aspects.

Selection can be aided by addressing the following consecutive questions:

— What are the soil characteristics of interest?

— What type of sample is therefore required (5.3 and ISO 18400-104)?

— What amount of sample is needed for the investigations planned (5.4 and ISO 18400-104)?

— What precision of results is required and therefore, what method can be used?

— What is the accessibility of the sampling site?

— What sampling depth shall be reached (ISO 18400-104) and what are the anticipated basic physical soil characteristics?

— Which substances are expected (volatile compounds, minerals) and will they be analysed for?

NOTE 8 It might also be useful to consult the analyst or scientist responsible for subsequent determination or testing, for example, about such matters as the size and type of samples required.

In addition, costs, safety (5.1), availability of suitably experienced and competent staff (7.10), machinery or instruments; time, and environmental aspects (7.2) should be taken into account.

All sampling equipment and ancillary apparatus should be

— suitable for purpose,

— safe in operation,

— able to take a representative sample from the required sampling point,

— capable of preserving the integrity of the sample until it can be transferred to a sample container,

— cleanable,

— simple to use,

— practical to use, and

— able to withstand rough usage.

The size of the sampling equipment required depends on the (maximum) particle size of the soil and the quantity of sample required. Depending on whether increments or samples are taken, the size of the sampling equipment should at least be equal to the actual increment or sample size, respectively. 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.

Table 5 — Some issues to consider when selecting a sampling technique

Soil characteristics that are characteristic of particular soil horizons require horizon-related sampling.
If the spatial variation of soil characteristics is of interest, spot samples are usually required.
Samples taken to identify the distribution and concentration of particular elements or compounds are normally spot samples [cluster samples may, however, be used with benefit under some circumstances (see 5.3)].
Samples taken to assess the overall quality or nature of the ground in an area, e.g. for certain agricultural purposes, are spatial (when sampling the surface and near-surface materials, composite samples may be appropriate).
Sample size should be sufficiently large to enable all tests and analyses to be performed.
Sample size should be sufficiently large to represent all soil characteristics of interest.
Soil characteristics of interest should not be affected by the sampling process.
Soil characteristics of interest should not be affected by the transportation and storage of samples.
Representative sampling usually means that increments with different properties should be (if applicable at all) combined into a composite sample only according to their volume fraction of the soil to be sampled.
Cross-contamination should be avoided.
Spread of contaminants should be avoided.

6.2 Drilling rigs and ancillary equipment

The drilling and sampling equipment selected shall be of the appropriate size and type in order to produce the required quality.

If applicable, the drilling and sampling equipment shall be in accordance with ISO 3551-1, ISO 3552-1 and ISO 10097-1.

Drilling rigs with appropriate stability, power, and equipment such as drill rods, casing, core barrels, and bits shall be selected in order that the required sampling and borehole tests can be carried out to the required depth of the borehole and sampling categories.

NOTE 1 The requirements in 6.2 are taken from ISO 22475-1.

NOTE 2 Safety requirements for drilling equipment are provided in the EN 16228 series.

7 General aspects of application

7.1 General aspects of field work

The sampling plan (in accordance with ISO 18400-101) should specify the sampling locations and the number, size, and type of samples to be taken from each location. The instructions to those carrying out the work should also include procedures to be followed if unexpected hazardous conditions are encountered (see ISO 18400-103).

Analysis for volatile and semi-volatile components should be carried out as quickly as possible after sampling, and for these components, it is not possible to store the samples on site for later analysis (see ISO 18512, the ISO 22475 series, ISO 18400-201, and ISO 18400-204).

Where near surface samples are not required and samples are required only at greater depth within the ground, an appropriate method of rapid development of a borehole to the required depth may be used. Care should be taken, however, to protect the bore and to clean out material before taking a sample to avoid cross-contamination.

If at any time during the investigation it becomes evident that the implemented strategy has not been optimal, the chosen methods should be altered immediately (e.g. if the depth to groundwater differs markedly from the expected depth). In some cases, it could be necessary to take additional samples on the basis of the adjusted strategy or to take into account the unforeseen conditions. However, where this situation is not clearly evident, the original strategy should be followed according to the procedure specified in ISO 18400-101.

Sampling locations should be surveyed accurately in both plan and elevation. Where possible, the location and elevation should be related respectively to a national survey grid and to a known datum point.

Descriptions of ground strata should be drawn up in the field immediately after a sampling location has been completed if this has not been done during formation following the guidance in ISO 25177.

Photographs should be taken while sampling.

Good practice for application of particular techniques should be followed in order to obtain samples of the required quality.

Equipment and tools shall only be used by trained personnel and used and operated in accordance with statutory requirements following the manufacturer’s guidelines.

It will sometimes not be necessary to analyze all the samples that have been taken, but it could be expensive to have to return to the location to obtain additional samples. This will particularly be the case if samples are taken at a considerable depth in the soil profile. It is therefore advisable to take samples even when it is anticipated that they may not be required for analysis and testing. Such samples should be preserved and stored following the guidance in ISO 18512 and ISO 18400-105, as appropriate.

NOTE Instead of taking samples, it may sometimes be advantageous to use on-site and/or *in situ* methods for testing and analysis (see ISO 12404).

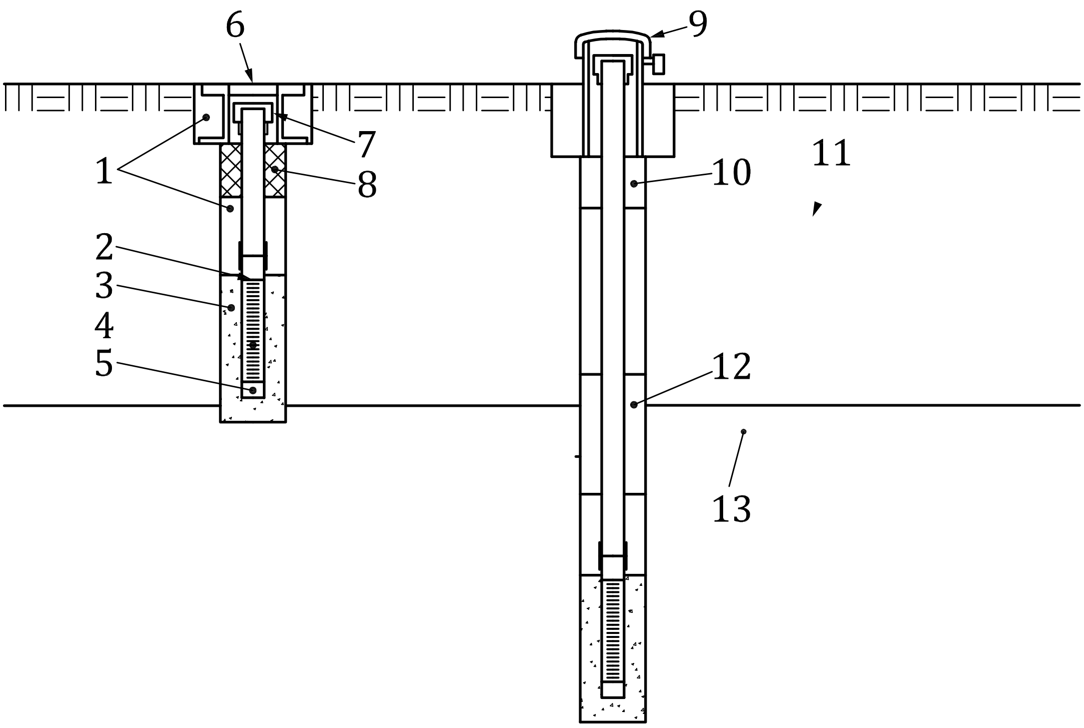
7.2 Environmental considerations

When selecting the sample collection technique, consideration should be given to the following:

— preventing the creation of routes for migration of contamination (hence, spreading the problem and incurring liability);

— avoiding migration at the surface due to wind blow or the action of water;

— contaminating the surface of the site with contaminated arisings.



Key

1	fill with clean soil	8	bentonite
2	tightening strap	9	protective casing
3	filter sand	10	bentonite plug to prevent vertical infiltration of rainstorm water or floods
4	filter gauze	11	ground water table
5	bottom cap	12	extra bentonite plug to prevent cross flow to other water conducting layers
6	monitoring well cover	13	impermeable layer or bedrock
7	top cap		

Figure 2 — Impermeable layers for monitoring wells

All deep borings should be backfilled with clean, low permeability material (e.g. bentonite grout), unless monitoring wells are to be installed (see also 7.8). Alternatively, arisings can sometimes be used if it is assessed it is appropriate to do so, e.g. it would not present a risk of contamination to groundwater directly or through creation of a migration pathway.

Particular care should be taken where low permeability strata (aquicludes) are penetrated to avoid creation of new connections between two aquifers.

NOTE 1 The migration of contamination can be exacerbated by the formation of preferential pathways within the ground. In general, the deeper the sampling requirement, the greater is the risk.

NOTE 2 The use of a double penetration technique (forming a larger borehole with a bentonite seal which is then penetrated by a smaller borehole through the seal) to prevent boreholes forming a contamination migration pathway is likely to be necessary when an aquiclude is penetrated.

Low-permeability layers that are inadvertently penetrated should be repaired by placing a bentonite seal or a bentonite-cement-water mixture (grout) to prevent exchange of (polluted) water between different layers (see Figure 2).

If monitoring wells are installed, a bentonite seal should be formed near to the top of the borehole to prevent infiltration of water from the surface.

When forming trial pits, the initial surface layer should be separated from other excavated material with this further separated on the basis of depth, appearance, or evident contamination, as appropriate.

Excavated material should be reinstated as closely as possible to the depth from which it was removed, subject to an assessment of the potential risks to the environment that any disturbed contaminated material might present according to national regulations, etc. and the requirements of the sampling plan. The surface material should then be replaced to provide a cover (see 7.8 for further guidance on reinstatement of trial pits and other exploratory holes).

NOTE 3 Regulations or consideration of the potential risks to the environment might dictate that no material known to be contaminated is to be returned to the excavation (of course, it might not be known when the work is carried out that the material is contaminated it will usually be the purpose of the investigation to determine this).

The redeposited material should be compacted in layers with the digger bucket and consideration given to mounding material to allow for settlement (it might not be acceptable if it interferes with trafficking of the site).

In order to prevent the site surface becoming contaminated, it may be necessary to place excavated material and other arisings on strong plastic sheeting or geotextile to prevent contact. The sheet material should then be safely disposed of on completion of the backfilling.

For drilling methods requiring the use of water flush, the water should be potable water to avoid cross-contamination and should be disposed of appropriately (see also 7.3).

NOTE 4 Where impermeable cover (e.g. concrete hardstanding) has been penetrated, it might be necessary to reinstate with a suitable low permeability cover to prevent the location becoming a source of ingress of rainwater resulting in contamination migration.

Care should be taken to ensure that the surrounding area is not affected by contaminated spoil left after reinstatement.

Investigation of a potentially contaminated site might pose a risk to the general environment. The work should therefore be planned to prevent the spread of contaminated material by site working clothes, samples, machinery, and vehicle wheels.

Care should be taken to avoid the spread of invasive and noxious plants [e.g. Japanese Knotweed (*Fallopia japonica*), the spread of infective agents, including, e.g. those causing, foot/hoof and mouth disease (*Aphatae epizooticae*) and Rhizomania [*Benyvirus* – Beet Necrotic Yellow Vein Virus (BNYVV)] or of genetically modified (GM) crops outside of areas approved for their growth (see also ISO 18400-103)].

NOTE 5 The listing of invasive and noxious plants above is not exhaustive.

7.3 Cross-contamination

Whatever method is used for obtaining the sample, it is important that the sampling system used and the material from which the equipment is made do not contaminate the sample.

When taking samples below surface level at a site, it is important that the sample is not affected by material (soil or water) falling from more shallow depths. Thus, where trial pits are used, the base of each pit should be cleared of debris before using the machine bucket to obtain a good sample of the material at the base.

With a borehole or driven sampler, the base of the hole should be cleared of debris before the sample is taken. With driven samplers, it could be necessary to reject material in the upper portion of the sampling tube which is potentially affected by debris.

The sampling equipment should be kept clean so that parts of a previous sample are not transmitted to a subsequent sample causing cross-contamination. For agricultural purposes, even with repetitive sampling across a field to form a composite sample, the sampling device should be cleaned between each location. All sampling equipment used in contamination investigations should be thoroughly cleaned between each sample.

Drilling equipment should be cleaned between sampling locations and more frequently, if necessary, in contaminated ground.

Contamination of samples due to lubrication used to ease sample collection or contamination due to lubricants and oils, greases or fuels due to the machinery used for sampling, should be avoided. Where it is necessary to use lubrication, e.g. to ease formation of a borehole to enable sample collection, only lubrication should be used which will not conflict with or confound the analysis to be performed on the samples in the sense of matrix effects or contribution to the contamination.

Where water has to be added to a borehole in order to assist the drilling process, only clean water should be used (preferably from public potable drinking water mains when available) and the volume should be recorded. When polymer is used to assist with drilling, complete records should be kept of its use to allow consideration of any potential effects on groundwater quality and on the results of subsequent chemical analysis of samples.

Only devices of controlled chemical quality and composition should be used to handle samples. For example, a hand trowel of stainless steel can be useful when investigating organic compounds while plastics normally do not interfere with heavy metals. When a stainless steel trowel is used, the quality of the stainless steel should be determined to ensure that cross-contamination of the samples will not occur or interfere with the quality of the analytical data. Devices that have contact with samples should never be painted, greased, or have otherwise, chemically treated surfaces.

Prior to taking a sample, the sampling tool should be cleaned using, e.g. deionized water (or alcohol wipes where organic contamination is present) to avoid cross-contamination.

NOTE 1 Drilling equipment is normally cleaned using pressure jet or steam-cleaning equipment in ground badly contaminated with organic chemicals. Washings from the cleaning process should be collected and then disposed of at a suitable facility off-site. Guidance on how this can be done is provided in Reference [9].

NOTE 2 Samples can become contaminated by:

— transmission of substances to sampling equipment or containers;

— uncontrolled transport of soil particles to the sampling point from adjacent points of a site or a soil profile, especially by material dropping into the sample from higher up a borehole, either during augering or drilling or during withdrawal of the sample;

— transfer of substances from the sampling device or container;

— introduction of auxiliary substances used to enable or facilitate the sampling (fuels, exhaust fumes, greases, oils, lubricants, glues, and others);

— introduction of wind-blown particles, spread liquids, or precipitation.

NOTE 3 Lining the borehole can prevent cross-contamination from material dropping into the sample from higher up the bore.

NOTE 4 The operation of equipment, due to poor maintenance, lack of cleanliness or carelessness during refuelling, can result in the contamination of samples due to exhaust fumes, hydraulic fluids, lubricating oils, or fuel.

7.4 Preparing to sample

Prior to locating the sampling locations,

— a plan showing the locations of all known services (services plan) should be obtained,

— if unexploded ordinance (UXO) is known to be present, a plan showing locations should be obtained (see ISO 18400-103 and Reference [2]), and

— If UXO is considered likely to be present, but no plan is available, an appropriate survey should be carried out before any other activities related to sampling.

Prior to sampling,

— any safety measures should be put in place and a health and safety plan should be prepared,

— the sampling locations detailed in the sampling plan should be located and marked,

— superficial material that will interfere with sampling should be removed (samples should be taken from these when appropriate),

— checks should be made for the presence of buried utilities using service plans (where available), on-site observations and cable-detecting instruments, etc., and

— starter pits should be formed by hand or vacuum extraction when these are required prior to formation of a borehole, etc.

7.5 Breaking out

Different techniques are available for breaking out the hardcover on a site (see Table 4). The technique selected should be determined taking into account the nature of the hardcover and the area necessary to break out for the purpose of the investigation. Regard should also be paid to safety (e.g. possible presence of utilities), impact on neighbours or site occupants (e.g. noise), and possible impact on buildings, boundary walls, etc. It might be necessary to obtain permissions in some cases, e.g. from utility providers.

Pneumatic drills may be used, but these require an experienced operator suitably competent and a source of compressed air and will not be appropriate for penetrating thick concrete (more than 250 mm) or where concrete is reinforced.

In some cases, the equipment selected for the site investigation is capable of also carrying out the breaking out of:

— cable percussion equipment can chisel through concrete (less than 100 mm thick) and tarmac;

— excavators can be fitted with hydraulic breakers which can break through substantial thicknesses (up to 500 mm) of concrete including reinforced concrete (depending on the diameter of reinforcing bar).

A specialized diamond-tipped coring drill may be required to drill a suitably sized hole, particularly through thick concrete. This drill can be used for borehole formation and probing methods of investigation, but is not suitable for excavations. The method has the advantage of forming a very neat hole which can be easily reinstated to the original surface. If a hand-dug starter pit is required, this should be taken into account when deciding on the diameter of the hole.

7.6 Collection of samples

Samples should be collected following the guidance in Clauses 8 to 10.

The samples collected should be as representative as possible of the material at the location and depth being sampled.

Precautions should be taken to prevent the samples undergoing any changes during sampling, including cross-contamination or during the interval between sampling and analysis.

Disturbed samples may be taken by most of the methods listed in Table 2 since such samples do not require maintenance of the original ground structure. Such samples should be transferred to the appropriate sample container using an inert tool such as a stainless steel trowel or by hand using clean protective gloves.

Where loss of soil structure is likely to affect the subsequent examination, e.g. microbiological examinations, certain physical measurements, and determination of volatile organic compounds, undisturbed samples should be collected to minimize the loss of structure and volatiles.

7.7 Transport, storage, and preservation of samples

Samples once collected should be transported, stored, and preserved in accordance with ISO 18400-105.

7.8 Backfilling of exploratory holes

If not used for installation of monitoring devices, profiling, or foundation holes, excavations originating from soil sampling should be refilled. It is essential that the site is restored and no hazards are left that would be of potential harm to the public, the environment, or animals. The backfilling should be carried out in accordance with national regulations and other regulatory requirements and technical objectives taking into consideration the strata, contamination of the ground, and its bearing capacity.

Soil-sampling processes produce voids where the sample has been removed or access to the sampling point was enabled. These voids can present new migratory pathways which should be considered, especially in contaminated ground. Large holes and excavations present a hazard to humans, other animals, and machines that may fall into them and may influence the stability of the surrounding ground.

When backfilling trial pits, the excavated material may be used, in which case it should be returned to the original depth below ground level, i.e. in reverse order to that they were excavated in. The material should be replaced in layers and compacted in an appropriate manner (the aim is to reinstall the soil in a way that enables the same soil functions and utilization as before the sampling). To compensate for subsidence of a refilled pit, additional filling material should be added to level an uneven soil surface. In trafficked areas where reinstatement of trial pits could cause a problem, an alternative technique should be considered to ensure the area will accept likely loadings without settlement. When appropriate, the client and/or landowner should agree the specification for backfilling and might need to be asked to confirm that reinstatement has been satisfactorily completed.

NOTE 1 While the text above suggests that contaminated material may be returned with care to the excavation, this is not always acceptable taking into account the relevant regulations and site conditions. In particular, where this method of backfilling could result in suspect material coming into contact with apparently uncontaminated ground, it may be necessary to use clean material for backfilling all, or at least part, of the excavation.

No additional contamination should be left at the surface of the site on completion of the investigation. It might be necessary to import clean material to form a surface layer over the excavation upon completion of the backfilling process.

Where there is a risk of contaminated groundwater or other liquid, e.g. oil being brought to the surface, special care should be taken to prevent dispersal of the contaminated water or other liquid during the investigation and also during subsequent backfilling. Hence, trial pits should not usually be excavated after water is encountered (see A.1).

Boreholes should normally be filled with materials of equal or less permeability than the surrounding ground, e.g. in order to prevent contamination and any connections between aquifers. If mixed grout is used, it should be placed by means of a tremie lowered to the base of the borehole. The tremie should be slowly raised as the grout is placed. If there is an influence on future projects, special technical requirements for backfilling should be specified in advance. Voids should not be permitted to occur during the placement of the filling material in the borehole.

NOTE 2 The person carrying out the filling of boreholes needs to know the depth to the base of the casing.

7.9 Disposal of waste materials

Any surplus excavated material or other arisings (e.g. contaminated groundwater) should be collected for safe disposal in accordance with local and national legislation and regulations.

Suitable disposal routes should be identified and arranged before the work begins. When this has not been done in advance or the results of testing are awaited so that a suitable disposal route can be identified, the material should be made secure and stored in such a way as to minimize the risk of spread of contamination.

NOTE Solid materials may be stored, e.g. in covered stockpiles on plastic sheeting, in sheeted skips, and in drums depending on the amount and nature of the material.

7.10 Personnel

Guidance on the skills, training, and other attributes required by those carrying out the work are described in ISO 18400-106. Some guidance is also provided in ISO 18400-103.

NOTE Guidance on qualification criteria for enterprises and personnel engaged in geotechnical investigations is provided in ISO/TS 22475-2. ISO/TS 22475-3 provides guidance on conformity assessment of enterprises and personnel by a third party.

8 Taking samples of top-soil and other near surface materials

8.1 Undisturbed samples

8.1.1 General

NOTE 1 The guidance provided below is particularly applicable to the investigation of natural and agricultural sites (see ISO 18400-205[4]). However, undisturbed samples are also frequently required for the determination of volatile organic compounds (VOCs) (see ISO 18400-204 and the ISO 22475 series).

If undisturbed samples are required, they should be taken by means appropriate to the objectives of the investigation, for example, using a sampling frame, a coring tool (Figure C.1), cutting cylinder (Figure C.22), or a Kubiëna tin (Figure C.21). In each case, the sampling device should be pushed into the soil and subsequently removed with the sample so that the soil is collected in its original physical form.

When dealing with highly contaminated sites, sampling techniques minimizing contact of the investigator with the soil should be employed (see ISO 18400-103 and ISO 18400-203[5] for further details).

NOTE 2 Other tools that may be appropriate (see Table 3 and Table 4) include the following:

— special hand augers [gauge auger (shallow-profile sampler), bucket auger to bring down borings for cutting cylinder application)], piston sampler (see Figure C.4).

4) Under preparation.

5) Under preparation.

NOTE 3 Methods for recovering samples from a trial pit are illustrated in Figures C.8 and C.9 (both could be used at the surface).

NOTE 4 Cutting cylinders are available conforming to a number of standard specifications.

8.1.2 Procedure for use of sampling cylinders

The aim is to obtain a sample in such a way that the natural soil structure of the sample is not changed compared to the bedding of the soil at the site, i.e. volume-proportional sampling. In top soil, horizon-related sampling is common.

Following the selection of the exact sampling point, the soil surface should be cleared of loose materials and remnants of vegetation.

If several cylinder samples are taken at one level, a systematic arrangement of the sampling cylinders, preferably equidistant, should be adopted. It is recommended that five parallel samples be obtained at each level, e.g. for investigations of percolating soil water, pore volume, or bulk density.

Join the cutting cylinder and fix it to the protective cap. Using a hydraulically or manually operated device, drive the cylinder into the soil until the lower edge of the protective cap penetrates into the soil. Remove the cap and supporting ring. Then, undercut the cutting cylinder and remove it from the soil using appropriate tools. Level the upper cutting areas of the cylinder, cut the roots, and remove projecting stones. Then, cap the cylinder carefully remove it from its base (using a spade or similar tool) and lay it into the special case.

The following general rules should be followed:

- when taking cylinder samples from the top soil, loosely bedding soil should be rejected, thus, avoiding loss of soil during the process;
- while the surface is being levelled, the pores of the cylinder contents should not be closed by smearing or pressing;
- to reduce wall friction, soil sampling cylinders should be plunged into water or greased with vegetable oil before application;
- tilting of the soil sample cylinder while pushing it into soil should be avoided.

If undisturbed samples cannot be taken, casting techniques (using gypsum, paraffin, wax, or resin) should be considered.

When sampling a soil profile, samples should be numbered from top to bottom.

NOTE If soil is silty, loamy, or clay-like, sampling is only possible in moist conditions.

8.2 Disturbed samples

8.2.1 General

Any of the following equipment and exploratory holes may be used as appropriate:

- trial pits;
- hand auger;
- trowel, spade or similar;
- cutting frame (for sampling organic matter such as mull, moder, mor, peat);
- other additional tools and equipment.

Top-soil samples may also be taken during the formation of boreholes, etc.

8.2.2 Procedure

8.2.2.1 Agricultural sites, etc.

Spatial (area-wide) composite samples should be prepared as follows:

— after selection of a suitable sampling pattern (see ISO 18400-104 for suitable examples), single samples or incremental samples are combined to form a composite sample per area unit or soil unit (the depth of sampling depends on the objective of investigation and on the utilization of the area);

— to form a composite sample per area unit or soil unit, procedures should be selected so that the final sample contains equal parts of the incremental samples and to ensure that it is representative of all the incremental samples;

— if the stone content is small (check profile, otherwise X = 5 %), it usually can be neglected, but larger stone contents should be estimated or determined following separation of soil particles smaller than a predetermined size.

NOTE Spatial composite samples will require homogenization when they arrive in the laboratory.

8.2.2.2 Forest sites

For sampling organic horizons (undecomposed or partially decomposed litter) above mineral horizons in forest soils, place a cutting frame on the surface and sample the content of the framed area down to the underlying soil horizon. Usually, a small shovel should be used to gather thin layers of litter (L), fermentation (F), and humus (H) horizons. Stones and roots should be removed from samples.

NOTE 1 The organic horizon can be sampled as one layer or, for specific purposes (e.g. diffuse pollution), as individual layers: litter (L), fermentation (F), and humus (H).

NOTE 2 It is not possible to sample organic horizons using augers.

8.2.2.3 Contaminated sites

Spot samples, composite samples, or cluster samples should usually be obtained. The depth of sampling depends on the objective of investigation.

NOTE For more detailed guidance, see ISO 18400-104 and ISO 18400-203.

9 Sampling at greater depths

9.1 Undisturbed samples

9.1.1 Sampling from trial pits

Different sampling techniques can be used to obtain undisturbed samples from trial pits, but care should be taken when entering trial pits as required by ISO 18400-103 (see also A.1.3). Hand augers, soil sampling rings and cylinders, cutting frames, and other tools are suitable.

In order to apply cutting cylinders at each of the predetermined sampling depths, a horizontal area should be prepared starting at the top, i.e. the undisturbed soil is cut and levelled and loose material removed. From this area, cutting cylinders are taken as described in 8.2. If the cylinders are arranged in rows, it is appropriate to start at the inside of the area to be sampled. After all the cylinders have been pushed into the soil, they should be dug out from the side, cut and smoothed at the ends, and the remaining soil material of this area dug out until the top of the next sampling level is reached.

Undisturbed samples suitable for agricultural investigations may also be obtained using a spade, shovel, or similar tools carefully. The soil aggregate to be removed in such a way needs to be of greater volume for subsequent shaping, e.g. using a knife to obtain an adequate volume of soil for field and laboratory investigations. Such a sample would not be regarded as sufficiently "undisturbed" for many other purposes.

NOTE A trial pit permits undisturbed and disturbed samples to be obtained related to horizon, layer, or depth depending on the reasons and objective of field and laboratory investigations (see also ISO 18400-104). Sampling is possible in both horizontal and vertical directions. These techniques are preferred for carrying out pedological, geological, and hydrogeological evaluations.

9.1.2 Other sampling methods

For collecting undisturbed soil samples at depths down to several metres or more, sample tubes with or without plastic liners are suitable for various physical measurements, soil research, and to provide undisturbed analytical samples. For example, transparent sampling tubes, split tube samplers, soil column cylinders, and core samplers are appropriate.

NOTE Illustrations of some suitable equipment are provided as Figures C.10 to C.15 and C.17.

9.2 Disturbed samples

9.2.1 General

Any of the following equipment and techniques may be used as appropriate:

— trial pits;

— drilling tools;

— special boring tools to obtain samples from water-saturated soil layers and from peat soils;

— static and dynamic probes;

— soil sample cylinders (for application in trial pits).

For sampling under difficult conditions (e.g. clay soils, sampling at very great depth, large number of subsamples), labour-saving techniques are available (e.g. partially or fully mechanical sampling tools, tools coupled to vehicles, mobile sampling tools).

9.2.2 Agricultural sites, etc.

The reasons for and objective of investigations in the field and in the laboratory determine the type and procedure of sampling. For the determination of nutrient supply in the subsoil of agricultural areas, incremental samples can be taken following comparable field patterns to those that would be used when sampling top-soil and then combined in a composite sample to represent an area or soil unit.

The incremental samples should be taken from the same depth or stratum depending on the objectives of the investigation.

9.2.3 Contaminated sites

Composite samples, cluster samples, or spot samples may be used (see ISO 18400-104) depending on:

— the purpose of the investigation;

— the depth(s) from which samples are to be taken;

— regulatory requirements;

— the requirements of guidance relating to application of assessment criteria.

NOTE 1 See also 5.3.

Only samples from a specific depth should be used for assessments for contamination.

Sampling and the subsequent assessment for contamination should be made to the full depth of potential interest. However, the samples that are taken should refer to a limited depth range of no more than about 100 mm rather than for a depth range of say 0,5 m or 1,0 m as is common in geotechnical investigations (for detailed guidance, see ISO 18400-104 and ISO 18400-203).

When sampling from trial pits where access is possible, the sample may be taken from a single spot or to be representative of a small horizontal band. For reasons of safety, samples from greater depths should be taken from the excavator bucket either directly or from material deposited on the ground. In which case, a cluster sample (i.e. one composed of a number of increments) should be taken (see also 5.3).

NOTE 2 Due to the small amount of soil exposed in window or windowless samplers, the sample obtained may have to be taken over a depth range of up to about 150 mm of the same strata in order to ensure that there is sufficient material available for all the analyses required.

10 Sampling stockpiles

10.1 General

Guidance on strategies for sampling stockpiles and other above-ground deposits is provided in ISO 18400-104.

Prior to sampling, information should be obtained (where possible) or developed on those factors that might have a particular impact on the selection of the equipment and the sampling method including:

— the risk assessment of the sampling activities and the safety procedures to be implemented during sampling and transport;

— the moisture content of the soil;

— the maximum size and size distribution of the soil particles;

— the accessibility of sampling points;

— the quantity of soil necessary for the tests and analyses.

10.2 Sampling equipment

Selecting suitable sampling equipment is important for obtaining good quality samples. The guidance in Clauses 6 and 7 on selection and application should be followed as appropriate.

Suggested applications for generic types of equipment are detailed in Table 6. Detailed descriptions of sampling techniques and equipment are provided in Annex D.

Table 6 — Suggested applications for generic types of sampling equipment suitable for sampling soil stockpiles and other above-ground deposits

Generic sampling equipment	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 (e.g. wheel loader, digger, excavator)	−	−	−	+	+
Rota-sonic	+	+	+	+	+

[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.

\+ applicable

− not applicable

Annex A
(informative)

Application of particular techniques

A.1 Trial pits

A.1.1 General aspects

The reasons and objective of the investigations and the intended field and laboratory activities determine the locations and dimensions of a trial pit.

NOTE 1 The advantages of the method are the applicability over a wide range of ground conditions, the opportunity for close visual examination of the strata, and the speed with which the work can be carried out.

NOTE 2 A schematic drawing of a trial pit used for sampling for pedological purposes is provided as Figure A.1 and of one used for sampling in made ground (e.g. when looking for contamination) in Figure A.2.

In identifying whether trial pits are suitable for the investigation, the following questions should be taken into consideration:

— Have services been identified?

— Is there space available for performing the excavation?

— Will the damage to the site surface be acceptable to the client and/or landowner?

— Can hand-dug or machine-dug excavations achieve the anticipated depth of sampling required?

— Is there likely to be groundwater present within the depth to be sampled?

NOTE 3 A trial pit excavated by machine will usually require approximately 3 m × 1 m for the excavation (depending on depth and the nature of the ground) plus space for the machine to operate and space for the excavated soil to be placed (see Reference [7]).

Different machines can achieve different depths of excavation and the machine used should be capable of easily achieving the depth required.

The presence of water will usually prevent satisfactory samples being obtained and can also lead to the collapse of the sides of the pit.

Trial pits should

— only be used where the ground will stand temporarily unsupported and permit the observation of the *in situ* condition of the ground both vertically and laterally,

— be sufficiently large to provide safe working conditions (of appropriate width and length depending on the type and cohesion of soil),

— have the head side exposed to the light, if practicable,

— not be entered unless safe to do so, e.g. if shored by a competent person (see also A.1.3),

— not have excavated material stored directly at the pit shoulders,

— be compliant with national regulations and industry guidance regarding safety (see ISO 18400-103), and

— be secured (e.g. fenced in the case of long-term operation).

Steps should be available to enter and leave the pit (this should only be done if the pit has been shored by a competent person).

The material removed from trial pits should

— be placed separately in piles of same strata on sheeting where required, and

— be replaced in reverse order.

A.1.2 Formation of trial pits

Hand tools such as shovels, forks, and picks may be used to excavate to depths of about 2 m, but only with due regard to safety and the possible danger of damaging services or putting the worker using the tools at risk of injury. The hand-dug pit should have a plan area of approximately 1 m × 1 m to enable easy collection of soil or samples and recording of the soil profile. It might be necessary to slope the sides of deeper excavations to ensure the safety of those digging them and those who might later inspect them.

NOTE Hand excavation is particularly necessary in urban areas if services (e.g. water, gas, electricity) are known to exist in the vicinity and, particularly, if their location is uncertain. Once the base of the excavation is below the depth at which any services may exist, then the excavation or borehole formation can be continued using the appropriate machinery.

Mechanical excavators which range greatly in size and reach are required to achieve greater depths and can be beneficially used even when pits only about 0,5 m deep are required because they permit rapid working and expose a greater amount of soil for inspection and sampling than is possible using hand-dug pits. Further information on the use of mechanical excavators is provided in A.5.

Small tracked mechanical excavators can be used to form trial pits to about 2 m and are particularly useful when only small shallow pits are required, or access is restricted.

A wheel-driven back-hoe excavator can be used to excavate trial pits typically to a maximum depth of about 5 m. The trial pit should be wide enough to accommodate the bucket and of adequate length to allow excavation to the required depth and plan area (usually, approximately 3 m to 4 m × 1 m).

A track-driven machine is necessary to reach depths such as 6 m below ground level. A wider bucket is usually necessary than when using a wheeled excavator to provide clear vision to the bottom of the trial pit because of its greater depth.

The width of bucket required will depend on the finished width that is required. It is usual to have at least two buckets of differing widths available, e.g. a 0,5 m or 0,6 m wide bucket and a 0,9 m wide bucket. While a toothed bucket will aid progress in compacted ground, consideration should be given to the use of a toothless bucket at shallow depths in order to lessen the chances of damaging any unidentified utilities especially, e.g. drainage runs.

Whatever technique is used to form a trial pit, the excavated material should be placed on the adjacent ground (this should be protected as necessary from contamination) in a way that ensures it will not fall back into the excavation causing cross-contamination. The surface soil layer should be kept separate so that it can be replaced on the surface after the trial pit is backfilled. It may be necessary to separate other material as it is excavated so that any deep-lying contamination is replaced at the same depth when backfilling and not mixed with other material or replaced near the surface. After completion of fieldwork and sampling, trial pits should be backfilled (see 7.8) and any surplus material removed from site in accordance with local regulations (see 7.9).

After excavation of a trial pit, walls should be cleared carefully of loose soil material so that the (natural) structure of horizons can clearly be seen. Treading on the pit shoulders should be avoided in investigations for agricultural purposes because this may cause changes in the soil structure.

When water is present, the trial pit may be dewatered by pumping provided that there is a safe and suitable means of disposal of the water or an alternative technique of sampling should be used.

A.1.3 Safety

Detailed guidance on all aspects of safety is provided in ISO 18400-103.

Entry of the excavation by personnel should be avoided where possible irrespective of the depth of the pit since the unsupported sides of a trial pit can readily collapse. In unstable ground, the trial pit can collapse and extra care should be taken when observing the excavation and collecting samples. The potential for collapse is increased if excavated materials have been stockpiled too close to the edge of the pit. If necessary, the sides should be supported or made to slope to improve stability.

Entry into shallow pits can be facilitated by cutting steps or using a ladder.

Entry to deeper shored pits should only be made using a ladder that has been properly secured to avoid it slipping while in use and tests have been made for the presence of hazardous vapours and gases and oxygen deficiency.

NOTE For guidance on the safe excavation of trial pits, see Reference [7].

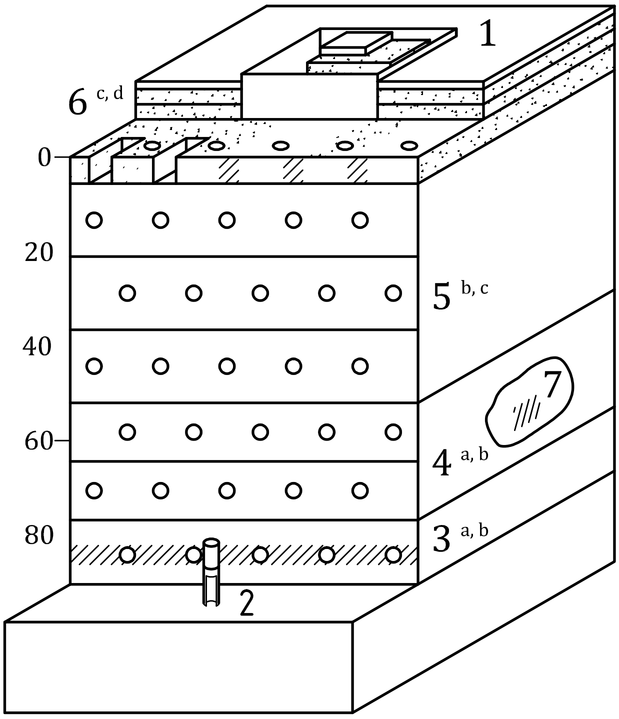
A.1.4 Taking samples

In deep trial pits formed by machines, samples of the ground can be collected by careful use of the machine bucket, thereby avoiding any need to enter the trial pit. Before collecting a sample (disturbed or undisturbed), the base of the excavation should be cleared of any loose or fallen material, etc.

A representative sample of the material removed from the base of the excavation with the excavator bucket should be collected using an appropriate tool, e.g. a trowel that will not contaminate the sample or absorb contaminants (see 7.1), i.e. a cluster sample formed from small point samples (increments) taken close together, unless the examination requires some other specific form of sample.

For physical, geological, pedological, and biological examinations where undisturbed samples are required, such samples can be taken from a deep excavation using a Kubiëna tin, or a coring tool, or cylinder without entering the excavation. In each case, the sampling device is pushed into the soil exposed at the base of the pit. The sampling device is then carefully removed using the excavator bucket so that the soil is collected in the device in its original form (see also 9.1.1).

Depth scale in centimetres



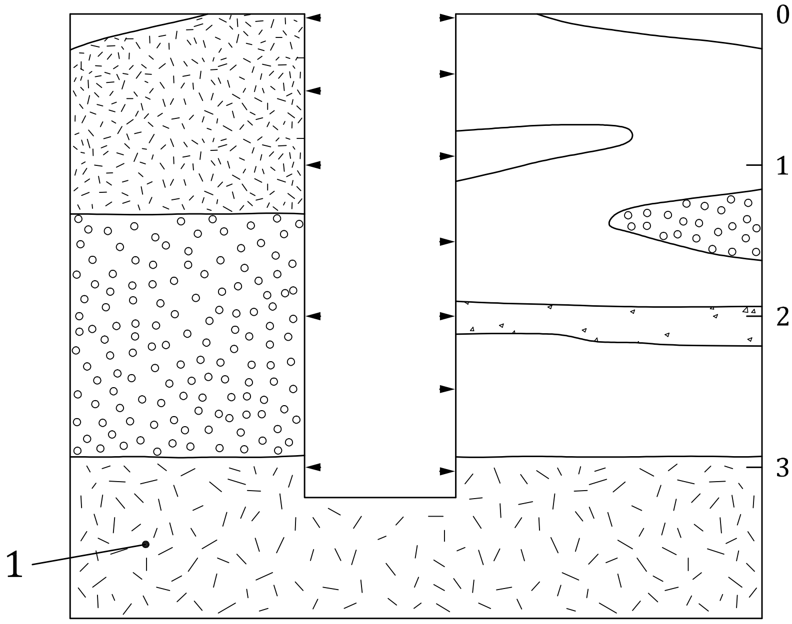
Key

1 sampling of organic matter (e.g. forest soils) by cutting frame
2 sampling from deeper horizons by boring tools
3 sampling from middle of horizon (thickness)
4 sampling in case of share samples (horizon thickness)
5 sampling of total horizon thickness (share samples at thickness)
6 sampling of total horizon thickness
7 share sample out of the typical area

0 undisturbed soil sample removed by cutting cylinders
/// disturbed soil sample removed by boring tools
[a] Horizontal sampling by split boring.
[b] Horizontal sampling by cutting cylinders.
[c] Vertical sampling by split boring.
[d] Vertical sampling by cutting cylinders.

Figure A.1 — Schematic description of soil sampling in a trial pit formed to sample natural ground

Dimensions in metres



Key

1 natural ground

Figure A.2 — Schematic drawing of trial pit showing how samples may be taken to reflect strata (right-hand side) and/or at fixed depths (left-hand side)

A.2 Small augers (hand-operated auger techniques)

Soil augers consist of a central shaft on the end of which a two-bladed drill is connected. The width of the blades varies for different types of soil augers making them suitable for different soil types. The small bladed types (wide opening) are suitable for moist or well-consolidated soils. The wide blade types (small opening) are suitable for dry or non-consolidated soils. A number of hand augers are illustrated in Figures C.2, C.3, C.5, and C.6.

The soil auger is pushed into the soil with a turning motion. When filled, the soil auger is pulled up and the soil material discharged from the auger.

Using a soil auger will result in a more or less disturbed sample, although the continuous discharge of the auger will give a good description of present soil layering.

Samples taken with a hand auger are not usually suitable for determination of volatiles, but a hole formed with a hand auger can be used to permit use of a coring device to take a suitable undisturbed sample.

When using hand augers,

— care should be taken to ensure that the soil is not contaminated by material dropping into the sample from higher up the bore either during augering or during withdrawal of the samples (lining the borehole carefully with a plastic tube can prevent this cross-contamination),

— particular care should be taken to obtain representative samples if localized contamination is penetrated, and

— when testing soil samples for agricultural purposes and the samples are to be composited, the auger should be capable of consistently collecting the same sample volume (such sampling is normally of the near-surface soil approximately 150 mm to 250 mm depth).

NOTE 1 Many designs of hand-auger samplers are available. The designs have been developed over many years to deal with different soil types and conditions. Ease of use depends upon the nature of the ground to be sampled. In general, hand augers are easier to use in a sandy soil than in other soils, particularly where obstructions such as stones are encountered. In sandy soils, hand augers can be used to sample to a depth of about 5 m. Hand augers are usually used for sampling homogeneous soils, e.g. agricultural soils.

NOTE 2 Preferred forms of hand augers to be used for collection of soil samples are those which take a core sample. Other types of auger may be used to facilitate drilling to the requisite depth for sampling provided that it is possible to clean the bore to prevent cross-contamination.

NOTE 3 Sampling by hand augers allows observation of the ground profile and the collection of samples at pre-selected depths.

NOTE 4 There is a risk of lower-back injury when using hand-augers and driven-augers (see ISO 18400-103).

Annex B
(informative)

Manually and power-operated sampling equipment

NOTE 1 This annex provides limited information on a selection of equipment that can be used to obtain soil samples in soil quality investigations. More detailed guidance on these and other drilling and sampling methods can be found in ISO 22475-1.

NOTE 2 Illustrations of some of the equipment described here are provided in Annex C.

NOTE 3 A Kubiëna tin and a cutting cylinder are illustrated in Figures C.21 and C.22, respectively. The use of cutting cylinders to provide undisturbed samples is described in 8.1.2 and 9.1.1 (the process of using a Kubiëna tin is similar).

B.1 Sampling tubes

B.1.1 General

Sampling tubes may be made from a variety of materials, but the most common material used is stainless steel.

B.1.2 Open sampling tube (Gouge auger)

The open sampling tube consists of a tube that is cut in half over the full length of the tube. The tube is pushed into the soil by a vertical or (partly) rotating motion until it is fully filled and then pulled back. This type of sampling tube is only suitable for fine-grained slightly moist soils.

NOTE See, for example, Figures C.5 and C.6.

B.1.3 Half-cut sampling tube

This tool consists of two concentric tubes closely fitted into each other throughout their entire length so that one tube can be rotated within the other. Longitudinal openings are cut in each tube. In one position, the tube is open and admits the sample. By turning the inner tube, it becomes a sealed container. This type of sampling tube is only suitable for fine grained dry soils or fine grained soil sludge. In both cases, the soil is free flowing and can enter the sampling tube without further handling of the soil.

B.1.4 Piston sampling tube

The sampling tube contains a piston or plunger. The piston is moved upwards while inserting the sampling tube in the soil and thereby, letting the soil into the tube. Sampled soil can be discharged from the tube by pressing the piston down. An undisturbed sample can be obtained under suitable circumstances, although the soil will be compressed when not fully consolidated. This type of sampling tube is most suitable for sampling sludge, but also fine-grained soils with relatively high moisture content can be sampled.

NOTE See, for example, Figure C.4.

B.2 Percussive drilling

B.2.1 General

There are a variety of techniques utilizing similar principles for forming probe holes for sampling. These involve driving a hollow tube with or without a driving cone or a solid bar into the ground using hydraulic power or mechanical force. Mechanical forces are normally applied by repeated hammer blows on the end of the probe while the hydraulic action applies pressure on the probe using a wheeled or tracked vehicle as the jacking point.

The probe is advanced to the depth where soil, groundwater, or soil gas is to be sampled. The depths which can be achieved by these techniques depend particularly on the system and the driving force which can be applied in conjunction with the weight of the vehicle. The presence of obstructions may also be a limiting factor. Hand-held driven probes typically reach 2 m, van-based systems 5 m to 12 m, and truck-based systems [including cone penetrometers (CPT)] 25 m to 30 m.

In general, the diameter of the sampler can be reduced in stages to aid penetration to greater depths.

B.2.2 Probes, window and windowless samplers

Percussive sampling involves driving cylindrical steel tubes into the ground using a high-frequency percussive hammer (a small rig is shown in Figure C.16). Usually, the hammer is driven by a hydraulic power pack, but electric and pneumatic hammers are also available to suit particular site conditions. Hand-operated systems are also available (see Figure C.15).

In window sampling, metal sample tubes are 1 m or 2 m long and have a broad slot or window cut down one side (see Figure C.13). The soil material passes into the sample tube through a cutting shoe at the end as it is driven into the ground. Drill rods are used to drive the sample tubes to greater depths. On reaching the required depth for sampling, the sample tube and any drill rods are withdrawn using a mechanical jack.

Where the ground is unstable, a steel casing can be employed around the outside of the driven tubes.

In windowless sampling, soil samples may be obtained using a metal tube combined with an inert liner to enable easy removal of the core from the sampler (see Figure C.14). The system can be used to collect samples at different depths to rapidly penetrate to the depth at which the sample is to be taken or to provide a continuous core. Soil samples may also be obtained using split tubes or split-spoon samplers which are effectively a tube which is linearly split in half, but held together by securing rings during sampling. These devices are often used in conjunction with driven bar probes. These samplers allow ready retrieval of the core. This system also enables undisturbed samples to be collected.

The depth which can be achieved depends upon the soil type and, particularly, the presence of obstructions. Depths of 10 m to 12 m can be achieved where the borehole remains open without support.

Systems are available to allow a probe head with a sampling device to be inserted into the previously formed hole to the depth at which it is desired to sample. The probe head is then unscrewed and withdrawn up the inside of the shaft and the exposed sampling device pushed into the ground to collect the sample. The sampling head is then withdrawn and the sample removed for investigation.

Application

The system may be used to collect samples at different depths to rapidly penetrate to the depth at which the sample is to be taken or to provide a continuous core. This system also enables undisturbed samples to be collected.

After removal of the sampler (window or windowless) from the borehole, the soil material can be inspected and the strata logged and sampled from the window in the case of window sampling or from the extruded core in the case of windowless sampling.

Piezometers and ground gas monitoring pipes can be installed in the resultant holes where the ground is sufficiently stable and the hole of sufficient diameter.

B.2.3 Rotary percussive drilling

In sampling by rotary percussive drilling, a clay cutter tube device with a cutting shoe fitted to the lower end is driven into the soil by hammer blows and the supporting drill rods slowly rotated. It is generally suitable for clays, silt, and soils with a particle size up to $D_e/3$ and a borehole diameter up to 300 mm. The sample is retained within the clay cutter tube.

NOTE D_e is the external diameter of the clay cutter tube.

B.2.4 Closed piston sampler

This is a variation on the percussive open tube (windowless) sampler described in B.2.1. in which a piston is in place in the tube when it is driven. Once the sampling depth required is achieved, the piston is released and the outer tube advanced to collect the sample.

NOTE See Figure C.17.

B.2.5 Continuous samplers

Continuous soil samplers can produce core samples up to 30 m length in ground such as fine alluvial deposits. This may be of particular value and are considered to yield samples superior to those obtained by consecutive drive-in sampling.

The samplers normally are made in sizes between 30 mm and 70 mm diameter and consist of an outer driven tube with an internal system providing a sheath to the core as the sampler is driven into the ground. Extension tubes of 1 m length are added to the sampler as the ground is penetrated. On removal from the ground, the continuous core is cut to suitable lengths, frequently 1 m, and placed in purpose-made sample cases for storage. Samples may be removed from the core for testing and the core itself observed and recorded.

B.2.6 Driven probes

Driven probes can be used to make continuous measurements of geophysical, hydrogeological, geochemical, or geotechnical subsurface parameters (e.g. resistance to penetration and detection and measurement of VOCs and hydrocarbons). Care should be taken to avoid cross-contamination from the sides of the probe hole and from the base of the probe hole. This system can be used either to monitor ground water parameters such as pH, electrical conductivity, temperature, etc. using monitors in the probe or to access groundwater so that a representative sample can be taken without the need for purging associated with conventional monitoring wells. Ground gases can be similarly accessed and sampled.

Driven probes are considerably faster than traditional borehole forming techniques, but have the disadvantage of the difficulty experienced in penetrating ground with obstructions and, in addition, they cannot be used for logging the ground strata unless continuous soil samples are taken, although soil behaviour and soil type can, to a certain degree, be derived from *in situ* profiling data (e.g. through cone penetration testing).

B.2.7 Light-cable percussion boring

Light-cable percussion boring generally uses a single axle mobile rig with winch of 1 t to 2 t capacity driven by a diesel engine and a tripod derrick of about 6 m height. With many types, the derrick folds down so that the rig can be towed by a small vehicle (frequently, 4-wheel drive).

The light-cable percussion technique is commonly used for geotechnical purposes and deep boreholes of over 20 m depth can be constructed. This technique can be of particular use in investigating deep sites such as refuse tips and other unstable ground.

The ground is penetrated using different tools which depend on the strata. A clay cutter can be used for cohesive soils and a shell (or bailer) for cohesionless soils. Chisels can be used to penetrate very hard ground and obstructions. The borehole formed by these tools is supported by a steel casing which is advanced as the borehole proceeds. The casing avoids most of the problems of cross-contamination, but the borehole should be cleaned out each time the supporting casing is driven further into the borehole, before taking a sample.

Depending upon the nature of the ground, the tool can form the borehole in advance of the steel casing being pushed down the hole in, e.g. clay strata. This often results in material from the side of the borehole being dislodged as the casing is pushed down the borehole. This can result in cross-contamination.

If the borehole is being formed in sands or gravels, particularly in the saturated zone, the steel casing may be pushed into place to support the borehole sides before the material is removed with the shell. This can disturb the ground and make sampling difficult.

The technique can be used to form a bore of decreasing diameter in stages. This enables “clean-drilling”, e.g. through an aquiclude, by placing a bentonite plug at the base of the initial wider diameter bore and then continuing to drill through the plug to form a narrower diameter hole.

NOTE 1 See Figure C.18.

NOTE 2 For guidance on the space requirements for operation of a light-cable percussion rig, see Reference [1].

Application

In some strata, it may be necessary to add water to the borehole to provide lubrication. In this situation, potable water should be used, if available, and care should be taken with respect to the effects on both soil and water samples. The addition of water should be recorded on the borehole log and, if appropriate, on the sample details.

The clay cutter and the shell bring up disturbed material from the borehole which is generally sufficiently representative to permit recording of the strata, but care should be taken to avoid misinterpretation due to ground being pushed down within the borehole, for example, when the casing is moved. Samples may be collected from both the clay cutter and the shell. The resultant sample size, although larger than obtained by hand-augering techniques, is still restricted.

Undisturbed samples may be collected in cohesive strata and in weak rock (e.g. chalk) by driving a hollow tube (100 mm open tube sampler) into the ground and withdrawing the resultant core for examination and analysis. Use of such undisturbed sampling equipment may be preferred in order to minimize cross-contamination of samples collected for testing purposes.

Water samples may be obtained as drilling proceeds and, because the casing of the borehole seals the borehole from the surrounding ground as the borehole advances, it is possible to sample water horizons at different depths with minimal risk of cross-contamination, but such samples are unlikely to be representative and may give misleading results. Water samples truly representative of the ground water necessitate installation of an appropriately designed monitoring well.

The borehole atmosphere can be monitored for gas concentrations (including VOCs) as the borehole proceeds or gas samples may be taken so that the profile of the ground gas composition can be determined.

B.3 Rotary drilling

B.3.1 General

Powered rotary cutting tools use a cutter head on the end of a shaft or string which is driven into the ground as it rotates. The system requires some form of lubrication (air, water, or drilling mud) to keep the cutting head cool and remove the soil, etc. which has been cut through. The lubricant lifts the debris from the cutting head up the borehole formed and ejects the material at ground level resulting in a potential for cross-contamination due to contact of the debris with the ground forming the sides of the hole. There are two basic types of rotary drilling, open-hole (or full-hole) drilling in which the drill cuts all the material within the diameter of the borehole and core drilling in which an annular bit fixed to the bottom of the outer rotating tube of the core barrel assembly cuts a core which is recovered within the innermost tube of the core barrel assembly and is brought to the surface for examination and testing.

Application

This technique is particularly useful for forming a hole quickly in order to form a deep observation well or for obtaining samples using an appropriate technique at greater depths only.

The uncontrolled ejection of material that can occur with this technique (for instance, where air or water is used for lubrication) can lead to extensive surface contamination when drilling through contaminated ground. This may be hazardous, both to the investigation team and to the environment.

Rotary drilling is not suitable for accurate logging or taking accurate depth-related samples.

B.3.2 Open-hole drilling

Open-hole drilling should only be used for the rapid formation of a hole to enable sampling at a greater depth by an alternative method or for the installation of monitoring wells. It should not be used for sampling because material is recovered from the drill hole accompanied with the drilling fluid.

The technique can be used to form a bore of decreasing diameter in stages. This enables “clean-drilling”, for example, through an aquiclude by placing a bentonite plug at the base of the initial wider diameter bore and then continuing to drill through the plug to form a narrower diameter hole (this may require combination with a less destructive technique if a reliable seal is to be obtained).

B.3.3 Rotary core drilling

This is usually carried out using conventional, wireline, or double- or triple-tube core barrels with diamond- or tungsten-tipped core bits. The objective is to achieve optimum core recovery and core quality consistent with cost. The choice of drill and compatible in-hole and surface equipment is most important if the objective is to be achieved. Detailed guidance is beyond the scope of this document and advice should be sought from a drilling specialist.

NOTE Detailed guidance on design and application is provided in ISO 22475-1.

B.4 Mechanical augers

B.4.1 Driven auger

An auger consists of a hard metal central shaft with sharpened spiral blades around that discharge cuttings upwards as the shaft is rotated down through the soil. The driven auger is powered by machine so that great force can be exerted downwards. The cutter head consists of one or more 360° spirals, usually with a shallow pitch to prevent ground falling off when withdrawn from the borehole. The method of forming the borehole is to advance the cutter head approximately 1 m into the ground, withdraw the head from the hole, and spin off the spoil. This process is repeated until the required depth is reached. Lubrication of the auger is not required, but some dispersal of contaminated material can occur as the spoil is spun off the cutter head.

A disturbed sample is obtained (i.e. it is not possible to distinguish layered material during one sampling movement).

A large variety of soils can be sampled with a driven auger. However, the equipment is not suitable for use in non-cohesive soils (e.g. dry sandy soil or highly moist sandy soils).

B.4.2 Continuous-flight auger

The continuous-flight auger consists of a continuous helix welded to a solid central shaft. It employs a similar driving system to driven augers. Downward force is similarly provided by the machine and continuous rotation lifts the ground to the surface from the base of the hole. Lubrication of the auger is not required. Sampling by continuous-flight auger drilling is suitable for cohesive soils and soils above the groundwater surface.

The following two sampling methods can be used:

— continuous sampling method;

— non-continuous sampling method.

In the continuous sampling method, the flights act as a screw conveyor and continuously bring the cuttings to the surface. Additional sections of auger can be added until the required depth is reached. At the mouth of the borehole, the obtained samples are remoulded.

In the non-continuous sampling method, the flight auger is screwed into the soil with the penetration rate suitable for the auger rotational speed and the pitch of the flight auger. The sampling length into the soil should not exceed the maximum length of the flight auger. During the screwing of the flight auger, the vertical displacement of the soil between the flights is minimized. After the screwing, the drilling tool is completely removed from the borehole without rotation of the auger and the samples are taken from the material adhering to the auger flights.

The non-continuous sampling method can be only used if the borehole is stable or if stabilized with an auxiliary casing.

NOTE See Figure C.19.

B.4.3 Hollow-stem auger

Technique

Hollow-stem augers are a form of continuous-flight auger in which the continuous helix is attached to a hollow central shaft. The drill head is formed of two pieces, the circular outer head and the inner pilot or centre bit which is fixed on a plug on the hollow shaft and can be withdrawn through the centre of the auger up to the surface.

This ability to withdraw the centre bit and plug while leaving the auger in place is the principal advantage of the hollow-stem auger. Withdrawing the plug provides an open-cored hole into which samplers, undisturbed samplers, instruments, borehole casing, and numerous other items can be inserted to the depth achieved.

Removal of any such equipment and replacing the centre plug and bit enables the continuation of the borehole.

The technique provides a fully cased hole and can avoid some of the potential cross-contamination problems of percussion boring. Ground samples are collected by open-drive samplers or core barrels inserted down the hollow stem.

Some versions of the hollow-stem auger allow continuous access to the bottom of the borehole and will permit percussion drilling or driven sampling through the centre while the hollow-stem auger is actually forming the hole.

Lubrication of the auger is not required.

An advantage of hollow-stem augers is that it is possible to obtain undisturbed samples of peat because the auger hangs from the rig during drilling and sampling and does not therefore impose any pressure on the material being sampled. The water content in the sample can be as much as 20 times the mass of the peat itself.

A disadvantage is that limited depth that can usually be achieved (30 m; see Table 3) due to the need for the rig to be able to support the weight of the auger.

NOTE See Figure C.20.

B.4.4 Sonic drilling

The sonic drilling technique uses high-frequency resonant technology. During drilling, the resonant energy is transferred down the drill string to the drill bit. Two eccentrics inside the sonic drill head generate the resonant energy. The driller controls the resonant energy to match the formation being penetrated. This results in a reduction of soil resistance and thereby high penetration rates. Casing the hole as it advances is an integral part of the method. The sonic method of drilling is suited for penetration of (very) soft and mixed formations and can provide very high recovery of the soil profile and a high quality undisturbed samples.

The sonic barrel can be lined with a rigid plastic liner in which the recovered material is retained after being brought to the surface. Alternatively, if the sonic barrel is unlined, the recovered material should be “extruded” by resonance into a flexible polythene “sausage” bag for examination and subsequent taking of disturbed samples. Recovery of approaching 100 % of the soil or rock profile can be achieved in favourable circumstances. However, in some instances, resonance can induce high temperatures in the ground leading to a change in water content in the soil sample and loss of volatile organic compounds.

B.4.5 Rota-sonic drilling

The rota-sonic drilling technique uses high-frequency resonant technology. During drilling, the resonant energy is transferred down the drill string to the drill bit. Simultaneously, rotating the drill string will make it possible to break hard layers. Two eccentrics inside the sonic drill head generate the resonant energy. The driller controls the resonant and rotation energy to match the formation being penetrated. This results in a reduction of soil resistance and thereby high penetration rates. Casing the hole as it advances is an integral part of the method.

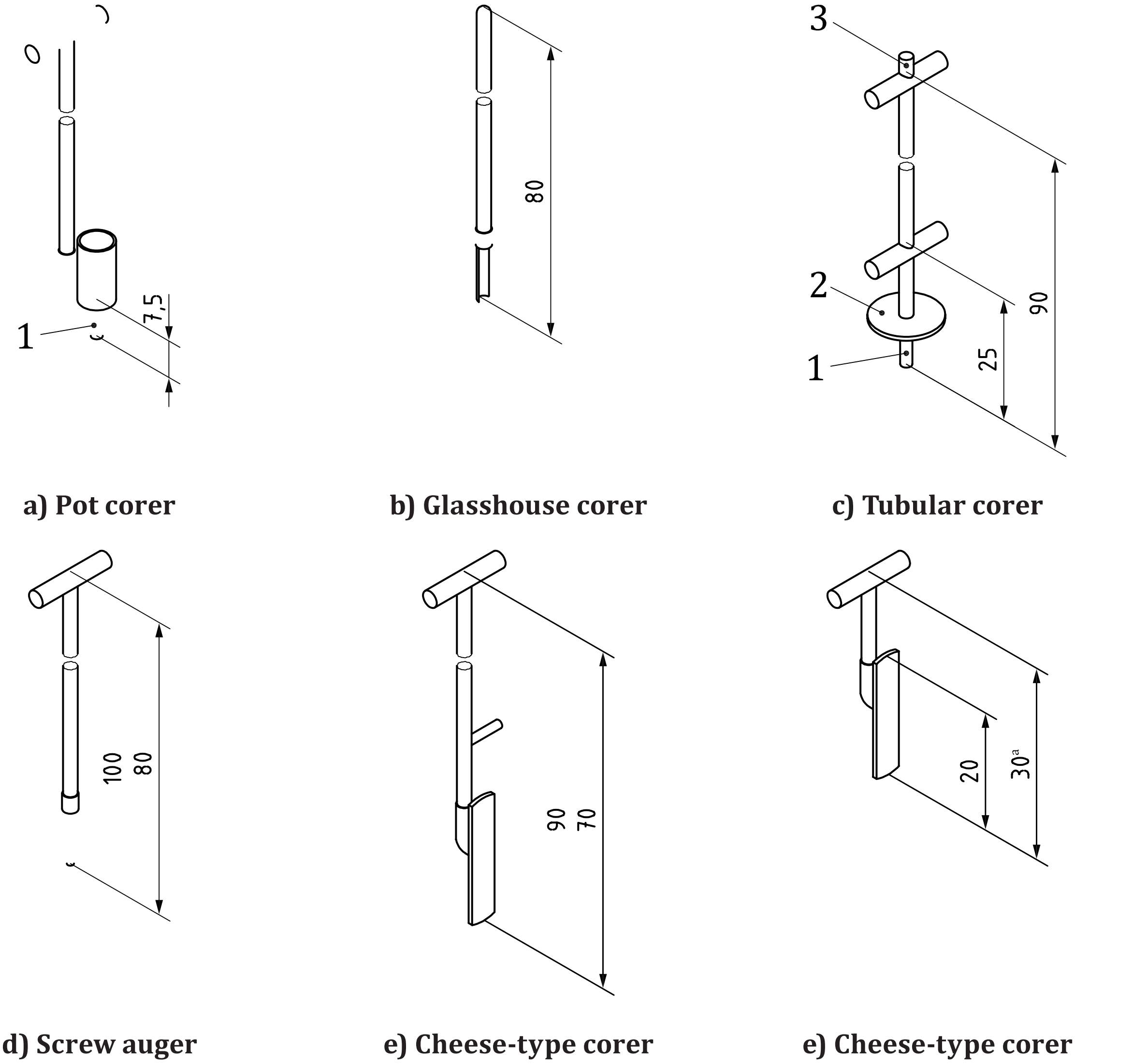
The rota-sonic method of drilling is suited for penetration of (very) soft, mixed, and harder formations (all overburden types). It can provide very high recovery of the soil profile and a high quality undisturbed samples.

The sonic barrel can be lined with a rigid plastic liner in which the recovered material is retained after being brought to the surface. Alternatively, if the sonic barrel is unlined, the recovered material should be “extruded” by resonance into a flexible polythene “sausage” bag for examination and subsequent taking of disturbed samples. Recovery of approaching 100 % of the soil or rock profile can be achieved in favourable circumstances. However, in some instances, resonance can induce high temperatures in the ground leading to a change in water content in the soil sample and loss of volatile organic compounds.

Annex C
(informative)

Illustration of some selected drilling and sampling equipment

Dimensions in centimetres



Key

1 open end with cutting edge of smaller diameter than hollow tube

2 adjustable circular plate to control depth of penetration

a Approximately.

Figure C.1 — Example of hand-held sampling devices mainly used for sampling natural surface

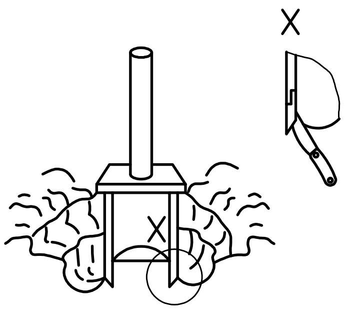
Figure C.2 — Edelman auger

Figure C.3 — “Riverside” and gravel augers

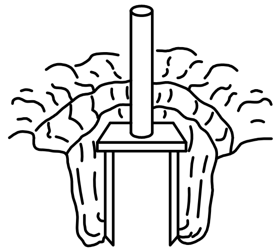
Figure C.4 — Piston sampler

Figure C.5 — Gouge auger

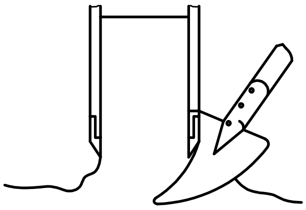
Figure C.6 — Gouge augers



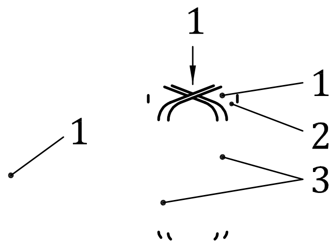
a) Positioning the sampler



b) Pushing the sampler into the soil



c) Removing the sampler from the soil



d) Sealing the sample

Key

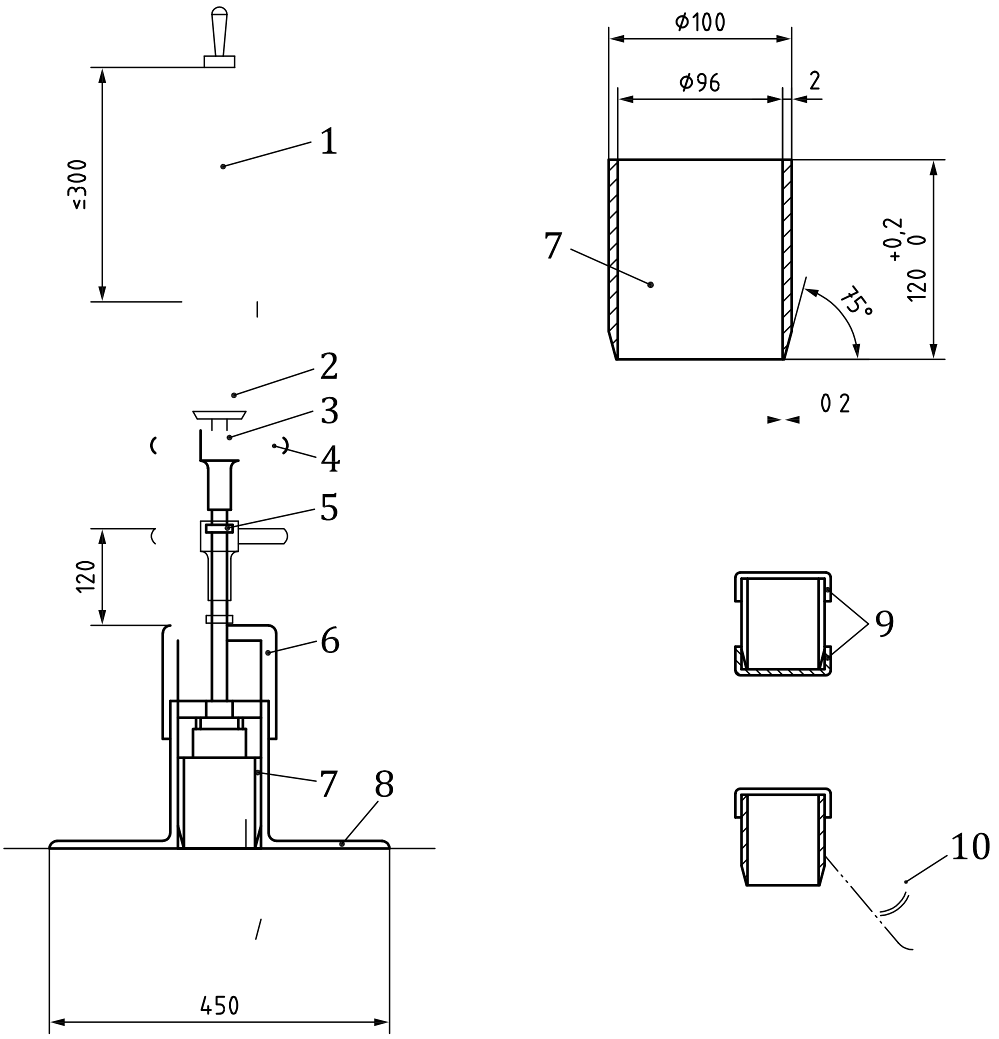
1 waterproof cap

2 paraffin or waterproof seal

3 strong tape

Figure C.7 — Method of recovering undisturbed samples from trial pits

Dimensions in millimetres

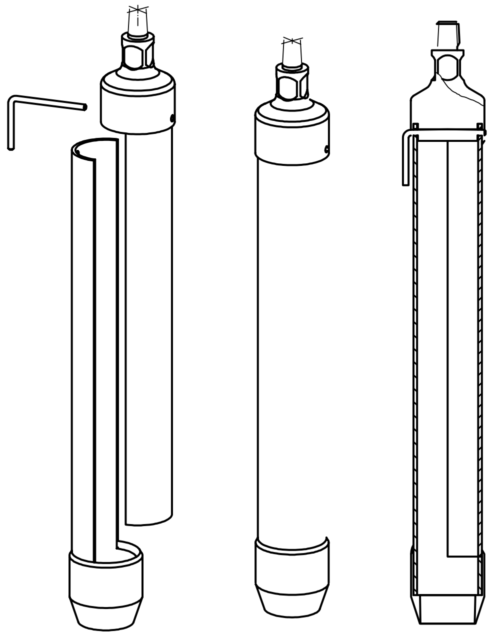


Key

1 percussion drill rods
2 drop weight
3 anvil
4 driving device
5 ring mark
6 guide hood
7 sampler tube (cutting cylinder)
8 guide plate
9 end caps (sealed with adhesive tape)
10 metal plate for limiting depth of penetration

NOTE For cutting cylinders, see also Figure C.22.

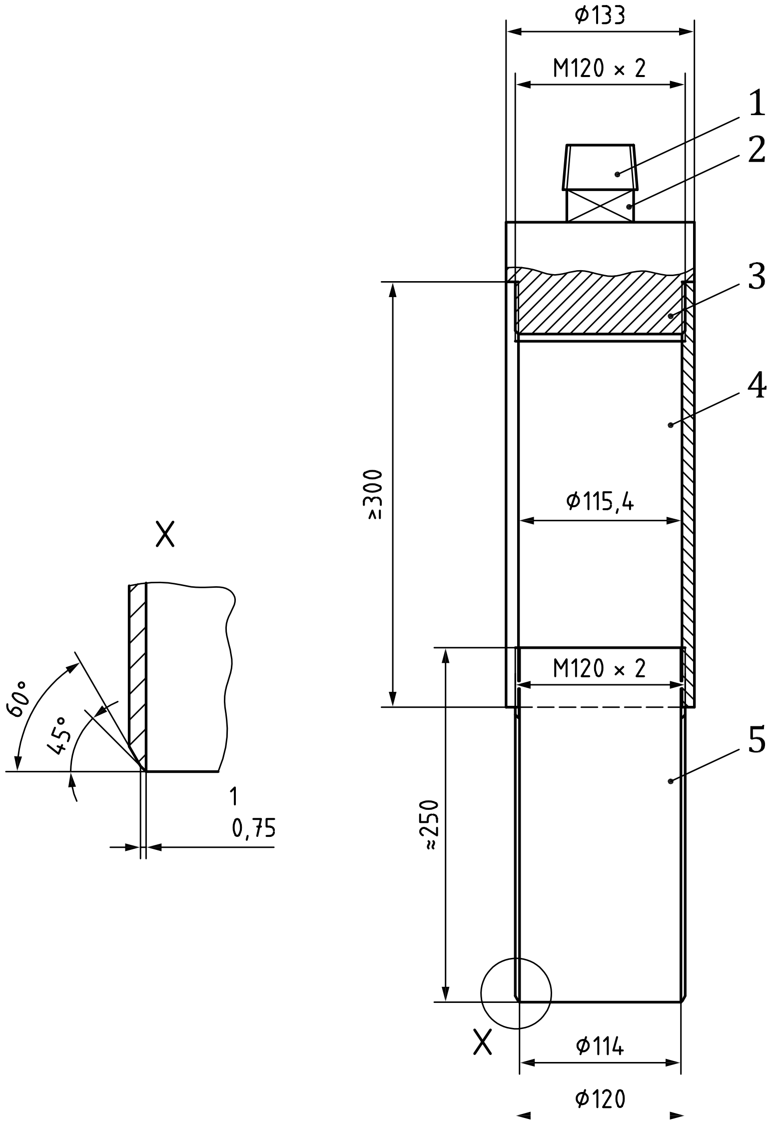
Figure C.8 — Method for recovering undisturbed samples from trial pits — Example



NOTE Source: Eijkelkamp Agrisearch Equipment, The Netherlands.

Figure C.9 — Split tube sampler

Dimensions in millimetres



Key

1 pipe tread

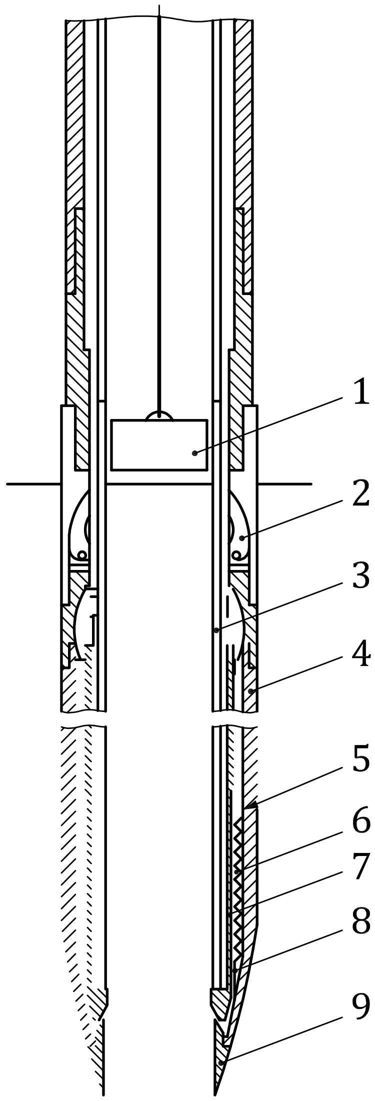
2 width across flats

3 sampler head with non-return valve (not shown)

4 overdrive space

5 sampler tube

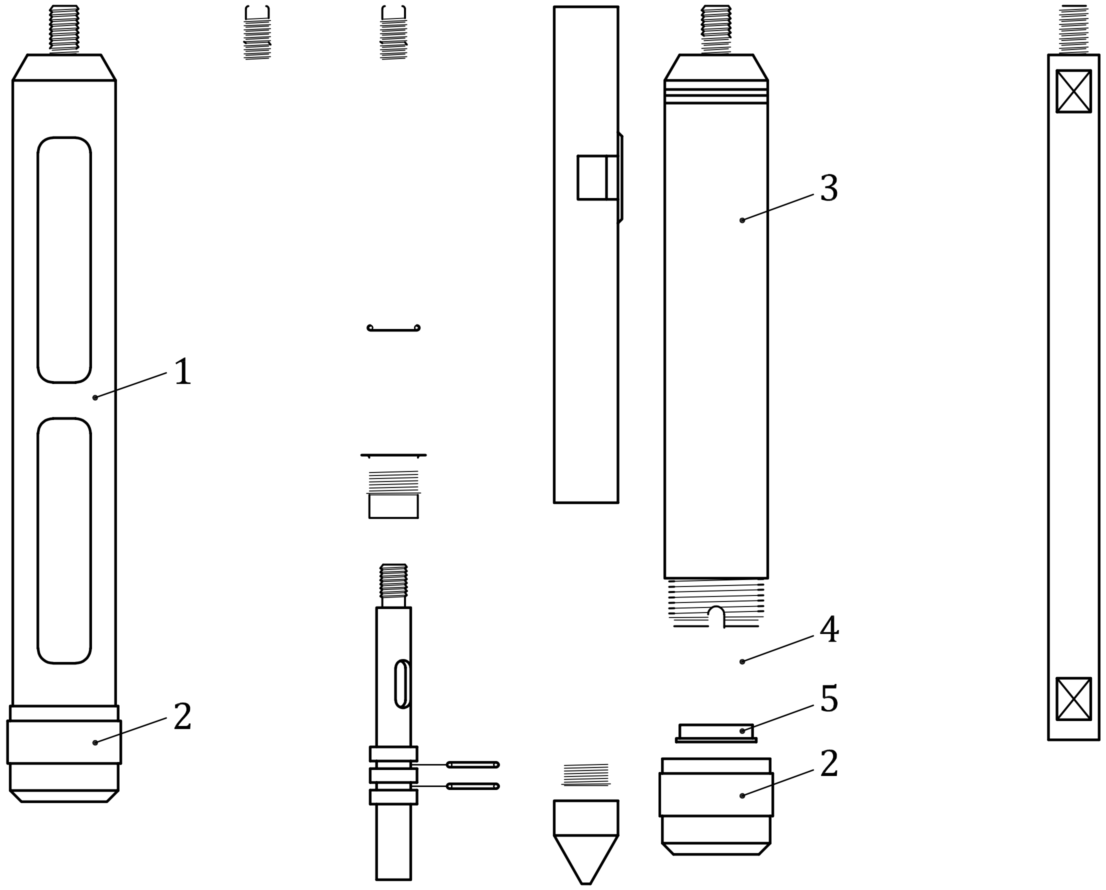
Figure C.10 — Example of thin walled sample tube



Key

1 stock clamp
2 core lifter
3 plastic liner
4 outer barrel
5 stocking tube
6 stocking chamber
7 steel tube
8 nylon stocking (up to 20 m long)
9 cutting shoe

Figure C.11 — Example of thick walled sample tube



a) Window sampler **b) Window sampler with 35 mm and 50 mm diameter** **c) Windowless sampler** **d) Driving rod**

Key

1 sample tube-window
2 shoe
3 sample tube
4 plastic liner
5 retainer

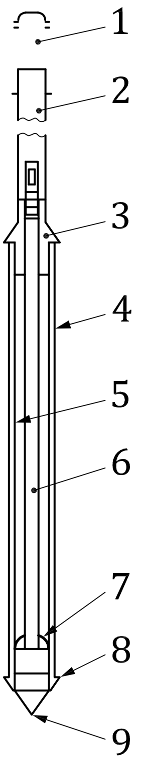
Figure C.12 — Window and windowless samplers (used with percussion drilling rig)

Figure C.13 — Window sampler tubes — Note reducing diameter with depth

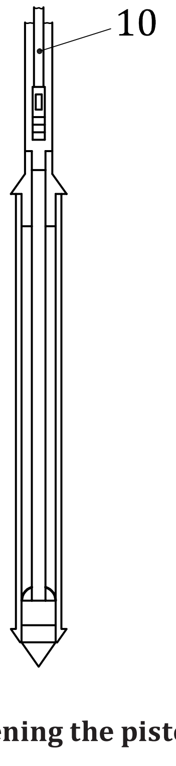
Figure C.14 — Plastic liners from windowless sampler cut open to reveal core

Figure C.15 — Hand-operated window sampler

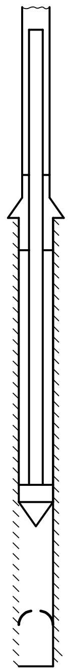
Figure C.16 — Small percussion (RHS) and SPT rigs (LHS)



a) Driving the sampler



b) Opening the piston tip

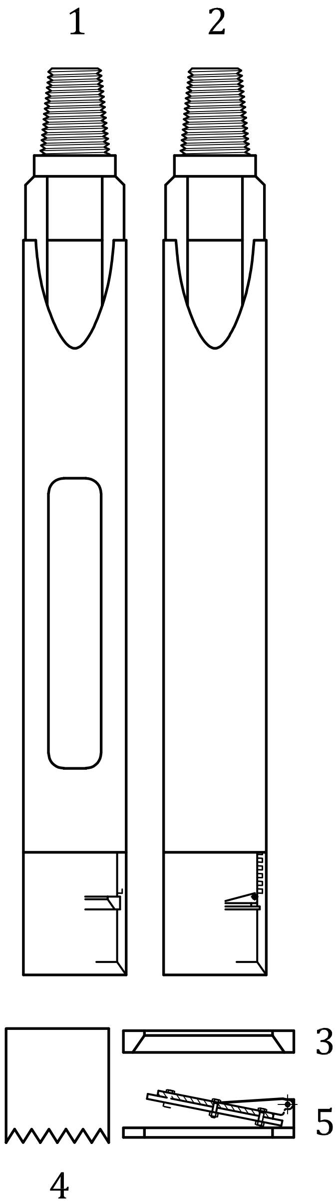


c) Sampling soil

Key

1) knocking head
2) drive rod
3) drive head
4) outer tube
5) sampling tube
6) piston rod
7) core catcher
8) cutting shoe
9) piston tip
10) release rod

Figure C.17 — Closed piston sampler



Key

1 clay cutter

2 shell or bailer

3 clay cutter ring

4 serrated tool shoe

5 leather clack

Figure C.18 — Cable percussion drilling tools

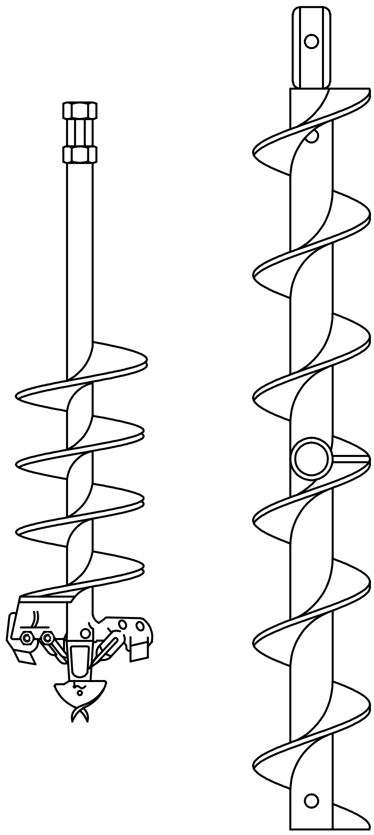
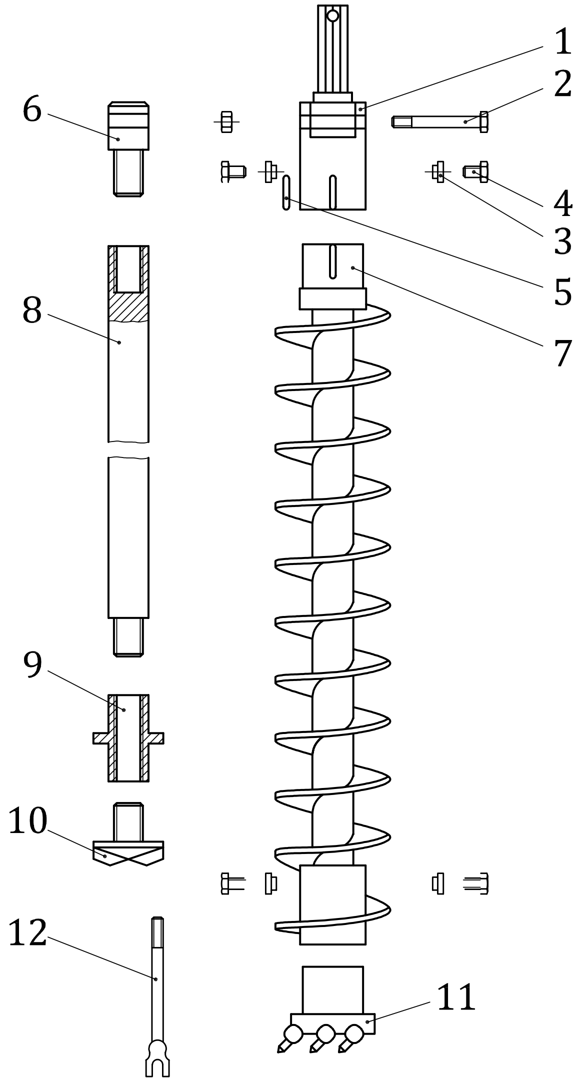


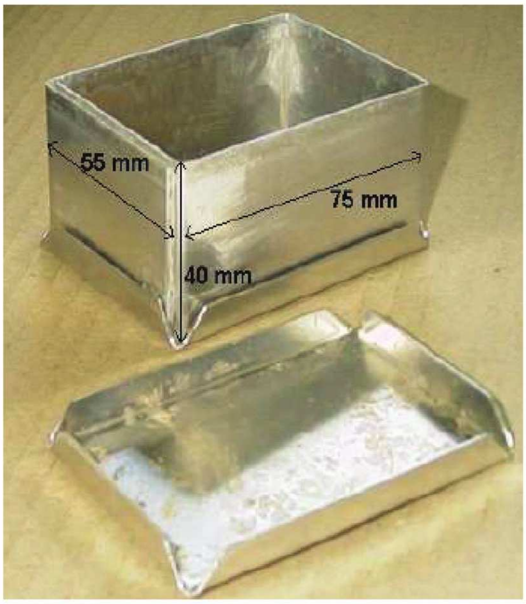
Figure C.19 — Continuous flight augers



Key

1 drive cap
2 nut and bolt for rod to cap adaptor
3 bushing nut
4 lock nut
5 drive key
6 rod-to-cap adaptor
7 hollow stem auger
8 drill rod
9 pilot bit connector
10 pilot bit
11 cutter head
12 knockout wrench

Figure C.20 — Hollow stem auger



NOTE Most Kubiëna tins open on one corner to ease extraction. The tin, which should be oblong rather than square, should be sharp at the leading edge to ease penetration.

Figure C.21 — Example of a Kubiëna tin

Figure C.22 — Example of cutting cylinders

The cylinders shown are used to obtain undisturbed samples, e.g. for determination of soil density. An illustration of how they can be used is provided in Figure C.8.

Annex D
(informative)

Sampling equipment for stockpiles

D.1 Augers

D.1.1 Soil auger

See A.2.

D.1.2 Driven auger

See B.4.1.

D.2 Sampling tubes

See B.1.

D.3 Scoops

Soils can be sampled with a sampling scoop. This equipment is however not suitable for sampling at significant depths within the soil stockpile without the aid of other equipment to reach the sampling location (like a mechanical excavator).

The sampling scoop is pushed into the soil at the sampling location and withdrawn. The excess material above the sides of the scoop is pushed off. The rest of the material is the sample.

Hand-held shovels and spades are seldom suitable for use as sampling scoops, although it is important to recognize that they come in a wide variety of sizes and shapes and some may be suitable. Difficulty arises because the soil that is originally sampled might fall off the shovel after sampling, the larger particles will have a greater tendency to roll off the heap that is formed on a shovel, and it can be difficult to transfer the soil from the shovel to a sample container in its entirety to form the laboratory sample. The comparatively large size of the sample on the shovel can require reduction with consequential difficulty ensuring that any subsample that is taken (e.g. following the procedures described in ISO 18400-201) remains representative.

D.4 Mechanical excavator

A mechanical excavator or comparable mechanized equipment for digging and excavation work can be suitable for taking samples from a soil stockpile. The excavator can be used in two ways:

— for sampling;

— for excavating the soil stockpile making the sampling location accessible for other sampling equipment.

Due to the large size of the shovel, in most situations, a full load of the shovel will be much too large as a sample. Using the mechanical shovel as a sampling tool therefore necessitates sample pretreatment directly after sampling (see ISO 18400-201). Only for soils that consist of (very) large particles will a mechanical excavator be the most appropriate sampling equipment.

When applying the mechanical excavator for excavating the soil stockpile in order to make it accessible for other sampling equipment, a safe boundary layer should be maintained between the excavation and the sampling location. This is necessary to ensure the consistency of the sample.

NOTE The dimensions of the boundary layer will depend on the properties of the soil (e.g. particle sizes), the slope of the soil at the sampling location, and the degree of consolidation and can therefore not be described precisely.

Annex E
(informative)

Examples of large samplers

E.1 Method of sampling using a large sampler

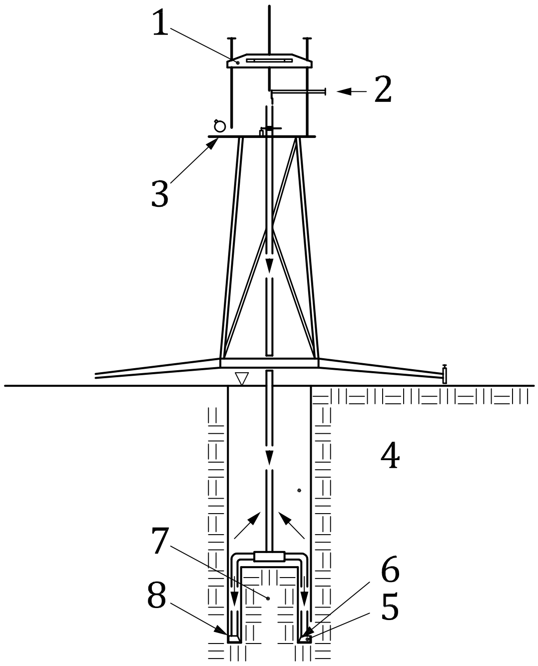
E.1.1 Method of sampling using a Sherbrooke block sampler

a) Preparation of the borehole

The preparation of the borehole for a Sherbrooke block sampler requires use of a solid auger with a diameter of 400 mm. The borehole can be supported by mud or be cased down to the sampling level. Before lowering a large sampler into the borehole (see Figure E.1), any loose debris or disturbed material is removed from the bottom of the borehole using a flat bottom auger with a diameter of 400 mm.

b) Sampling procedure with sample recovery

The Sherbrooke block sampler carves a cylindrical soil block of 250 mm in diameter by three cutting knives. These tools have an annular motion that permits carving of a 5 cm wide slot around a clay cylinder. At each cutting tool, water or mud is fed from the surface to help evacuate the clay cuttings during sampling. The sampler is connected to an ordinary drill rod system that provides rotation of the sampler at about 5 r/min during the carving. The rate of vertical progression can vary with the clay types, but it generally takes 25 min to 30 min to achieve the full depth of about 350 mm. When carving of the about 350 mm high soil cylinder is completed, a horizontal diaphragm fixed at each cutting tool is activated from the surface and pushed into the lower end of the soil block. About 5 min are required to let these bottom diaphragm elements cut their way under the sample as the sampler continues to rotate. The closure of the diaphragms separates the sample from the surrounding soil and provides support beneath the sample when this is lifted to the surface. The sample is separated very slowly for the first few centimetres to permit good circulation of water under the sample to avoid suction.



Key

1 control of vertical progression (manually)
2 annulus slot
3 rotation (mechanic or electrical)
4 water or bentonite mud
5 borehole 400 mm in diameter
6 water circulating at each leg
7 sample being carved (bottom diaphragm opened)
8 cutting tools at every 120°

Figure E.1 — Example of sampling from borehole bottom using a Sherbrooke sampler

E.2 Method of sampling using a Laval sampler

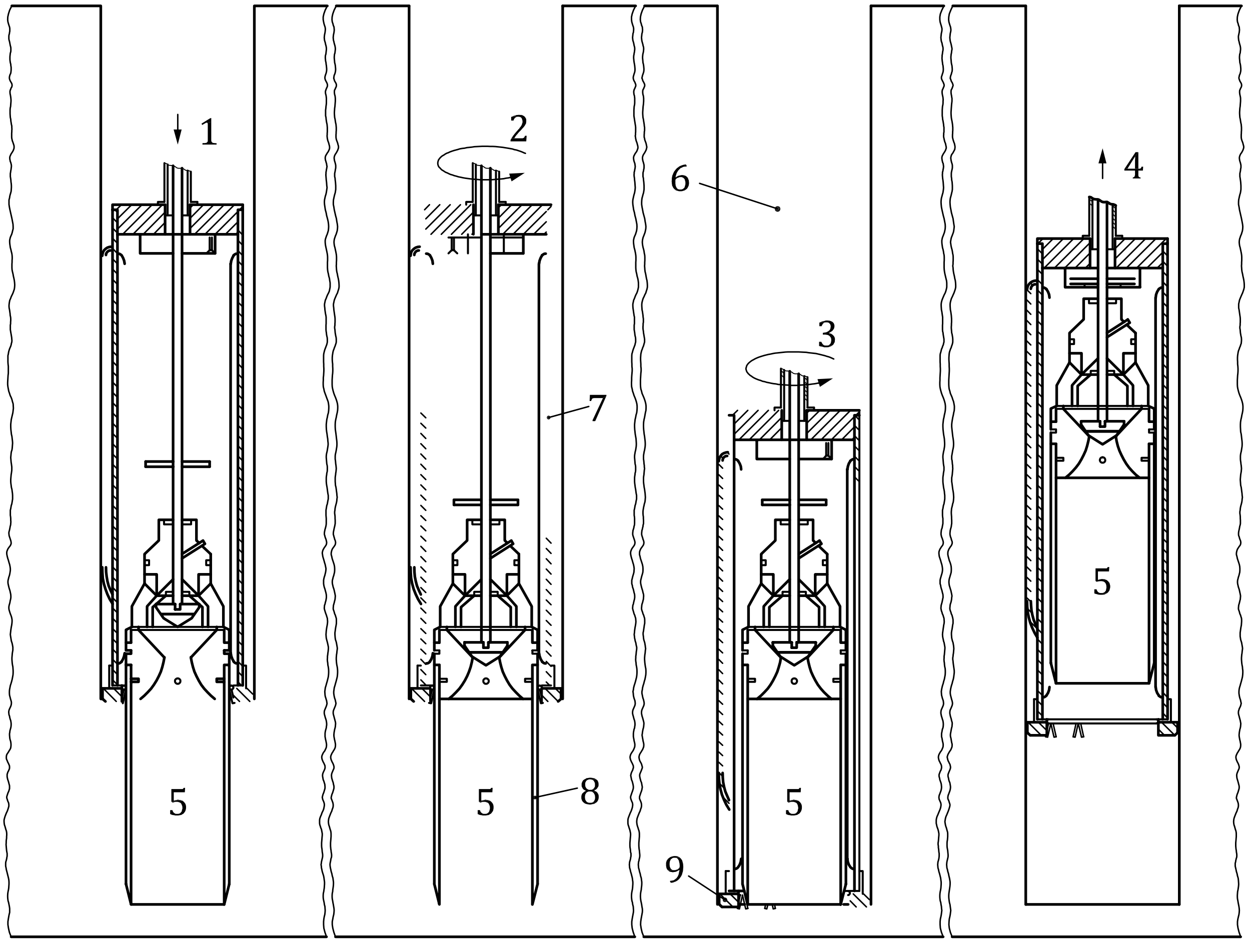
a) Preparation of the borehole

The Laval sampler can either be used in a previously drilled hole or in a purposely formed borehole made using a solid auger with a diameter of 400 mm. The borehole can be supported by mud or be cased down to the sampling level. Before lowering a large sampler into the borehole (see Figure E.2). Any loose debris or disturbed material is removed from the bottom of the borehole using a flat bottom auger with a diameter of 400 mm.

b) Sampling procedure with sampling recovery

The sampler assembly is lowered into the borehole with the sampler hooked up inside the coring tube and with the head valve open. The mud can then flow freely through the sampler. When the lower edge of the coring tube reaches the bottom of the borehole, the coring tube is held fixed from the surface and the sampler is unhooked by pulling up and turning the central rod slightly. As the tube sampler is pushed down into the soil by a continuous thrust, the mud flows out of the tube through the head valve of the sampler. To make sure that no pressure is applied on the soil sample, the movement of the sampler is stopped when the head of the sampler has reached an elevation of approximately 50 mm above the top of the sample. The head valve is then closed and the coring operation is carried out by rotating the coring tube, at the same time injecting under pressure the bentonite mud. This flows through the drill rod down between the sampling and coring tubes, around the lower remoulding ring, and up outside the coring tube into the borehole. The injection of mud aims at washing the remoulded clay out of the teeth and cutters of the remoulding ring. When the coring ring has reached a depth of approximately 20 mm below the edge of the sampler, the coring is stopped and the sampler rotated through 90°, pulled up gently, and hooked back on the collar of the coring tube ready to be retrieved from the borehole.

The soil samples are extruded immediately after sampling in the field. They are cut out with a wire in slices 130 mm or 200 mm high, depending on the type of tests to be carried out. The slices are put on waxed plywood board, wrapped in special paper, sandwiched between layers of a paraffin wax and Vaseline mixture, and are then ready to be transported and stored.



Key

1 tube sampler is pushed down

2 head valve is closed by screwing the inner string of rods

3 coring operation is carried out by rotating the coring tube

4 sampling tube is hooked back on the collar of the coring tube and the sampler is retrieved from the borehole

5 sample

6 borehole 300 mm in diameter

7 coring tube

8 sampling tube

9 cutting teeth

Figure E.2 — Method of sampling using a Laval sampler

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