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Soil quality — Sampling —

Part 2: Guidance on sampling techniques

Qualité du sol — Échantillonnage —

Partie 2: Lignes directrices pour les techniques d'échantillonnage

Reference number
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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 3.

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

Attention is drawn to the possibility that some of the elements of this part of ISO 10381 may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

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

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

— *Part 1: Guidance on the design of sampling programmes*

— *Part 2: Guidance on sampling techniques*

— *Part 3: Guidance on safety*

— *Part 4: Guidance on the procedure for the investigation of natural, near-natural and cultivated sites*

— *Part 5: Guidance on investigation of soil contamination of urban and industrial sites*

— *Part 6: Guidance on the collection, handling and storage of soil for the assessment of aerobic microbial processes in the laboratory*

The following parts are under preparation:

— *Part 7: Guidance on the investigation and sampling of soil gas*

— *Part 8: Guidance on the sampling of stockpiles*

Annex A of this part of ISO 10381 is for information only.

Introduction

This part of ISO 10381 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 and contamination investigations, but is not applicable to investigations for geotechnical purposes.

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 pollution of soil and related material are given in ISO 10381-1. ISO 10381-1, ISO 10381-4 and ISO 10381-5 should be consulted regarding the appropriate equipment, information about where to sample, the tests to be conducted, the type of sample, the depth of sampling, soil type and the required representativeness of the sampling system.

Soil quality — Sampling —

Part 2: Guidance on sampling techniques

1 Scope

This part of ISO 10381 gives guidance on techniques for taking and storing soil samples so that these can subsequently be examined for the purpose of providing information on soil quality.

This part of ISO 10381 gives information on typical equipment that is 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.

The guidance provided is intended to assist in the collection of samples for soil quality for agricultural purposes and also provide guidance for the collection of samples for contamination investigations which will require different techniques and skills.

This part of ISO 10381 makes reference to some aspects of the collection of samples of groundwater and soil gas as part of a soil sampling programme.

This part of ISO 10381 specifically does not cover investigations for geotechnical purposes, though where redevelopment of a site is envisaged the soil quality investigation and the geotechnical investigation may be beneficially combined.

This part of ISO 10381 is not applicable to the sampling of hard strata such as bedrock.

Techniques to collect information on soil quality without taking samples, such as geophysical methods, are not covered by this part of ISO 10381.

2 Normative references

The following normative documents contain provisions which, through reference in this text, constitute provisions of this part of ISO 10381. For dated references, subsequent amendments to, or revisions of, any of these publications do not apply. However, parties to agreements based on this part of ISO 10381 are encouraged to investigate the possibility of applying the most recent editions of the normative documents indicated below. For undated references, the latest edition of the normative document referred to applies. Members of ISO and IEC maintain registers of currently valid International Standards.

ISO 11074-1, *Soil quality — Vocabulary — Part 1: Terms and definitions relating to the protection and pollution of the soil*

ISO 11074-2, *Soil quality — Vocabulary — Part 2: Terms and definitions relating to sampling*

ISO 11074-4, *Soil quality — Vocabulary — Part 4: Terms and definitions related to rehabilitation of soils and sites*

3 Terms and definitions

For the purposes of this part of ISO 10381, the terms and definitions in ISO 11074-1, ISO 11074-2, ISO 11074-4 and the following apply.

3.1
spot sample
single sample
sample of material collected from a single point

NOTE This may be a disturbed or undisturbed sample.

3.2
slot sample
sample taken as a vertical slot from within a stratum or other subpart which is putatively homogeneous

NOTE This is a disturbed sample.

3.3
stratified sample
sample obtained as a combination of spot samples from strata or subparts, putatively homogeneous

NOTE This is a disturbed sample.

3.4
cluster sample
sample which is a composite of small incremental point samples taken close together

NOTE This is a disturbed sample.

3.5
spatial sample
sample which is a composite of small incremental point samples taken over an area (such as a field)

NOTE This is a disturbed sample.

4 Principle

4.1 Sampling of soil

Soil samples are collected and examined primarily to determine associated physical, chemical, biological and radiological parameters. This clause outlines the more general factors to be considered when selecting sampling equipment and its use. More detailed information is given in subsequent clauses.

Whenever a volume of soil is to be characterized, it is generally impossible to examine the whole and it is therefore necessary to take samples. The samples collected need to be as fully representative as possible of the whole to be characterized, and all precautions should be taken to ensure that, as far as possible, the samples do not undergo any changes in the interval between sampling and analysis. The samples normally collected are described as disturbed samples, i.e. the soil particles become loosened and separated in the sampling process. If it is necessary to collect undisturbed samples, e.g. for microbiological or geotechnical purposes, the samples need to be collected in such a manner that the soil particles and pore structure remain unaltered in comparison with the original ground structure. The sampling of multiphase systems, such as soils containing water or gases which are not of natural origin (e.g. waste materials), can present special problems.

The sampling technique should be selected to enable the collection of samples of ground material which can be presented to the laboratory for examination or analysis to establish basic information on the pedology and distribution of naturally occurring or manmade soils, their chemical, mineralogical and biological composition, and their physical properties at selected locations.

The choice of sampling technique depends, in addition, on 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.

Sampling equipment should be carefully selected in relation to the different materials which may be present in the ground and the analysis to be carried out. Utmost care should be taken to avoid cross-contamination, loss of volatile compounds, change of composition due to exposure to air, and other changes which may occur between sampling and the testing of the sample.

Every soil sampling technique usually consists of two separate steps:

a) gaining access to the point of sampling (removing the cover or sealing, digging or drilling a hole to reach the desired depth of sampling), and

b) taking the soil sample.

Both steps depend on each other and both shall meet the requirements of the sampling principles.

4.2 Sampling of water

Soil investigation programmes, particularly those carried out at contaminated sites, may also require water samples to be taken. These should be collected in accordance with appropriate International Standards on ground or surface water sampling with regard to ground investigation. For further information see ISO 10381-1.

4.3 Sampling of soil gas

Ground investigation programmes may involve assessment of soil gas composition for typical landfill gas components such as methane and carbon dioxide. In the case of contaminated sites, the suspected presence of solvents or fuels may require investigation. An International Standard (ISO 10381-7) is in the course of preparation to cover such investigations, and some indicative guidance is incorporated in this part of ISO 10381.

5 Choice of sampling technique

5.1 Preliminary information

The choice of sampling technique, the selection of the sampling equipment and the method of taking soil samples depends 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.

Thus certain information is needed to make this choice. This information may include

— the size and topography of the area to be sampled,

— the nature of the ground to be sampled,

— some indication of the possible lateral and vertical variations of soil type or strata,

— the geology of the site and surrounding area,

— the depth to groundwater and its direction of flow,

— the depths from which samples are to be taken, taking into consideration the future use of the site, including depth of excavations or foundations,

— previous usage or treatment of the site,

- the presence of buildings and obstructions, such as foundations or hardstandings, buried tanks and underground services (e.g. electricity, sewers, mains, cables),
- indications of the presence of underground tanks and service (for example inspection covers, inspection chambers, vent pipes),
- the presence of concrete or tarmac pathways, roadways or hardstandings,
- the safety of the site personnel and protection of the environment,
- the growth of vegetation leading to extensive root development,
- the presence of unexpected surface-water pools or water-saturated ground,
- the presence of fences, walls or earthworks designed to prevent access to the site,
- the presence of tipped material above the level of the site, or material from the demolition of buildings,
- location of water bodies at risk from contamination, including surface and ground water.

Extreme natural circumstances, such as permafrost, laterization, calcrete or other indurations, may occur which require special techniques in order to obtain samples. This shall be known prior to the design of a sampling programme.

To collect this information, a desk study or preliminary survey of the site is strongly recommended. When investigating soils suspected of contamination, the preliminary survey is an essential part of the investigation programme [see clause 6 of ISO 10381-1:—[1)] and clause 6 of ISO 10381-5:—[1)]]. Its main relevant concerns are

a) to ensure an investigation which is both technically and cost effective;

b) to ensure the safety of personnel and to protect the environment.

The preliminary survey may comprise both desktop studies and site reconnaissance (field work). It does not normally include taking samples, but in some circumstances limited sampling may be useful in relation to determining the parameters for the site investigation, investigating some metholodical aspects, and identifying possible hazards to the investigating personnel.

5.2 Type of sample

There are two basic types of sample which are collected for the purposes of investigating soil and ground conditions. These are:

a) disturbed samples: samples obtained from the ground without any attempt to preserve the soil structure; that is the soil particles are collected “loose” and are allowed to move in relation to each other;

b) undisturbed samples: samples obtained from the ground using a method designed to preserve the soil structure; i.e. special sampling equipment is used so that the soil particles and voids cannot change from the distribution which exists in the ground before sampling.

Disturbed samples are suitable for most purposes, except for some physical measurements, profiles and microbiological examinations for which undisturbed samples may be required. Undisturbed samples should be collected if it is intended to determine the presence and concentration of volatile organic compounds, since disturbance will result in loss of these compounds to the atmosphere.

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1) To be published.

If undisturbed samples are required for soil sampling, these can be taken, for example, using a Kubiena Box, a coring tool or coring cylinder. In each case the sampling device is pushed into the soil and subsequently removed with the sample, so that the soil is collected in its original physical form.

There are different methods of taking samples from the ground for the purpose of investigating soil quality (see clause 3).

If a slot sample (single sample) is small it may be taken for a spot sample. All other sampling methods produce composite samples (average samples, aggregate samples). Composite samples are not useful to determine soil characteristics that suffer changes during the composition process, such as concentrations of volatile compounds. They also cannot be used if peak concentrations of any substance or variations of soil characteristics are to be determined.

Spot samples can be readily collected using hand augers and other similar sampling techniques. Where undisturbed samples are required, special equipment (see above) is necessary in order to collect the sample whilst maintaining the original ground structure.

Cluster samples are appropriate when using machines for excavating ground to obtain samples. In these circumstances, the samples should be formed by taking portions from locations within the bucket of excavated material (e.g. nine-point sample).

Spatial samples or other composite samples can be collected using hand or powered augers, but care shall be taken to ensure the auger repetitively collects the same amount of sample.

5.3 Selection of sampling technique

Within this International Standard, it is not possible to fix one sampling technique to every possible sampling objective, because there are so many objectives and many of them are satisfied by more than one technique.

The following examples indicate some of the main rules that shall be followed.

- Soil characteristics that are bound to soil horizons (which are most of them) require horizon-bound (stratified) sampling.
- If the spatial variation of soil characteristics is of interest, spot samples are required. If the required precision of the results is low, other types of sample also may be accepted.
- Samples taken to identify the distribution and concentration of particular elements or compounds are normally spot samples, or perhaps slot or cluster samples within the area being examined.
- Samples taken to assess the overall quality or nature of the ground in an area, e.g. for certain agricultural purposes, are spatial samples.
- Sample size shall be sufficiently large to enable all tests and analyses to be performed.
- Sample size shall be sufficiently large to represent all soil characteristics of interest.
- Samples shall not be too large to obscure variations in soil characteristics of interest.
- Soil characteristics of interest shall not be affected by the sampling process, nor by the transportation and storage of samples.
- Representative sampling usually means that increments with different properties shall be (if applicable at all) combined into a composite sample only according to their volume fraction of the parent population to be sampled.
- Cross-contamination shall be avoided, as well as the spread of contaminants.

5.4 Cross-contamination

Chemical soil properties, in particular, can be changed by the sampling procedure in many ways:

- by transmission of substances fixed to sampling equipment or containers;
- by 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 bore hole, either during augering/drilling or during withdrawal of the sample;
- by transfer of substances from the sampling device or container;
- by loss of volatile compounds, leakage of liquids or mechanical separation;
- by contamination with auxiliary substances used to enable or facilitate the sampling (fuels, exhaust fumes, greases, oils, lubricants, glues and others);
- by contamination with wind-blown particles, spread liquids or precipitation.

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.

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

Where it is necessary to use lubrication, e.g. water, to ease formation of a borehole to enable sample collection, only lubrication should be used which will not conflict with nor confound the analysis to be performed on the samples in the sense of matrix effects or contribution to the contamination.

Only devices of controlled chemical quality and composition shall 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. Devices that have contact with samples shall never be painted, greased or have otherwise chemically treated surfaces.

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

6 Safety and environmental protection in the investigation

In any soil-sampling investigation there is some disturbance of the ground. In areas of agricultural use, woodland and semi-natural vegetation, this disturbance is usually minimal and unlikely to result in the creation of any hazard.

When carrying out investigations on highly contaminated sites, consideration should be given to using probehole, borehole or similar techniques, rather than excavations, in order to minimize and reduce problems due to exposure, disturbance and potential dispersal of the contamination.

When the site surface prior to the investigation is obviously contaminated, or presents a general environmental problem due to exposure to humans or animals, and there is the possibility of dispersal of contaminated dust or water pollution, in addition to taking precautions to minimize disturbance and dispersal of contamination during the site investigation, the situation should be brought to the attention of the landowner and local authorities, so that preventative measures can be implemented. National or local regulations on information procedures or obligations shall be obeyed.

NOTE See also ISO 10381-3.

6.1 Personal protection

During a soil-sampling investigation there are different procedures that may influence human health and safety:

— handling sampling instruments and machinery;

— unstable ground or slopes, open holes or excavations;

— exposure of contaminants to sampling personnel and people living near by or passing by;

— exposure of sampling personnel to contaminants released from transport or storage containers or during sample pretreatment;

— inconveniences from noise, dust, odours and so on, resulting from heavy fieldwork.

Where there is the possibility of munitions or explosives residues, the assistance of a specialist may be necessary to ensure that the site has been cleared and made safe before the commencement of any on-site work.

All possible hazardous effects of soil sampling on human health shall be considered when selecting appropriate sampling methods. If this is done carefully, most adverse effects on other organisms, constructions and the environment will be regarded automatically.

6.2 Protection of buildings and installations

Prior to the commencement of any intrusive survey, it is essential that the location of any below-ground services be identified to prevent damage, and the location of any overhead cables (power lines and telecommunications) be identified. In agricultural surveys, features such as irrigation and drainage lines should be identified.

Locations of services and other features which shall not be damaged can be identified by consultation with the landowner (or tenant) and the service utilities. Even when service locations have been identified, the sampling location should be checked with a services monitor before commencement of the intrusive investigation. If there is doubt about the possibility of services being present, the initial 1,0 m to 1,5 m, or the maximum depth of the services, should be dug by hand.

Excavations shall be planned with respect to slope stability, stability of the ground of adjacent buildings and possible emissions of hazardous substances from contaminated ground. If problem is suspected, bores or drillings should be used instead of excavations.

6.3 Environmental protection

Material exposed on the surface can present a hazard to the environment due to the release of odours, fumes, dust, liquid contaminants or contaminated water. For example, dust or contaminated water can wash into streams or ponds or onto adjoining land. This can be difficult to control and can only be minimized by carrying out work carefully. This is equally important on completion of the investigation; the backfilling of trial pits and cleanup of the site after the investigation should ensure that such exposure does not occur.

When the arisings are a result of drilling and construction of boreholes, the amount is likely to be small and unlikely to create any disposal problem outside the site. Such arisings should be collected together and disposed of to a suitable location upon completion of the investigation.

If the water table is reached, trial pits will fill with groundwater that may be contaminated or covered with non-aqueous fluids such as oils. In these situations, special care is required in backfilling in order to prevent the escape or dispersal of the contaminated liquids onto the site surface or into uncontaminated soil.

Open water with contamination or oil sheets poses a danger to waterfowl and other animals.

If boreholes are installed or excavations penetrate impermeable strata, e.g. clay, new pathways can be created which result in increased dispersion of contamination. In these situations, the excavations should avoid penetrating the protective impermeable strata. For boreholes, it is possible to drill down to the impermeable strata, and insert an impermeable protective plug of bentonite or similar material, through which a smaller-diameter inner borehole can be drilled to greater depth. In this way a seal is established which prevents the dispersion of the contamination.

Increased dispersal can also result where contamination exists beneath a relatively impermeable layer, such as tarmac or concrete hardstanding. If such a layer is broken through and the impermeable layer is not replaced, then the resultant increased penetration of rainwater can result in greater percolation and dispersion of contamination into the ground and groundwater. In such circumstances the borehole or excavation should be reinstated with an appropriate low-permeability cover layer of appropriate thickness. Also, in such circumstances, because of the possible settlement of the backfilled trial pits, a period of maintenance should be incorporated into the site investigation specification, so that the possible effects of any settlement can be rectified.

6.4 Backfilling

Each soil-sampling process produces voids where the sample has been removed or access to the sampling point was enabled. These voids can present new migratory pathways which shall be considered, especially in contaminated ground. Big holes and excavations present a hazard to organisms and machines that may fall into them and may influence the stability of the surrounding ground. If not used for installation of monitoring devices, profiling or foundation holes, excavations originated from soil sampling therefore usually must be refilled.

When backfilling trial pits, the excavated material may be used, in which case it should be returned to the original depth below ground level, ensuring that any obviously suspect material is buried well below the ground surface. 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 at least part of the excavation. Measures should be taken so that no additional contamination is left at the surface of the site on completion of the investigation. It may be necessary to import clean material to form a surface layer over the excavation upon completion of the backfilling process. It may also be considered appropriate to backfill with clean material and dispose of the excavated material off-site to a suitable location.

Local regulations and national legislation shall be observed.

When backfilling boreholes where contamination is suspected, it is advisable to grout the borehole to prevent the possible dispersal of contamination and dispose of the arisings off-site to a suitable location.

Any surplus excavated material should be collected for safe disposal.

7 Techniques

7.1 General

The selection of sampling techniques should be guided by the following consecutive questions:

a) What are the soil characteristics of interest?

b) What type of sample is therefore required?

c) What amount of sample is needed for the investigations planned?

d) What precision of results is required and therefore what method can be used?

e) What is the accessibility of the sampling site?

f) What sampling depth must be reached and what are the basic physical soil characteristics?

Additionally, costs, safety, availability of qualified staff, machinery or instruments, time and environmental aspects will lead to the final selection of the appropriate sampling technique. The arguments for the final decision should be documented.

Specialized tools and techniques may 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.

Choices of sampling method include the use of machinery or manual methods. The sampling may be carried out near the ground surface, at some depth below ground level or from locations deep below the ground surface. Methods of achieving the desired depth for sampling are by formation of excavations (e.g. trial pits), by driven probes, or by drilling (e.g. boreholes).

Table 1 gives guidance on the selection of appropriate sampling techniques for the circumstances anticipated in a site investigation. It is not possible to include all possible circumstances in such a table, and on occasion judgement will be necessary in determining the most appropriate sampling method.

The most commonly used methods of sampling and providing access to the sampling point are covered in annex A. This does not preclude the use of other techniques which are suited to the problems of a particular location, e.g. areas of permafrost, nor does it preclude the use of other methods which have been developed. Whatever technique is used, the principles of sample collection and the approach to sampling to obtain an appropriately representative sample should be adhered to.

The choice of sampling method is determined by taking into account all the needs of the investigation, including distribution of sampling locations, size and type of sample (see 5.2), and the nature of the site including any problems the site poses to carrying out the investigation.

Sampling during borehole construction allows the required integrity for the chemical, physical and biological investigation of selected soil horizons. Gas and water sampling may also be undertaken for specific purposes relating to the need to acquire information rapidly, for example monitoring the borehole for methane and carbon dioxide or volatile organic compounds and on occasions when the rapid identification of chemical constituents in groundwater is required. It is recommended that the monitoring over time, of groundwater horizons for hydrogeological and chemical parameters as well as ground composition, is undertaken from cased wells or standpipes installed in boreholes. The needs of the sampling strategy should identify the requirements of borehole construction so that the design can be specified in line with the monitoring needs.

Table 1 — Applicability of ground excavation, drilling and sampling techniques

Designa-tion	Method	Method of sample extraction	Normal area/ diameter	Soil profile detail mm	Suitability for ground type		Suitable below water table	Type of sampling possible	Depth of sampling m	Comments
					Unsuitable for soil type	Suitable for soil type				
Manual methods										
Hand auger	Rotary	With auger	50 mm to 100 mm	50	Non-cohesive gravel, stones, rubble, lumps of material	Clay, silt, cohesive sand and similar ground	No	Disturbed	0 to 2,0	Sampling to 5,0 m possible in cohesive sandy ground
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
Power-driven sampling holes										
Power auger	Rotary	With auger	50 mm	50	Non-cohesive gravel, large stones, lumps of material	Clay, silt, cohesive and similar ground	No	Disturbed and undisturbed	0,05 to 2,0	Sampling to 5,0 m possible in cohesive sandy ground
Pulse boring/ dynamic probe	Ramming	With sample tool on machine	50 mm	25	Gravels, large stones, lumps of material	Clay, silt, cohesive sand and similar ground	Yes	Disturbed and undisturbed	0,5 to 10	
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
Light cable	Percussion	With boring tools	150 mm to 250 mm	100	Obstructions, e.g. tyres, wood, concrete	Clay, silt, cohesive sand and similar ground	Yes	Disturbed and undisturbed	0,5 to 30	
Rotary driils (Open hole)	Rotary	Not possible. 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
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	
Continuous flight auger	Rotary	Not possible	150 mm to 500 mm	300 to 500	Solid obstructions	All soils	No	None	1,0 to 20	Suitable for passing through top layers which are of interest
Hollow stem auger	Rotary	With sampling equipment down stem	150 mm to 500 mm	50	Solid obstructions	All soils	Yes	Disturbed and undisturbed	1,0 to 20	Sampling down centre stem with auger *in situ*
Driven probes	Pressure	Retrieval of core	30 mm to 150 mm	10	Solid obstructions	All soils	Yes	Disturbed and undisturbed	0 to 30	Core obtained and *in situ* instruments possible in some cases
Machine excavations										
Trial pit	Digging	With sampling tools	3 m to 4 m × 1 m	10	Large solid obstructions	All soils and material	No	Disturbed and undisturbed	0 to 6	

7.2 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 does not contaminate the sample. This avoidance of contamination includes avoiding contamination of the sample due to contact with the sampling equipment or containers and also avoiding the loss of contaminants from the sample by adsorption or volatilization.

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. For geological and contamination investigations, all sampling equipment should be thoroughly cleaned between each sample.

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. If it is necessary to use lubrication, e.g. water, to ease formation of a borehole to enable sample collection, only lubrication should be used which will not conflict with nor confound the analysis to be performed on the samples in the sense of matrix effects or contribution to the contamination.

A hand trowel of stainless steel should be used to place samples into sample containers. The quality of the stainless steel should however first be verified to ensure that cross-contamination of the samples will not occur or interfere with the quality of the analytical data.

The most commonly used methods of drilling, excavation and sampling of the ground provide disturbed samples. If undisturbed samples are required, special sampling equipment is required and extra care should be taken in collecting such samples.

7.3 Undisturbed samples

If undisturbed samples are required for soil sampling, these can be taken using, for example, a sampling frame, a coring tool or cylinder. In each case the sampling device is pushed into the soil and subsequently removed with the sample so that the soil is collected in its original physical form.

8 Storage of samples

8.1 General

Methods of sampling and preservation of samples for physical, chemical and biological (including microbiological) examination may differ greatly, therefore storage of samples including method and speed of transport to the investigating laboratory should be carried out in accordance with the requirements of the aim of the investigation and the desired accuracy of the analytical results. It is essential that the laboratory which will perform the analysis is consulted prior to the commencement of the investigation, in order to ensure that the appropriate procedures are followed.

It is usually preferable to maintain the samples in a cooled condition (below 5 °C) particularly during transport to the laboratory, and ideally from the moment of sample collection. Use of recreational coolers for transport may not provide adequately controlled conditions.

NOTE See also ISO 10381-1 and ISO 10381-5.

8.2 Sample containers

8.2.1 General

For sampling uncontaminated soils, containers made of polyethylene (such as buckets, wide-mouth bottles and strong bags) may be used, as they are inert, relatively cheap and convenient.

When sampling areas are suspected of contamination, it is essential to ensure that the material of the sample container is such that the sample remains representative. It is essential that the sample container does not transfer contamination to the sample, nor should the sample container be capable of absorbing components of the sample, for example plastics containers may not be suitable where organic contamination, such as pesticides or oils, exists. Polyethylene bags are generally not suitable for contaminated soils (see 8.2.3 for possible exceptions).

The container should be securely sealed so that there is no loss of volatile components, such as moisture or solvents, between collection of the sample and delivery to the examining laboratory and no separation of components.

Special containers may be required for sampling of organic compounds such as solvents. Screw-capped bottles and jars are available that can be fitted with suitable closures to prevent loss of contaminant.

Addition of a non-aqueous solvent/liquid, e.g. methanol, may be required to minimize loss of volatile organic compounds.

Sample containers should always be filled and sealed so that there is minimum free air space. If plastics bags are used, these can only be made airtight by welding the open end, however the weld is a weak point which may readily tear.

See also Table 2.

Table 2 — Suitability of sample containers

Container material	Contamination present					Analytical requirements				Advantage	Disadvantage
	Acid	Alkaline	Oils and tars	Solvents	Gas	Inorgaic	Oils and tars	Solvents and organic com-pounds	Volatile com-pounds		
Plastic bag	++	++	–	–	+	+[a]	–	–	–	Low cost	Removing excess air Easily damaged
Plastic bucket	++	++	–	–	–	++[b]	–	–	–	Low cost	–
Wide-mouthed glass bottles [c, d] (screw-capped)	++	–	++	++	–	++	++	–	–	Inert	Fragile
Aluminium cans (screw-capped)	–	–	++	++	–	++	++	+	+	–	Cost Aluminium contamination Affected by acids/alkali
Fluorinated polymer containers e.g. PTFE	++	++	++	++	++	++	++	++	++	Inert	Costs
Tins with push-fit lids	–	–	++	++	–	++	++	+	+	–	Rusting Affected by acids

++ Very suitable
\+ May be suitable
– Unsuitable

It is recommended that the analysing laboratory be consulted to ensure that the appropriate sample container is used.

[a] Should not be used for contaminated land and investigation samples.

[b] Should not be used for contaminated land and investigation samples if analysis for organic contamination may be required.

[c] For optimum performance when volatile organic compounds are present, may require use of undisturbed sample with solvent such as methanol.

[d] Use of PTFE septum may be appropriate.

8.2.2 Sample containers for agricultural purposes

When sampling for agricultural purposes and forming a composite sample from repetitive sampling across an area, the container for the sample should be big enough to hold all the sample portions collected. A polyethylene bag or polyethylene or polypropylene bucket is suitable. When bags are used for sampling they should be new. Buckets or similar containers may be re-used, providing they are carefully washed out. Upon completion of sampling, the sample should be placed in a suitable container or the sample bag tied so that there is a minimum of air space associated with the sample during transport to the laboratory. Polyethylene bags, if used, should be protected against physical damage resulting in loss or contamination of the sample.

8.2.3 Sample containers for contaminated land

If no other specific requirement exists, the usual sample containers for these purposes are plastic buckets with fitted lids or strong plastic bags. For most routine work, plastic buckets (polyethylene or polypropylene), with lids, which can contain approximately 2 kg of sample are recommended. If a larger sample is required, then a heavy duty polyethylene bag is more convenient provided there is no interaction with the sample nor any volatile component which may be lost. Care should be taken to prevent physical damage to the bag resulting in loss or contamination of the sample; use of one bag inside another is a suitable precaution.

In all cases, the container should be filled and sealed so that there is minimum air space. It is essential that the container chosen does not transfer contamination to the sample nor absorb components of the sample.

If organic compounds are to be determined, it may be necessary to use a more inert container, rather than plastics, to prevent loss of volatile material or absorption into the sample container. The container should also be capable of being well sealed to prevent loss of volatile material. In these situations, wide-mouthed glass containers, screw-capped aluminium containers or tins with press-on lids may be used.

Vapour-seal caps should be used where head-space analysis is to be carried out. Special sample bottles are available for dynamic head-space analysis.

Addition of a non-aqueous solvent/liquid, e.g. methanol, may be required to minimize loss of volatile organic compounds.

It is prudent to have available, on-site, different kinds of sample container so that every material that might be expected according to the contamination hypothesis (see ISO 10381-1) can be properly sampled.

8.2.4 Sample containers for geological purposes

The sample containers for geological purposes are the same as those for contaminated land purposes. In many situations it may be acceptable to use plastics bags for the sample container. Strong paper bags and cotton sacks have also been found to be useful.

8.3 Labelling

Once a sample is obtained, it should be clearly and uniquely labelled. The details given in ISO 10381-1 should be put on the label. The sample can be labelled, for example, by using tie-on labels, adhesive labels (providing there is adequate adhesion of the label under on-site conditions), writing directly on the sample container, or placing a label inside the container providing it is suitably protected from the contents.

The labels used should be resistant to external influences on the site (rain, contamination) and to future treatment (abrasion, handling, chemicals). The labels should be large enough to contain all the relevant information in a legible form.

8.4 Sample storage

Cooling and storage of soil samples at below 5 °C is recommended, as this helps to slow down any change or deterioration in the sample. This can be effectively achieved on site by the use of cold boxes which can also be used for transporting the samples to the receiving laboratory.

NOTE Recreational cold boxes may not provide adequately controlled conditions.

Care shall be taken, especially in hot and humid climates, if cooling causes condensation of soil gas moisture that might leach the sample.

Hydrolysis, oxidation, enzymatic and microbial degradation or other loss of organic compounds may not be sufficiently suppressed at a temperature just below 5 °C. Where such occurrences would adversely affect the sample, storage at temperatures of less than −25 °C should be used, including during transportation. For transport, the temperature of −25 °C may be achieved by the use of dry ice (solid carbon dioxide) packing, or containers with liquid nitrogen or freezer boxes operated from car batteries.

For undisturbed samples, in addition to the recommendations for cooling and storage, care is required in handling to ensure that the original soil structure is not disrupted during transport to the laboratory.

9 Sampling report

The sampling report should contain, in addition to information on sampling location, personnel, observations and sample identification, a proper description of the sampling method and sampling devices used. If the actual sampling procedure differed from that originally planned, this also shall be reported, including the reasons for that change.

NOTE See also ISO 10381-1, ISO 10381-4 and ISO 10381-5.

Annex A
(informative)

Manually and power-operated sampling tools

A.1 Small augers

A.1.1 Hand-operated auger techniques

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.

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.

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, providing it is possible to clean the bore to prevent cross-contamination.

Sampling by hand augers allows observation of the ground profile and the collection of samples at pre-selected depths. Particular care should be taken to obtain representative samples if localized contamination is penetrated.

When a hand auger is to be used to take samples for testing soil for agricultural purposes, and the samples are to be composited, it is essential that the auger 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.

A.1.2 Power-operated auger techniques

It is possible to obtain augers powered by small motors to reduce the labour required to carry out the sampling.

The need to avoid cross-contamination within the bore (see 7.2 and A.1.1) applies to augering equally with power-operated augers and hand augers. Powered augers mounted on rough-terrain vehicles are available for repetitive sampling for agricultural purposes.

Care should be exercised when using fuel-driven motors because of possible contamination of the sample from the fuel used, the lubrication of the motor and the exhaust fumes. Augers powered by electric motors are available which minimize the risk of such contamination.

A.2 Boreholes

A.2.1 Light-cable percussion boring

Light-cable percussion boring general uses a 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 being 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.

In some strata, it may be necessary to add water to the borehole to provide lubrication. In this situation mains 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 shall 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. However, 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 as the borehole proceeds or gas samples may be taken, so that the profile of the ground gas composition can be determined.

A.2.2 Rotary drilling

A.2.2.1 General

Powered rotary cutting tools use a cutter head on the end of a shaft, 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. This results in the potential for cross-contamination due to contact with the ground forming the sides of the hole. 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.

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.

Rotary drilling requires well maintained equipment operated by a specialist driller who has had adequate training and considerable experience.

A.2.2.2 Open-hole drilling

Material is recovered from the drill hole accompanied with the drilling fluid. It is not suitable for sampling and it is difficult to observe and record the strata. The method is only suitable 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.

A.2.2.3 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 part of ISO 10381, and advice should be sought from a drilling specialist.

The conventional double-tube core barrel consists of two concentric barrels; the outer one is rotated by the drill rods and carries the coring bit at the lower end. The inner barrel does not rotate, and the core cut by the coring bit passes up into this inner barrel, enabling the core to be recovered when the assembly is brought to the surface.

The core is only in contact with the drill fluid as it passes through the core bit, however depending upon the strata and nature of the requirements of the investigation, this could be enough to prevent use of the core for sampling purposes.

Wireline core barrels are rotated from the surface by drill rods normally of the same diameter as the outer core barrel. The core is brought to the surface within the inner core barrel on a small-diameter wire rope or line which is attached to an “overshot” recovery tool. This system is particularly suitable for superficial or weak deposits, as any vibration from the drilling action is minimized due to the close-fitting nature of the rods within the borehole. The borehole wall is constantly supported during the drilling process and when recovering the inner core barrel. Core retrieval is quicker and production is improved.

With triple-core barrels, the non-rotating inner barrel contains a removable sample tube or liner. At the end of each run, this liner with the core it contains is extracted and stored in a core box. This method does not increase core recovery but is more likely to preserve the core in its original condition.

After recovery, the core should be extruded, preferably in the same direction as it entered the barrel, into a rigid half-round receiving tray (e.g. plastic guttering), where the strata can be logged and samples taken. Use of split tubes for collecting the core in double-tube and triple-tube core barrels can make the strata logging process much easier, but seamless or plastics liners are useful if the core is required for undisturbed samples.

A.2.3 Mechanical auger

A.2.3.1 Driven auger

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. This method is not very satisfactory for sampling, because of the potential for cross-contamination, nor is it suitable for strata logging. The method does enable the relatively quick formation of a large-diameter hole of depth up to 25 m.

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.2.3.2 Continuous-flight auger

The continuous-flight auger employs a similar system, which consists of a continuous helix welded to a central shaft. Downward force is again provided by the machine and continuous rotation lifts the ground to the surface from the base of the hole. This technique is of use in site investigations only to form a hole rapidly to give depth into the ground, and cannot be used for sampling or strata logging.

Lubrication of the auger is not required.

A.2.3.3 Hollow-stem auger

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 whilst 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. The method has been successful on some landfill sites and can be used for the installation of groundwater monitoring wells and gas standpipes.

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.

The technique allows collection of samples, particularly undisturbed samples, in addition to other downhole testing and also enables strata logs to be produced.

Lubrication of the auger is not required.

A.3 Probes and drive-in sampling devices

A.3.1 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, whilst the hydraulic action applies pressure on the probe using a 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-metres, van based systems 5 m to 12 m and truck based systems [including cone penetrometers (CPT)] 25 m to 30 m.

The systems 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.

A.3.2 Probes and window samplers

Percussive window sampling involves driving cylindrical steel tubes into the ground using a high frequency percussive hammer. Usually the hammer is driven by a hydraulic power pack, but electric and pneumatic hammers are also available to suit particular site conditions.

Sample tubes are 1 m or 2 m long and have a broad slot, or window, cut down one side. 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. After removal from the probehole, the soil material can then be inspected and the strata logged and sampled from the window.

Soil samples may also be obtained using split tubes or split-spoon samples, 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.

Soil samples may also be obtained using a tube combined with an inert liner to enable easy removal of the core from the sampler. 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.

Sample tubes of various diameters are available (35 mm to 80 mm) and selected according to the ground conditions. Tubes are normally selected in a sequence of reducing diameters to penetrate to depth.

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 probehole remains open without support. Piezometers and ground gas monitoring pipes can be installed in the resultant probeholes where the ground is sufficiently stable.

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 removed for analysis. This system also enables undisturbed samples to be collected.

A.3.3 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 is 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.

A.3.4 Driven probes

Driven probes can be used to make continuous geophysical measurements, for example resistance to penetration, or may be fitted with instruments. Care should be taken to avoid cross-contamination from the sides of the probehole and from the base of the probehole. This system can be used either to monitor ground water parameters such 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 have the normal disadvantage of the difficulty experienced in penetrating ground with obstructions, and cannot be used for logging the ground strata unless continuous soil samples are taken. Driven probes are however considerably faster than traditional boreholing techniques.

A.4 Excavations (trial pits)

A.4.1 General

This is a widely used technique for collecting samples for site investigations related to contamination. 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.

Trial pits can be formed where the ground will stand temporarily unsupported and permit the observation of the *in situ* condition of the ground both vertically and laterally. Where there is water present in the excavation, problems are presented due to instability of the sides, and the difficulty of obtaining representative samples of the ground (Finer material tends to wash out with the water as the sample is collected). In this situation, the trial pit may be dewatered by pumping, providing there is a safe and suitable means of disposal of the water, or an alternative technique of sampling should be used. In deeper 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.

In carrying out excavations, 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. As discussed in clause 7, it may be necessary to dispose of excavated material off-site and to complete the backfilling of the trial pit and restoration of the site using clean imported material.

A.4.2 Safety

Entry of the excavation by personnel should be avoided where possible, since the unsupported sides of a trial pit can readily collapse. If it is essential that an excavation be entered for sampling purposes, e.g. the collection of undisturbed samples, then shoring should be used and reference should be made to the guidance given in ISO 10381-3.

In unstable ground the trial pit can collapse, and extra care should be taken when observing the excavation and collecting samples. If necessary, the sides should be supported or made to slope to improve stability. For all ground conditions, if the depth of excavation is greater than 1 m to 1,2 m and the excavation is to be entered by personnel, the sides should be adequately shored to prevent collapse.

A.4.3 Manual excavation

Shovel, pick and fork can be used to excavate trial pits down to about 2 m and, if only a small number of such excavations are required, this may be the easiest technique of collecting soil samples.

The trial 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.

Hand excavation is particularly necessary in urban areas if services (water, gas, electricity, etc.) 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 boreholing can be continued using the appropriate machinery.

A.4.4 Machine excavation to between 3 m to 4,5 m depth

A wheel-driven back-hoe excavator is appropriate for excavating trial pits to a depth of about 3 m. Some machines of this type are capable of excavating down to about 5 m.

Usually a 0,9 m wide bucket is used for trial pit excavation, but a 0,6 m wide bucket should also be available.

The trial pit should be wide enough to accommodate the bucket, and of adequate length to allow excavation to the required depth (approximately 3 m to 4 m × 1 m plan area).

Before collecting a sample (disturbed or undisturbed), the base of the excavation should be cleared of any loose or fallen material, etc. A good disturbed sample can be obtained from the base of the excavation by careful use of the excavator bucket.

A representative sample of the material removed from the base of the excavation, with the excavator bucket, should be collected using a stainless steel trowel (see 7.1), i.e. a composite sample of small point samples taken close together, unless the examination requires some other specific form of sample. This method allows collection of samples relatively easily, avoiding the need to enter the excavation, and gives a clear view of the soil profile which can be accurately recorded.

For physical, geological and biological examinations where undisturbed samples are required, such samples can be taken using a Kubiena Box 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.

If groundwater is encountered, further excavation and sampling may be of limited value.

A.4.5 Machine excavation to 6 m depth

A track-driven machine is necessary to reach depths such as 6 m below ground level The comments given in A.4.4 regarding wheel-driven back-hoe excavators apply, with the proviso that a wider bucket is usually necessary to get clear vision to the bottom of the trial pit because of its greater depth.

A.5 Other methods

There are a variety of methods available for rapid formation of boreholes, but these normally only provide limited information on ground conditions and can be prejudicial to the collection of satisfactory samples.

There are a variety of techniques for collection of samples using powered augers or probes, some of which are motorized and mobile. The same comments given in A.3 apply to the use of such equipment.

Other methods which may be suitable in specific locations, or other methods which are developed, are not precluded by this part of ISO 10381 (see clause 7).

Different techniques are available for breaking out the hardcover on a site. The technique selected will be determined by the nature of the hardcover and the area necessary to break out for the purpose of the investigation.

- Pneumatic drills may be used but these require an experienced operator and a source of compressed air and will not be appropriate for penetrating thick concrete (more than 250 mm).

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

  - 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 thicknessses (up to 500 mm) of concrete.

- 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 boreholing 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.

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

a) Is there space available for performing the excavation?

A trial pit excavated by machine will require approximately 3 m × 1 m for the excavation, plus space for the machine to operate, plus space for the soil to be placed.

b) Will the damage to the site surface be a cause for concern?

Trial pits in a carpark area may not be acceptable due to the likelihood of settlement after the initial reinstatement, and the difficulty of a satisfactory reinstatement of the carpark surface.

c) Can hand-dug or machine-dug excavations achieve the depth of sampling required?

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

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

This would prevent obtaining satisfactory samples.

Bibliography

[1] ISO 5667-1, *Water quality — Sampling — Part 1: Guidance on the design of sampling programmes*

[2] ISO 5667-2, *Water quality — Sampling — Part 2: Guidance on sampling techniques*

[3] ISO 5667-3, *Water quality — Sampling — Part 3: Guidance on the preservation and handling of samples*

[4] ISO 5667-4, *Water quality — Sampling — Part 4: Guidance on sampling from lakes, natural and man-made*

[5] ISO 5667-6, *Water quality — Sampling — Part 6: Guidance on sampling from rivers and streams*

[6] ISO 9000, *Quality management systems — Fundamentals and vocabulary*

[7] ISO 10381-1:—[2], *Soil quality — Sampling — Part 1: Guidance on the design of sampling programmes*

[8] ISO 10381-3, *Soil quality — Sampling — Part 3: Guidance on safety*

[9] ISO 10381-4, *Soil quality — Sampling — Part 4: Guidance on the procedure for the investigation of natural, near-natural and cultivated sites*

[10] ISO 10381-5:—[2], *Soil quality — Sampling — Part 5: Guidance on investigation on soil contamination of urban and industrial sites*

[11] ISO 10381-6, *Soil quality — Sampling — Part 6: Guidance on the collection, handling and storage of soil for the assessment of aerobic microbial processes in the laboratory*

[12] ISO 10381-7, *Soil quality — Sampling — Part 7: Guidance on the investigation and sampling of soil gas*

[13] ISO 11259, *Soil quality — Simplified soil description*

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