INTERNATIONAL STANDARD

ISO 10381-3

First edition
2001-12-15

Soil quality — Sampling —

Part 3: Guidance on safety

Qualité du sol — Échantillonnage —

Partie 3: Lignes directrices relatives à la sécurité

Reference number
ISO 10381-3:2001(E)

ISO copyright office
Case postale 56 • CH-1211 Geneva 20
Tel. + 41 22 749 01 11
Fax + 41 22 749 09 47
E-mail copyright@iso.ch
Web www.iso.ch

Printed in Switzerland

Contents

Page

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 Internatinal 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.

International Standard ISO 10381-3 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 3: Guidance on safety*

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

Additional parts are in preparation.

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. ISO 10381-3 deals with safety for various purposes of soil investigation.

Soil quality — Sampling —

Part 3: Guidance on safety

1 Scope

This part of ISO 10381 provides guidance on the hazards that may exist during a site investigation and when collecting samples of soil and other ground material, including hazards that are intrinsic in the sampling operation in addition to the hazards that may arise from contamination and other physical hazards. Precautions are given so that the risks involved in any sampling or site investigation can be controlled and minimized.

This part of ISO 10381 gives guidance on hazards which may be encountered in a site investigation

— in general,

— on agricultural areas,

— on contaminated areas,

— in geological investigations,

and an indication of the activities which may give rise to risks. It then describes procedures which may be adopted to control risks.

This part of ISO 10381 is designed specifically to deal with the problems of safety during sampling and site investigation, and is not intended to provide guidance for other situations such as construction.

NOTE Former production sites for munitions and other warfare agents present special problems to investigators and others involved in handling samples collected at such locations. The guidance given in this part of ISO 10381 will be of assistance in these situations, but additional guidance on the precautionary measures to be taken should be obtained from the specialists responsible for the former operation of these sites.

2 Preliminary procedures

In all daily activities there is an element of risk and this risk is increased when the environment is unfamiliar. Even sampling an agricultural area involves an increased risk to the sampler, because the nature of the ground and possible hazards are not necessarily known to the sampler.

When examining a site for contamination, the risks are increased, due to the presence of chemicals, compounds and agents which present a hazard to human health. When examining a former industrial site, the risk of physical injury can be increased because of the possibility of voids and cavities (physical hazards) beneath ground level which may not have been properly filled in. Cavities may also be present where there has been underground combustion (for example in refuse sites and colliery waste disposal sites).

Physical injury is also possible in any sampling situation where machinery is being used; this applies to agricultural sampling as much as to contaminated-site investigations. Possibly the injuries could be more serious in a contaminated-site investigation because bigger and more powerful machines are involved, and even minor injuries may provide a pathway for toxic substances and pathogens to enter the body.

Care should also be taken to ensure the safety of the investigator when a preliminary site visit (site reconnaissance) is carried out prior to commencing the full site investigation, particularly as all potential hazards may not have been identified at that time.

The main objectives of this guidance on safety are

a) to identify the hazards that may exist in carrying out site investigations and soil sampling programmes,

b) to indicate management procedures to provide a framework for safe working and proper response in the case of accident,

c) to indicate what precautions can be taken in terms of personal protection and cleaning facilities to minimize any hazard, and

d) to indicate what working procedures can be adopted to minimize hazards from contaminants and physical hazards associated with the collection of samples and the use of machinery.

3 Concepts of hazards, risks and safety

It is not possible to identify all the hazards which may be encountered during site work, nor to provide guidance on how the associated risks may be dealt with in all situations. Safety depends ultimately on the adoption of an attitude and approach to any particular situation which will ensure that the hazards are identified and properly evaluated, and appropriate precautions taken.

Those authorizing, designing and supervising works, the employers, and those carrying out the work all have a joint responsibility for safety. This responsibility extends beyond the workforce to include the general public, who may be living or working close to the site to be investigated, or who may enter the site with or without permission while the works are in progress.

The guidance in this part of ISO 10381 should be read in conjunction with relevant national and international legislation and regulations regarding health and safety at work.

In general, achievement of safe working conditions requires the employing organizations to adopt formal “policies” and operating frameworks which will require and permit

— identification of hazards and evaluation of risks,

— avoidance of risks wherever possible,

— failing this, control of the risks through adoption of appropriate operating procedures, and

— failing this, or in addition, the protection of individuals against unavoidable risks.

It is necessary to provide training, to keep records of procedures adopted and of any incidents. It may be necessary to establish health screening and surveillance programmes.

In these ways it should be possible to reduce risks to an acceptable minimum.

In order that appropriate risk reduction and management procedures can be identified, it is necessary, on a site-specific basis, to

— identify hazards,

— identify under what circumstances the hazards may present a risk,

— quantify the actual risks.

In relation to contaminated sites, the importance of a desk study for identification of hazards from contamination and physical conditions must be emphasized.

4 Exposure of personnel to hazards

4.1 General

This clause deals with the way in which hazards present at a site may affect the investigators.

Different types of hazards have been identified as occurring in different situations. These can result in a range of effects, varying from skin irritation and simple physical injury to death. When establishing suitable safety procedures not only must the hazard be considered, but also the way the hazard is likely to be encountered by the investigator or sampler. In most cases the hazards are due to acute toxic effects but, in the case of regular investigators and samplers, chronic toxicity is a possible hazard.

4.2 Exposure by contact

Direct contact with chemicals such as chlorinated solvents, benzene, tars, oils and greases, phenols, chromium(VI) compounds, pesticides (e.g. insecticides, herbicides, fungicides) and many others can result in effects on humans. These effects can result in the development of skin rashes or irritation and other dermal effects and, where absorption occurs, more serious effects may result.

Some chemicals are potentially carcinogenic through skin contact.

The degreasing effect of solvents and oils also reduces the ability of the skin to prevent absorption of compounds and to prevent infection.

Some chemicals can be absorbed through the skin with adverse effects if the contact is sufficiently prolonged or of sufficient concentration. If the skin is broken due to cuts or abrasion, then absorption occurs much more readily and bacterial infections can be caused very easily, e.g. tetanus and suppurations. Weil's disease can be transmitted through breaks in the skin but the causative organism (*Leptospira*) can actually penetrate the skin if it is softened by prolonged exposure to water.

The eyes can suffer from contact as a result of splashing when dealing with liquids and wet material, and also by transfer from dirty hands, gloves or other articles of clothing. The eyes can suffer from irritation which may clear up as a result of bathing, but particulate matter may cause scratching and solvents can cause permanent damage.

4.3 Exposure through ingestion

Contaminants from a site can be ingested by eating food, smoking, taking refreshment or even careless wiping of the face with hands or gloves which have been dirtied with contaminated material.

Because the mucous membranes are generally more sensitive than skin, much less contamination is required to cause an adverse reaction. If contaminated material is inadvertently swallowed, then stomach upsets, infections and other short-term effects can ensue. It is also possible that ingestion will lead to more rapid absorption of toxic material and can also result in longer-term adverse effects.

4.4 Exposure through inhalation

The presence of gases and vapours can cause a variety of effects ranging from headaches to death, the degree of severity depending upon the toxicity of the chemical and the severity of the exposure. Carbon dioxide and hydrogen sulfide both cause the above range of reactions. Solvents and similar compounds can give rise to narcotic effects.

The effects caused by some compounds can be enhanced where the inhalation is a result of smoking, since the heat of the tobacco can cause the formation of breakdown products more toxic than the original fumes, for example chlorinated solvent vapours are converted to carbonyl chloride ($COCl_2$ phosgene) by the heat of a cigarette.

Exposure can also occur through inhalation of dust, fibres and fumes. The hazard from dusts may be due to different effects. For example, silica and asbestos are not active chemically but can be dangerous when inhaled. Other dusts which contain polyaromatic hydrocarbons or dioxins can cause cancers, while other chemicals can have toxic effects.

Exposure by inhalation can arise from the sampling process (e.g. inhalation of the exhaust fumes, or dust from drilling concrete), rather than from contaminants within the site.

The effects of exposure by inhalation varies; with some compounds the effects can be readily reversed by removal from exposure, while in other cases more serious long-term effects result, requiring a much longer recovery period.

4.5 Exposure to physical hazards

Physical hazards can range from simple damage to limbs and joints, as in sprains and broken bones, through to more serious injuries due to being hit by excavators or falling on equipment such as augers. Unstable ground around excavations, boggy ground and bodies of water can result in physical injury, ingestion of contamination material, and possibly in drowning.

Excavations, such as trial pits, are not normally entered during a site investigation but where entry is necessary, a hazard is present due to possible collapse of the sides. This becomes a serious hazard when the excavation is greater than about 1,2 m deep.

Excavations also present a hazard to personnel at ground level if the sides are not stable, due to the possibility of collapse into the base of the excavation, the hazard increasing with increasing depth and decreasing stability of the ground.

4.6 Exposure to fire and explosions

The presence of underground fires can present a hazard due to the formation of underground cavities, breakout of flames and the formation of toxic gases, including carbon dioxide and carbon monoxide.

The presence of flammable and explosive gases in situations such as landfills and underground tanks can present a hazard, particularly if some form of ignition is inadvertently provided.

Use of explosives may be necessary in very hard ground situations (for example in permafrost regions).

The presence of unexploded bombs and mines, etc. from former wartime activities can also present a hazard. Hazards due to explosives residues and munitions are likely to exist at sites which have produced and handled explosives and munitions.

5 Potential on-site hazards relating to sampling and the area of investigation

5.1 General

This clause describes the hazards that may be presented by different contaminants and physical aspects during the course of site investigations and sampling.

This part of ISO 10381 does not seek to address everyday hazards that may arise from the use of such items as sharp instruments, digging equipment such as forks, nor the hazards of driving to a site location. It is assumed that such hazards are satisfactorily dealt with by the personnel carrying out the investigation and the sampling.

5.2 General hazards

5.2.1 Hazards due to solid and liquid chemicals

These may be very obvious (as in the case of chemicals remaining on a former industrial site) or may not be apparent (for instance in the case of pesticides in a field). When devising a safe method of investigation and sampling, both situations have to be considered and precautions taken.

The hazard may be presented by direct contact due to lack of protective clothing or contact through transmission by hands. Where dusts are formed, inhalation can occur. Where wet conditions exist or there are liquids, inadvertent contact due to splashing is possible.

5.2.2 Hazards due to gases

Since most site investigations are carried out in the open air, hazardous concentrations of gases rarely develop due to dilution by the atmosphere. However there are recorded cases of drilling crews being overcome by fumes and being hospitalized, thus caution should be exercised when assessing the potential hazards.

It is possible, in particular situations (where there is active anaerobic degradation and substantial methane generation, for example in landfill sites), that dilution of the gas by the atmosphere could bring the concentration of methane to within the explosive range.

In other situations, although dilution by the atmosphere prevents exposure to hazardous concentrations, lower concentrations of gases can still cause symptoms such as headaches, runny eyes and are thus undesirable.

Use of machinery with closed unventilated cabs can lead to the development of toxic atmospheres which under extreme conditions can be fatal.

The exhausts of internal combustion engines emit fumes which can present a hazard.

Where the investigation requires entry into deep excavations or confined spaces, particularly those below ground level, the build-up of explosive and/or toxic gases and the formation of an atmosphere which is deficient in oxygen is a possibility. An atmosphere deficient in oxygen even by a small amount (1 %) can be fatal.

5.2.3 Hazards due to biological causes (bacteria and viruses)

Although accidents due to biological reasons rarely occur, there is a potential for illness due to the widespread nature of bacteria and viruses. These illnesses need not be fatal and may not necessarily be diagnosed as associated with the work that has been carried out. Because of the widespread distribution of bacteria, it is worthwhile considering the hazards that they may present and also taking precautions to prevent any adverse effects from them, however mild.

Some biological hazards are not site-specific (e.g. tetanus, typhoid and Weil's disease) and require appropriate general precautions in addition to any local prevention.

Weil's disease (*Leptospira* jaundice) occurs as a result of contact with water which has been contaminated by rat urine (see 4.2). Any outdoor body of water may therefore be a source of hazard, as can areas where there has been a high rat population, for instance landfill sites. Infection by *Leptospira* can be fatal if not diagnosed at an early stage.

The presence of anthrax spores can also present a hazard (see 5.3.4).

5.2.4 Hazards due to radiation

Radiation hazard is not usually very great in any normal site investigation or sampling exercise. The presence of a radiation hazard due to previous operations at a site should be identified by the desk study. With any site investigation, the transient nature of the exposure should ensure that harmful radioactive dosages are not received, but the need for precautions and personnel monitoring should be considered.

5.2.5 Hazards due to topography

Hazards due to physical features are part of normal daily life. However, for site investigators and sampling personnel dealing with an area with which they are not familiar, these same physical features can present a real and unexpected hazard. In some cases they may be life-threatening, but are more likely to result in injuries to limbs such as sprains and broken bones.

The ground can be unexpectedly uneven and features such as potholes and kerbs may be hidden by vegetation. On derelict sites, reinforcing bars and other debris can also cause tripping if care is not exercised. The presence of broken glass can increase the hazard from falling.

Excavations can present a hazard due to possible collapse of unstable sides, and below-ground cavities can present a hazard where their presence is not obvious or where their cover is insufficient to support weight, e.g. cavities formed as a result of below-ground combustion.

Overhead electrical cables present a hazard, particularly when using surveying poles and high machinery (backhoe excavators, drilling rigs), which can short-circuit, causing electrocution.

Underground services can present a hazard, particularly electrical supply, because of the danger of electrocution.

5.2.6 Hazards due to machines

Virtually any machinery can be hazardous if not operated sensibly and with regard to the manufacturer's instructions and the safety regulations which apply. However, in many cases these aspects are not wholly observed or appreciated.

When establishing a sampling location by breaking through concrete, the breaking of the concrete can result in hazardous flying particles.

Noise from machinery can be a hazard, and particularly when using concrete-breakers, heavy machinery or explosives.

When carrying out augering by hand, particularly to great depths, body strains can occur. With powered augers, forcing the auger or running at too high a rate can result in an accident due to obstructions encountered or other causes of a sharp change in movement.

Machines should always be operated in the correct manner. With large driver-operated machines, it is important that investigation personnel do not expose themselves to the risk of being hit by the machine as it is operated, either by standing too close, or carrying out operations where the driver cannot see them. Untrained personnel should never operate such machines.

With any machine, but particularly with larger machines, care should be taken when traversing a site to ensure that the ground does not collapse under the weight of the machine. This is particularly important in areas of dense vegetation and areas where there is the possibility of below-ground voids (subsidence, old empty tanks, combustion).

Machines which become bogged down can present hazards due to the unexpected movement as the problem occurs and subsequent sudden movement as the machine is extricated.

Machines powered by internal combustion engines can present a hazard due to the exhaust emissions.

Electrically powered machinery can be hazardous due to the possibility of current leakage to earth or short circuits.

Use of machines for excavating where mains services are located can result in damage to the services and hazard to the operator and investigators.

5.3 Particular hazards on agricultural sites

5.3.1 General

Hazards can exist on farms and agricultural installations due to machinery, animals, stored chemicals, stored produce and facilities such as silage pits, slurry storage areas and lagoons.

5.3.2 Hazards due to chemicals (see also 5.2.1)

A wide range of chemicals is applied to agricultural areas for widely different reasons. The method of application can also vary considerably. Chemicals applied include fertilisers such as ammonium nitrate, lime, compound fertilisers, mineral dressings for adding trace metals, pesticides (e.g. insecticides, herbicides, fungicides) and pollutants in organic wastes used for application to soil.

Chemicals can be applied by injection directly into the ground below the surface, by spreading on to the surface, by scattering on the surface or by spraying from land machines and aircraft.

Where material is applied directly, occasional over-treatment can occur due to machine stoppage or breakdown, which can result in increased chemical concentrations and greater hazards. This is unlikely with aerial spraying but could occur with machine spraying.

The amount of chemical needed to present a hazard varies with the nature of the chemical, with organic chemicals (including certain pesticides) probably presenting the greatest hazard and mineral additives presenting the least.

In areas of repeated application, accumulation of chemicals can occur, particularly of inorganic agents and persistent organic chemicals.

5.3.3 Hazards due to gases (see also 5.2.2)

There is not likely to be any particular hazard due to gases in agricultural areas. In isolated circumstances the release of hydrogen sulfide could occur from boggy ground which is disturbed by sampling, or where a poor quality sewage sludge has been recently applied to an area. Greater hazard could exist where an agricultural site has been created over a former refuse site, or around pits used for burial of animal carcasses where decay is not complete.

5.3.4 Hazards due to biological causes (bacteria and viruses) (see also 5.2.3)

Application of sewage sludge and animal wastes to land can result in a very high bacterial population. Where digested sludge is applied, the proportion of pathogenic bacteria is greatly reduced compared with the original primary sludge. However, where primary sludge is applied, the presence of pathogenic bacteria and of viruses can present a serious hazard to the sampler, particularly during application. Care should be taken not to enter an area where an aerosol is being created during the spreading operations. The risk from sewage sludge is generally reduced significantly by 10 months after application.

The presence of faeces from animals and birds can also present a hazard, if contact with such material is not avoided.

Other potential hazards include anthrax and other animal-derived pathogens. These can occur particularly where animal carcasses have been buried or animal skins treated.

5.3.5 Hazards due to radiation (see also 5.2.4)

Radiation hazards normally only exist from the existence of fall-out, due to either a public incident or the proximity of a nuclear installation. For such occasions on-site, it will be self-evident that a hazard may exist so that precautions can be taken.

5.3.6 Hazards due to topography

The hazard varies according to the nature of the site, with a ploughed field or similar unevenness presenting a risk if care is not taken in traversing the area. On grassland, rabbit burrows (and other animal holes) require caution, particularly where the ground vegetation is tall and rank so that the actual ground cannot be seen and holes and sharp depressions can be concealed.

Areas of soft ground due to waterlogging can present a particularly serious hazard when such land is concealed by vegetation cover.

5.3.7 Hazards due to machines (see also 5.2.6)

Sampling for agricultural purposes is carried out in most cases using hand augers down to approximately 250 mm, or by a wheeled or tracked vehicle with a mechanical auger or probe.

For hand-augering down to approximately 250 mm, there is little hazard providing normal physical exertion is applied.

The use of machines presents a greater hazard, since these may fall over and cause crushing if placed in an unstable situation, and carelessness or uncontrolled movement could result in similar injuries.

5.3.8 Hazards from livestock

Arrangements should be made with the operator of agricultural land for access, prior to entering the site. These should include removing potentially dangerous animals from the working area and the removal of any animals which may be at risk from the site works.

5.4 Particular hazards in contamination investigations

5.4.1 General

An essential preliminary to visiting a site, whether for reconnaissance or sampling, is the desk study. This will give some guidance on the chemical, physical and biological hazards which may exist, and enable an appreciation of the problems presented and what precautionary measures are appropriate.

5.4.2 Hazards due to chemicals (see also 5.2.1)

Knowledge of the former uses of the site should give some indication of the chemicals that may be present and hence some indication of the specific hazards. There is always a greater hazard on such sites than on undeveloped areas, because of the potential presence of contaminated materials and chemicals. However, this hazard is greatly increased when dealing with sites which have used or generated chemicals, or have been used for the disposal of waste. These sites include gas works and any form of chemical manufacture, including fertilizers, pharmaceuticals and pesticides, and sites used for toxic waste disposal. It should be remembered that the majority of industrial sites have used chemicals to some extent, many of which are toxic.

5.4.3 Hazards due to gases (see also 5.2.2)

Various toxic gases, including in particular hydrogen sulfide and hydrogen cyanide, may exist in sites contaminated by former use. These gases can be released by excavation and present a hazard.

Other gases can exist on sites used for chemical production or handling. This possibility should be identified by the desk study and from historical information on the former use of the site.

Carbon dioxide and carbon monoxide can be trapped in the ground where underground combustion has occurred or is currently occurring.

It is not normal to enter excavations as part of a sampling exercise or site investigation, but where this is necessary, to carry out *in-situ* measurements for instance, care should be taken that there is no hazardous gas concentration in the excavation, nor an oxygen-deficient atmosphere.

When installing boreholes, if there is any gas escape the atmospheric dilution is usually enough to prevent hazard. Where there are high concentrations of solvents, this may not be so and special precautions should be taken. The operator working adjacent to the borehole is at greatest risk from the escape of such gas or vapours.

The presence of high concentrations of methane in refuse sites can present a serious risk of fire or explosion from sparks in open excavation or borehole operations. In this situation, the dilution of the atmosphere can bring the concentrations of methane to within the flammable/explosive range (5 % to 15 % volume fraction in air).

5.4.4 Hazards due to biological causes (bacteria and viruses) (see also 5.2.3)

There is risk due to tetanus infection on any site, and risk of other infection will probably be related to the history and former uses of the site.

Investigation of refuse sites and other waste-disposal areas present the possibility of bacterial infection. Other specific sites, such as abattoirs, mortuaries, leather works and pharmaceutical works, present a hazard due to the possibilities of bacterial contamination of the ground.

5.4.5 Hazard due to radiation (see also 5.2.4)

In addition to possible fall-out hazard as covered in 5.3.5, it is also possible that the former industrial operations used radioactive material. Such usage or the possibility of such usage should become apparent from the desk study. Use of radioactive material is normally tightly controlled and monitored by the appropriate national authority, which can advise on the potential risks at a particular site.

5.4.6 Hazards due to buildings and other structures

Old buildings, particularly of former industrial use, can present a hazard due to the presence of asbestos material in an unconfined state so that fibres are readily released. The same hazard can be presented by old pipework insulation. The structures themselves can present a hazard if in a dilapidated condition, since vibration from the investigation can dislodge masonry. Underground voids and tanks can present a hazard due to the build-up of gases, and lack of maintenance can result in manholes and other covers which lack the strength to support the passage of pedestrian or machinery traffic.

Mains services such as gas, electricity (including overhead power lines), fuel and to a lesser extent water, can present a hazard, since these may not necessarily be totally disconnected even though the responsible authorities state that they are.

5.4.7 Hazards due to topography

Hazards due to physical structures such as kerbs or foundations are normally self-evident, but may be concealed by overgrown vegetation. Below-ground cavities which have not been properly backfilled present a hazard, particularly if overgrown, but the desk study should indicate their possible presence from the former use. Cavities with water (contaminated) or demolished steel work present a particular hazard which can dramatically increase when a trial pit is excavated in such areas.

Cavities can also result from below-ground combustion or, in certain strata, from water erosion.

Backfilled areas may not have been properly compacted and may be unstable.

Areas of open contaminated water, such as former gas holder pits, can present a hazard.

5.4.8 Hazards due to machines (see also 5.2.6)

If hand-augering is carried out, it is usually to a much greater depth than for agricultural purposes. This increases the possibility of strains and sprains of the operator. If a mechanically powered auger is used, there is a much greater risk of physical injury due to obstructions encountered or other problems resulting in violent movement of the auger.

Other machines used for the investigation of contaminated sites present a serious risk of injury during operations or movement about the site. This applies equally to backhoe excavators, mechanical excavators, drilling rigs and driven probe equipment.

If a machine is used for breaking through obstructions, there is a risk to all personnel in the area due to flying debris.

Holes excavated for sampling purposes can be a serious hazard if the ground is unstable and the sides of the excavation collapse. Where groundwater is present, excavation of wet material can result in splashing which, if it gets in the eyes, can be very painful. If such groundwater is contaminated with tars or other chemicals, permanent injury could result.

Use of machines for excavation or construction of boreholes normally results in fairly rapid penetration of the ground. If mains services are present, this can result in damage. In the case of electrical supply this can have serious consequences but there is also a risk if gas service lines are involved. Damage to water pipes presents a risk to the users of the water, but not necessarily the site investigation personnel.

Where machines are used for investigation, consideration should be given to the possible triggering of bombs and other munitions remaining from warfare and other military activities, and the appropriate care exercised.

5.5 Hazards in geological and geotechnical investigations

5.5.1 General

Geological and geotechnical investigations can be carried out in locations which may vary between green fields and derelict industrial sites. Reference should therefore be made to 5.3 and 5.4 as well as the subsequent paragraphs.

5.5.2 Hazards due to chemicals (see also 5.2.1)

Depending upon the nature of the site, the hazards described in 5.3.2 and 5.4.2 could apply to a site being investigated for geological or similar reasons. There could also be a hazard due to the natural occurrence of concentrations of toxic substances.

5.5.3 Hazards due to gases (see also 5.2.2)

Hazards that can exist in agricultural and contaminated land investigations can also exist in these investigations. See 5.3.3 and 5.4.3.

A geological investigation may involve entry of deeper excavations or could include investigation of caves and former mines and adits. In these confined spaces, particular care should be exercised because of the greater possibility of the presence of high concentrations of methane, carbon dioxide and hydrogen sulfide, and possible depletion of oxygen in the atmosphere.

5.5.4 Hazards due to biological causes (bacteria and viruses) (see also 5.2.3)

These hazards are those described in 5.3.4 and 5.4.4.

5.5.5 Hazards due to radiation

Apart from the hazards described in 5.3.5 and 5.4.5, there may be natural radioactivity as gas (radon) or possibly from rocks (granite) which might create a hazard if repeated exposure is experienced by a particular sampler. Such exposure is only likely to be of serious concern if it occurs frequently and in confined spaces such as underground caves or mines.

5.5.6 Hazards due to topography (see also 5.2.5)

In addition to the hazards for agricultural areas given in 5.3.6 and 5.4.7, hazards can exist due to unsafe or unsecured structures if working in caves, mineshafts or adits. In these areas the professional judgement of an engineer is required to determine the degree of hazard. Working in confined areas also presents the risk of personal injury.

5.5.7 Hazards due to machines (see also 5.5.3)

These hazards are those described in 5.3.7 and 5.4.8.

6 Safety precautions

6.1 Safety policy

Any organization involved in site investigations and sampling should have a safety policy which sets out the requirements for safe working. Adherence to the policy should be part of the conditions of employment of all personnel. The policy should

— insist on adherence to relevant legislation and regulations,

— emphasise the need for alertness and vigilance on the part of site personnel to protect themselves from hazards during investigation and sampling,

— emphasise the requirement to follow standard operating procedures where these exist,

— describe the responsibilities of each member of the investigation team, including the responsibilities to any sub-contracted personnel and to the general public,

— include a mandatory ban on smoking, eating or drinking while on site carrying out a sampling exercise or other site investigation.

The policy should be supported by standard procedures setting out the requirements for safe working in general, and in specific locations such as confined spaces. These standard procedures should include the provision and use of protective clothing and equipment, and the minimum number of personnel that should be involved in site work. The standard procedures should also specify the requirements for contacting local emergency services, methods of communication and methods of washing and decontamination.

6.2 Planning and managing for safety

To assure the safety of personnel in site investigations or sampling exercises, it is necessary to plan and manage for safety. This requires a combination of measures which may need to include

— assessment of the hazards arising from the site,

— avoidance of hazards where possible,

— selection of sampling methods with safety in mind,

— provision and use of personal protection equipment,

— provision of equipment for the detection of hazardous environments,

— provision of appropriate personnel site facilities,

— provision of decontamination facilities for personnel and equipment,

— appointment of an individual to take responsibility for implementation of safety plan and measures,

— clear assignment of responsibilities,

— documentation of safe working procedures,

— “permit to work” system,

— provision of information to all concerned,

— training,

— provision of first aid facilities,

— planning and use of emergency procedures,

— installation of system of record-keeping of “incidents” and possible exposures,

— health surveillance,

— compliance with company safety policy (see 6.1),

— compliance with national laws and regulations concerning the health and safety of the personnel and the general public.

Some measures for protection, monitoring and control are given in Table 1. Some of these are discussed in detail in 6.3.

Table 1 — Health and safety measures that may be required for site investigations

Protective clothing and equipment	Monitoring equipment	Safety procedures
Overalls, boots, gloves and helmets	Hand-held gas monitors	Training
	Automatic gas detectors	Permit to work systems
Eye protection	Personal monitors	Notification to emergency services
Ear protection	Environmental monitoring	Access to telephone contact
Face masks and filters		Decontamination facilities for plant
Breathing apparatus		Decontamination facilities for personnel
Safety harness and lanyards		Safe sampling procedures
Safety torches		Safe sample-handling procedures
Fire extinguishers		Access for emergency vehicles
First aid equipment		

Prior to undertaking any form of investigation on a site, it is essential that an assessment of hazards be carried out. This is particularly important on former industrial sites and waste sites. If site reconnaissance forms part of the preliminary investigation, the hazard assessment should be based on the results of the desk study. It may be possible to refine the assessment once the preliminary investigation is completed, and it should be kept under review as the investigation proceeds. If there is any doubt as to the presence or degree of contamination, then protective equipment should be used.

National legislation and systems for controlling the exposure of workers to substances hazardous to health should be complied with. Precise requirements may differ, but often include a framework requiring

— avoidance of exposure when this is reasonably practicable,

— if this is not possible, use of control measures to prevent exposure or limit exposure to “permitted levels” (these may be defined in national regulations), and

— if this is not possible, the use of personal protective equipment.

They may also require

— the provision of information and training,

— health surveillance programmes, and

— the preservation of personnel exposure records for an extended period of time.

In the absence of any legal requirements, the above provides a useful framework for a policy to protect personnel from hazardous substances.

6.3 Safety precautions in relation to particular hazards

6.3.1 General

In general, safety precautions against a particular hazard are independent of the type or location of investigation being carried out. Some precautions may need to be more extensive, for instance those relating to machinery, depending on the size and the nature of the machinery to be used.

Use of specialized sampling techniques, for instance involving explosives, requires specialized personnel.

Where munitions from former warfare may be present, excavations should be closely observed and the relevant authorities called to site if suspicious articles are seen.

Excavations should always be closely observed for the presence of services at shallow depths, even where none are expected; use of hand-dug excavations is prudent.

6.3.2 Chemicals

Precautions against chemicals entail protection of the site investigator, sampler and any other personnel involved in the site work to avoid direct contact with chemicals, and to avoid possible ingestion or inhalation of contaminated material, fumes or gases.

In most sampling situations, the feet and hands are the first parts of the body likely to come into contact with the site, and then the face. The rest of the body can come into contact with the site by falling down or being splashed.

Chemical-resistant safety boots should be worn to avoid contact with the site. The use of laced boots is not recommended because of the possibility of penetration of contamination to the feet, particularly in wet situations.

Gloves should be worn to avoid contact between hands and any contamination, wearing a suitable overall reduces the risk of contact of the remainder of the body. The gloves should be heavy duty of a suitably chemical-resistant material and the overalls should be at least strong cotton material. Where appropriate, impervious overalls should be worn.

Contamination of the face from hands can be avoided by removing gloves, but splashes to the face are difficult to avoid, other than by exercising care. Where there is a serious risk of splashing, and particularly where hazardous liquids are known to exist, at least eye protection should be worn and preferably the whole face should be protected. If working on a contaminated site with chemical hazards, then wearing of eye protection such as safety glasses, goggles or full face protection would be sensible.

Inhalation and ingestion of contaminants during smoking or eating should be avoided by ensuring a good standard of personal hygiene, including washing of hands before and after using the toilet, and hands and face before eating, drinking or smoking. Smoking, eating and drinking should be banned except in designated areas. Smoking, eating and drinking should be prohibited on suspect sites and on sites known as likely to be contaminated.

The possibility of transferring contamination to the face and eyes by dirty hands and gloves should be emphasised.

Inhalation of dusts or aerosols caused or liberated during the investigation or sampling can only usually be avoided by moving away from the area and allowing the problem to subside. It may be possible to reduce the risk by damping the material with a water spray. If neither of these precautions is possible, then other methods, such as full protective clothing with an independent air supply, may be appropriate.

Use of disposable protective clothing should be considered as a means of avoiding dispersal of contamination from the site, but the protective clothing must then be disposed by a suitable approved method.

In extreme cases, use of full protective clothing with an independent external air supply may be necessary to protect the investigator from contact with the hazards.

All equipment, machinery and wheels of vehicles should be cleaned before leaving contaminated sites and the washings disposed of in a suitable manner, in order to prevent spread of contamination.

6.3.3 Gases

In most cases adequate dilution of any gases liberated is sufficient precaution, nevertheless, any operations should be carried out in such a way that the liberation of gases is minimized. All personnel should be on the upwind side of any problem area so that gases are blown away from them.

If the presence of toxic gases is suspected or anticipated, gas monitors should be issued before work commences to ensure the absence of hazardous gas concentrations. This is particularly important in confined spaces and where work is more than 1 m to 1,2 m below ground level, but is necessary in any situation where gases can be released by the investigation work or may have built up.

Where any operations involve personnel in work below ground or in confined spaces, it is essential to monitor the area for flammable gas, toxic gas and oxygen content prior to entry, and to maintain continuous monitoring while the work is in progress. Only trained personnel should carry out such work. In these situations a method of safe withdrawal and rescue should be prepared before work commences. This is likely to include personnel outside the area of work to raise the alarm and assist in any rescue necessary using rope harness and breathing apparatus. There should be no unprotected entry to rescue someone who has collapsed (this is likely to result in multiple deaths rather than a single death).

Where there is a risk of flammable gas or fumes, the monitoring equipment used should be intrinsically safe.

In some cases, provision of an independent external source of air for breathing may be necessary, for example by use of a breathing apparatus. This, however, requires specialist instruction and training before use.

On contaminated sites all machines should be located on the upwind side of the investigation location so that any fumes or gases are blown away from the operators. It is essential that machine operators always work with the machine cab door or windows open so that there can be no accumulation of gas. Alternatively, the use of closed air-conditioned cabs may be appropriate, providing there is no ingress of outside air, and if necessary an independent source of fresh air is provided.

Personnel working with machinery should stand so that they do not inhale the exhaust emissions.

6.3.4 Biological hazards (bacteria and viruses)

The precautions in relation to chemical hazards (6.3.2) apply equally to bacterial hazards. However one additional problem is the possibility of contracting Weil's disease through contact with water that has been infected by rat urine (see 4.2). If such a situation is possible, appropriate waterproof clothing should be worn.

Injections to protect against typhoid, hepatitis and tetanus infections are recommended for site investigation personnel.

6.3.5 Radiation hazards

Where radiation hazard is possible, dose-monitoring badges should be worn as minimum, but it is preferable to take specific advice from a national radiation authority. If personnel are routinely involved in work below ground level in an area of known significant radon concentrations, specialist advise should also be obtained.

6.3.6 Topography

Many of the safety requirements due to topography hazards are self-evident, such as watching where the feet are placed. However site investigators and samplers should be warned that if the ground is unfamiliar, extra care must be taken in walking on a site.

Care should be exercised when traversing a site to inspect for unsafe ground, sudden depressions, holes or obstructions. This is particularly important where the ground is overgrown with tall or rank vegetation. In such circumstances, it is preferable to break down the vegetation and check the ground before traversing, particularly where heavy machinery is being used.

On former industrial sites, care should be exercised with respect to manholes and filled-in areas, in case these are not capable of supporting a mass or are unstable.

Running should be forbidden on a site which is subject to investigation.

Particular care should be exercised if working near bodies of water, such as rivers, lakes or docks, etc.

If water samples are to be taken, the site of sampling should be safe and secure and if necessary a life-line fitted to prevent the sampler falling in the water.

When excavating trial pits it is not uncommon for the sides to be unstable and collapse. This may not be obvious from the surface. The edge of the trial pit should be checked from all sides, to ensure the ground is firm and not falling away or undermined, before approaching.

When necessary the sides of the trial pit should be supported. This should always be done if anyone is to enter an excavation more than 1 m to 1,2 m deep.

Below-ground excavations which are to be entered require shoring by experts.

Trial pits should be backfilled as soon as possible, and should not be left open overnight. If it is not possible to avoid leaving an excavation open overnight, then it should be securely fenced to prevent unauthorized or inadvertent access.

In caves, mines and adits an engineer should provide a professional judgement on the stability of the walls and roof before work is carried out. Such below-ground work is likely to involve areas where roofs are low; in these locations a protective helmet should be worn.

6.3.7 Machines

Some safety precautions are inherent to the particular machine being used, and in general if machines are used in an improper manner there is a hazard.

Wearing steel-toe-capped boots will help reduce some of the hazards as will wearing safety helmets where appropriate. It is imperative that care is always taken when operating machinery, to ensure that the machine is on a stable base and the machine operator can see both what he is doing, and what other site personnel are doing. Site personnel should always ensure that the machinery operator sees them before moving to take samples, measure depths or make any other observation.

When carrying out augering by hand, particularly to great depths, care is necessary to ensure that body strains do not result. When using motor-powered augers care is necessary not to force the auger or run at too high a rate in order to reduce the possibility of accident due to obstructions or similar sharp change in movement.

Where the operations being carried out can cause flying particles, eye protection should be worn.

Where the operations involve the generation of noise or the machinery is noisy, ear protectors should be worn.

Similarly, in wet ground and where there is the possibility of splashing with contaminated material, personnel should either stand beyond the range of splashing or should be protected so that splashing cannot affect them. Particular care should be taken to protect the face and the eyes.

When working with machines which are powered by internal combustion engines, care should be taken to ensure that personnel involved do not stand in a location which permits the inhalation of exhaust fumes.

When working with electrically powered machinery, it is essential that the equipment be in a safe electrical condition and operate at a safe voltage. (Reference should be made to national safety requirements.) Where there is risk of flammable gases or fumes, then intrinsically safe equipment should be used.

Care should be exercised in moving machinery of any sort over ground for the first time, in case there are areas which are soft or will collapse under the weight of the machine. During site investigations where there is extensive vegetation, it is essential to check that the route of the machinery does not cross soft ground, voids or depressions before moving into place.

When using machines for sampling in urban areas, it is essential that mains services be located before commencement of the site work. This can be done by consultation with the land owner and the service utilities. Even when the service locations have been identified, the sample location should be checked with a service monitor before commencement. If there is any doubt about the possibility of services being present, the initial excavation down to 1 m to 1,5 m, or the maximum possible depth of the services, should be carried out by hand.

Where there are overhead electric power cables, all investigations should be kept a safe distance from the cables. Particular care is necessary with respect to surveyor's poles and tall machinery such as excavators and drilling rigs.

If necessary a safety zone adjacent to the line of the cable should be clearly marked using brightly coloured hazard warning tape or other suitable means.

6.4 Safety procedures

6.4.1 General

Each site should be studied prior to a visit and safety procedures reviewed in the light of the particular features involved. In the case of agricultural investigations, little variation is likely to be required from one site to another. In the case of contaminated site investigations, although the general requirements will be consistent, there are likely to be particular precautions or more stringent application of precautions due to the features of a particular site.

In most cases, a minimum of two people should be on a site, with means of external communication. If only one person is on site, e.g. for agricultural purposes, some system of reporting should be established to ensure the safety and well-being of the site worker.

Upon completion of the sampling, any protective clothing should be carefully removed and wrapped up to prevent spread of contamination. If the clothing is to be cleaned, it should be sent to an appropriate specialist cleaner together with a note of any particularly dangerous contamination which may have occurred. Clothing and other protective equipment should not be taken to any residence for washing or cleaning under any circumstances.

Hands and face should be washed before leaving the site.

Sample equipment should be cleansed and any contaminants contained to prevent their spread. The samples should be prepared for despatch with suitable labels, ensuring that there is no contaminated material on the outside of the container. There should be a special note on the label to advise the laboratory, or other persons receiving the sample, if there is any known or suspected contamination which presents a particular hazard. The method of despatch should ensure that samples arrive at their destination without spillage or distribution of contamination.

National regulations and legislation regarding packaging and transport of hazardous materials and wastes should be observed where appropriate.

6.4.2 Safety on agricultural sites (see also 6.3)

Sound safety boots should be worn with gloves and an appropriate overall. If working with a machine for collecting samples, the boots should have steel toe protection.

Care should be exercised on ploughed fields, particularly if the area is covered by tall vegetation.

Particular care should be exercised if working near bodies of water such as streams, pools, rivers and lakes, and also in the vicinity of slurry or manure storage and if machinery is used for sampling. Particular care should be exercised if it is known or suspected that there has been recent treatment of the land with chemicals or there is some feature of the land which may present a hazard.

The presence of livestock should be noted and, if necessary, arrangements made for their removal to another location before commencing the site work.

6.4.3 Safety on contaminated sites (see also 6.3)

6.4.3.1 Preliminary investigation or site reconnaissance

Sound chemical-resistant safety boots should be worn with gloves and appropriate overalls. If the ground is to be disturbed, the appropriate equipment should be brought to site with the necessary provision for cleaning.

Some information should be obtained about the site before the preliminary visit, so there is some indication of former use, and the possibility of chemical hazards and physical hazards (e.g. below-ground cavities).

Care should be exercised whilst on site in relation to the physical state of buildings. Very dilapidated buildings should not be entered, and such buildings should also be treated with caution where there is a possibility of falling masonry or other debris. Where loose asbestos is in evidence, the area should be avoided until appropriate precautions can be taken (either sealing or removal of the asbestos or wearing respiratory protection equipment to enable sampling to be carried out).

On very contaminated sites, initial observations may best be made from the perimeter using binoculars or a video camera.

6.4.3.2 Site investigation

On very seriously contaminated sites it may be appropriate to have a designated clean area, with access to and from the site by way of a decontamination unit. All eating, drinking and smoking is then restricted to this designated clean area.

Sound chemical-resistant safety boots should be worn with gloves and appropriate overalls. If machinery is to be used, the boots should have steel toe protection and a safety helmet should be worn.

The desk study and site reconnaissance carried out prior to the on-site work should indicate

a) the potential for below ground cavities, voids and storage tanks,

b) the location of below-ground cavities, voids and storage tanks,

c) the existence and location of services,

d) the locations of unsafe buildings,

e) the location of asbestos requiring precautions.

It is essential to avoid damage to any mains services, if necessary by using hand excavation. Even if the information provided indicates that the services are disconnected, caution should be used, particularly concerning electrical services.

Before commencement of the investigation, it should be known whether below-ground voids are to be entered and provision made for shoring the walls of any excavation. Other precautions should also be taken, such as the supply of safety harnesses and breathing apparatus. If the need to enter a below-ground void becomes apparent during the course of the site work, it is imperative that full precautions be taken to protect the investigators, even if this entails returning to the site on another occasion.

For all personnel, washing and toilet facilities should be provided, as well as provision of somewhere to eat and drink away from any contamination. For small-site investigations, this may be simply provision of a bowl with soap and water and a towel and leaving the site for meals. For a large investigation, provision of proper mess-room facilities and a decontamination unit are more appropriate.

Provision should be made for either cleaning sampling equipment on site or for suitable wrapping for the equipment so that distribution of contamination does not occur while the equipment is being transported to a place for cleaning.

Vehicle wheels should be washed every time before they leave the site, but the site operation should also be designed to minimize the possibility of transfer of contamination to vehicles and wheels. This is most readily achieved by minimizing vehicle access to the site.

6.4.4 Safety in geological investigations (see also 6.3)

The considerations under 6.4.2 and 6.4.3 apply equally to geological investigations. A difference in the hazards, and hence the safety precautions, arises if work is carried out underground in such locations as caves, mines and adits.

Where caves or former workings are to be investigated, it is prudent for a preliminary assessment to be carried out by an appropriately qualified engineer to examine the stability of the structure. Protective helmets should be worn and monitoring of the atmosphere carried out to check for adequate oxygen content and absence of toxic gases.

A means of communication with the surface should exist, as well as a system for checking that personnel have returned to the surface.

A method statement should be prepared for the actions to be taken in case of problems below ground.

6.5 Safety equipment

The following list provides a guide to the items required to assist in making site investigations and sampling a safe operation. Variations may be required due to local legislation or the local availability of some items.

The most important aspect is that, however much safety equipment is provided and used, its effectiveness can be totally negated by carelessness or inattention on the part of the user. The ultimate safe operation of any sampling or site investigation exercise is in the hands of the operating personnel. It is essential that the personnel involved are aware and understand the hazards and have been properly trained so that the risks are minimized. The list includes:

— chemical-resistant safety boots (not laced) with steel toe and sole protection;

— gloves (heavy-duty chemical-resistant);

— overalls (waterproof if necessary);

— eye protection such as glasses, goggles or face shield;

— ear protectors;

— protective helmet;

— high-visibility vest or jacket;

— safety harness;

— breathing apparatus and operator;

— washing and toilet facilities (these can vary from provision of water, soap and a towel for a “walk-on” site inspection, to a fully plumbed-in decontamination unit for a major investigation of a former industrial site, e.g. chemical works);

— gas monitors;

— radiation monitors;

— services monitors/detectors;

— site telephone;

— eating and resting area;

— vehicle-washing facility to prevent transport of contamination from the site.

The use of safety or protective equipment should not result in contamination of the samples collected, and the equipment should be selected accordingly.

6.6 General environmental safety

In any sampling investigation there will be some disturbance of the ground. In agricultural investigations this disturbance is minimal and unlikely to result in the creation of any hazard to the environment. It is not considered necessary in those circumstances to take any particular steps to protect the environment in general other than the procedures already outlined relating to prevention and spread of contamination by clothing or on the outside of sample containers.

Examination of sites suspected of contamination does however pose some risk to the general environment.

Hazards due to distribution of contamination by site clothing, samples and machinery and vehicle wheels have been covered in 6.3.2.

Investigation of such sites results in contaminated material being brought to the site surface and disturbance of below-ground strata, in addition to the possible perforation or destruction of surface cover.

Where the turnings are a result of drilling, the amount is sufficiently small as to be unlikely to create any problem outside the site. Such turnings should be collected together and taken to a suitable off-site disposal upon completion of the investigation.

Material exposed on the surface can present a hazard to the environment due to the release of odours or fumes. This is difficult to control and can only be minimized by sampling at one such location at a time and backfilling immediately upon completion of the excavation.

When backfilling an excavation, any obviously suspect material should be buried well below the surface and if necessary clean material should be spread over the area of the excavation, or other measures taken, so that there is no additional contamination left at the surface of the site on completion of the investigation.

Regard should be paid to local regulations which may require off-site disposal of suspect material and backfilling with clean material.

In any case, care is necessary while the material is exposed so that animals or birds (or humans) do not come into contact with the contamination.

If the site surface is obviously contaminated prior to the investigation, and presents a general environmental problem due to exposure to birds and animals and possible dust distribution, in addition to taking precautions to minimize disturbance and distribution during the site investigation, the situation should be brought to the attention of the landowner so that preventative measures can be implemented.

When carrying out an investigation on highly contaminated sites, consideration should be given to using only borehole or probing techniques and not excavation, as a means of minimizing disturbance and reducing problems of increased distribution of contamination.

Increased distribution can also result where contamination exists beneath “waterproof” landscapes such as tarmac or concrete hardstanding. If these are broken through and the “impermeability” is not replaced, then the resultant penetration of rainwater can result in greater percolation and distribution of contamination in the ground and groundwater. In such circumstances the excavation should be reinstated with an appropriate impermeable cover, and may require maintenance to allow for settlement.

Where excavations penetrate clay strata for example, and particularly where boreholes are installed, pathways can be created which result in increased distribution of contamination, e.g. via leaching into ground water. 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 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 dissemination of the contamination.

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 of rivers and streams*

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

[7] 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*

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

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

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

ICS 13.080.05

Price based on 21 pages