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Soil quality — Sampling —

Part 103: **Safety**

Qualité du sol — Échantillonnage —

Partie 103: Sécurité

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Foreword

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

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

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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

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

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

This first edition of ISO 18400-103 cancels and replaces ISO 10381-3:2001, which has been technically and structurally revised. The ISO 18400 series is based on a modular structure and cannot be compared to ISO 10381-3 clause by clause.

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

Introduction

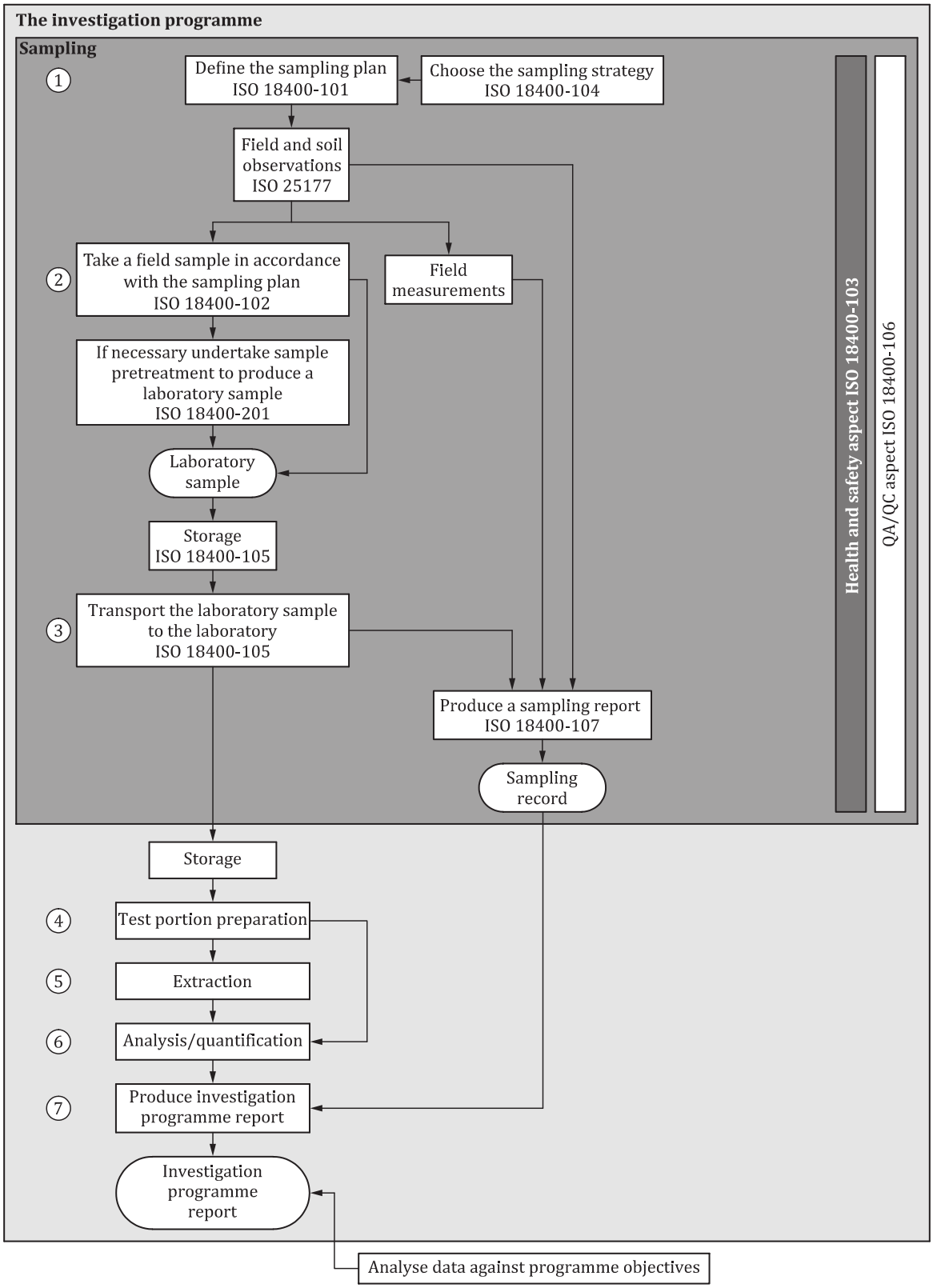
This document is one of a group of International Standards intended to be used in conjunction with each other where necessary (the role/position of the International Standards within the total Investigation programme is shown in Figure 1).

It deals with safety during sampling and other soil investigation activities. International and national regulations regarding health and safety at work and associated guidance produced by statutory bodies and trade associations could exist and may need to be taken into account.

It does not seek to address everyday hazards that could arise from the use of such items as sharp instruments, digging/drilling equipment, 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.

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 document will be of assistance in these situations, but additional guidance about the precautions to be taken should be obtained from specialists, such as those responsible for the former operation of these sites.

Geological and geotechnical investigations are outside of the scope of this document and for detailed guidance, reference is to be made to other relevant International Standards. However, soil quality investigations may sometimes be combined with geotechnical investigations for practical reasons and for economy and thus specific hazards and risks associated with geotechnical investigations might need to be addressed in the overall risk assessment.



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

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

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

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Part 103: Safety

1 Scope

This document gives guidelines for:

— identification of hazards that could be encountered during a site investigation and when collecting samples of soil and other ground material, including hazards that are intrinsic in the sampling operation (e.g. physical hazards) in addition to the hazards that might arise, e.g. from contamination with chemicals or biological agents;

— measures to be adopted to control risks once an appropriate risk assessment has been carried out.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 11074, *Soil quality — Vocabulary*

3 Terms and definitions

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

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

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

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

4 Preliminary considerations

The main objectives of this guidance on safety are to:

a) identify the hazards that could exist when carrying out site investigations and soil sampling programmes,

b) indicate management procedures to provide a framework for safe working,

c) indicate what working procedures can be adopted to minimize risks from contaminants, physical and other hazards associated with the collection of samples and the use of machinery, and

d) indicate what precautions can be taken in terms of personal protection and cleaning facilities to minimize any risks.

It is not possible, in a guidance document such as this, to identify all the hazards that could be encountered during site work, or to provide guidance on how the associated risks can be dealt with in all situations. Safety depends ultimately on the adoption of an attitude and approach to any particular

situation that will ensure that the hazards are identified and properly evaluated and appropriate precautions taken.

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

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 might not have been properly filled in. Cavities can 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. Even minor injuries can provide a pathway for toxic substances and pathogens to enter the body.

Care should 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 might not have been identified at that time.

At most active construction and industrial sites, special safety instructions are in effect. In addition, regulations could exist and may need to be taken into account on site. When relevant, the sampler should be informed before entering the site.

If during the site reconnaissance carried out as part of a preliminary investigation anything is seen that is considered likely to pose an immediate threat to human health and safety or the environment, this should be reported immediately to whoever is in control of the site so that any essential urgent action can be taken.

NOTE 1 There might be a duty under health and safety legislation and/or a professional code of conduct to do this.

When the site surface prior to the investigation is obviously contaminated, or presents a general environmental problem due to exposure of 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 authorities as appropriate, so that preventative measures can be implemented.

In addition to the guidance provided in this document, guidance can be found in:

— international and national legislation and associated guidance;

— industry codes of practice;

— safety documentation produced by employing companies and other organisations;

— site-specific safety instructions.

Some guidance document that might be relevant are listed in the Bibliography.

BS OHSAS 18001[7] specifies requirements for an occupational health and safety management system to enable an organization to control its occupational health and safety risks and improve its occupational health and safety performance. Guidelines for its implementation are provided in BS OHSAS 18002[8]. BS OHSAS 18001[7] is designed to be compatible with ISO 9001[2] (Quality) and ISO 14001[3]

(Environmental) management systems standards to facilitate the integration of quality, environmental and safety management systems by organizations, should they wish to do so.

NOTE 2 BS OHSAS 18001[7] is the internationally recognized assessment specification for occupational health and safety management systems. It was developed with the assistance of a range of national standardization bodies, regulatory and certification bodies, and trade bodies to address a gap where no third-party certifiable International Standard currently exists. It is planned that the future ISO 45001 will replace BS OHSAS 18001.

5 Concepts and processes

5.1 General

In order to properly address health and safety at work, it is necessary to

— identify hazards, i.e. anything with the potential to cause harm, (this can include substances or machines, methods of work and other aspects of the work organization),

— identify and quantify risks, i.e. the likelihood that a particular hazard might cause harm to those exposed to it and the consequences for them (risk therefore reflects both the likelihood that harm will occur and its severity),

— carry out a risk assessment (a careful examination of what could cause harm to people), to determine whether sufficient has been done (precautions taken) to manage the risks or what further needs to be done to prevent harm, and

— manage the risks by assessing them, putting sensible health and safety measures in place to control them and then making sure they work in practice (a process usually termed “risk management”).

5.2 Risk assessment

A risk assessment should be carried out by an appropriately qualified person before any sampling or other investigation activities, including a site reconnaissance, are carried out as part of a preliminary investigation. This is particularly important on former industrial sites and waste disposal sites. If site reconnaissance forms part of the preliminary investigation, the risk assessment should be based on the results of the desk study. It might be possible to refine the assessment once the preliminary investigation is completed, and it should be kept under review as the investigation proceeds.

Risk assessment typically involves:

— identification of the hazards;

— deciding who or what might be harmed and how;

— evaluating the risks and deciding on precautions;

— recording findings and implementing them;

— reviewing the risk assessment frequently (e.g. daily) and amending it as necessary.

The risk assessment should take into account that site investigation workers are typically:

— exposed to weather extremes;

— exposed to physical hazards;

— sometimes exposed to other potential hazardous substances such as cement and adhesives;

— are often peripatetic (move between sites and possibly employers).

The risk assessment record should show:

— a proper check of the hazards was made;

— that those who might be affected have been identified;

— all the obvious significant hazards have been dealt with, taking into account the number of people who could be involved;

— the control measures are acceptable, and the remaining risk is minimised;

— staff or their representatives were involved in the process;

— who carried out the risk assessment and their qualifications for this task.

NOTE 1 A common method for evaluating risks involves working out a risk level by categorizing the likelihood of the harm and the potential severity of harm and then plotting these two risk-determining factors against each other in a risk matrix (see Table 1). The risk level determines which risks should be tackled first.

Using a matrix can be very helpful for prioritizing actions. It is suitable for very many assessments but particularly lends itself to more complex situations. However, it does require a fair degree of expertise and experience to judge the likelihood of harm accurately. Getting this wrong could result in applying unnecessary controls or failing to take important ones. People working full time in health and safety often use a version of this method. It provides a good alternative to the "good practice" approach, i.e. adopting practices that are widely recognized and set out in authoritative guidance.

Table 1 — Risk matrix

		Potential severity of harm		
		Slightly harmful 1	Harmful 2	Extremely harmful 3
Likelihood of harm occurring	Highly unlikely 1	Trivial 1	Tolerable 2	Moderate 3
	Unlikely 2	Tolerable 2	Moderate 4	Substantial 6
	Likely 3	Moderate 3	Substantial 6	Intolerable 9

NOTE 2 An example of a risk assessment for driven probe boring (window/windowless drilling) is provided in Annex C.

5.3 Risk management

In order to achieve safe working conditions (i.e. to reduce risks to an acceptable minimum), the employing organizations should adopt formal "policies" and operating frameworks requiring (see also 6.1 and 6.2):

— identification of hazards and evaluation of risks;

— avoidance of risks wherever possible;

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

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

Employers should provide training and keep records of procedures adopted and of any incidents. It might be necessary to establish health screening and surveillance programmes.

In order that appropriate risk reduction and management procedures can be identified on a site-specific basis, those managing site investigations should:

— identify hazards;

— identify under what circumstances the hazards might present a risk;

— quantify the actual risks.

In relation to contaminated sites, the importance of a preliminary investigation (see ISO 18400-202[1)]) for identification of hazards from contamination and physically hazardous conditions is emphasized.

5.4 Identifying hazards

As indicated in 5.2, potential and actual hazards should be identified taking into account:

— the history of the site as established in the preliminary investigation (see ISO 18400-202[1)]);

— the activities to be carried out on the site (e.g. exploratory and sampling techniques);

— the nature of the site (e.g. agricultural land, industrial land, forest);

— topography and other physical aspects such as waterlogging;

— weather/climate.

NOTE Clause 6 and Annex B provide information on the hazards that could be encountered in a variety of situations including on agricultural and contaminated sites.

6 Safety precautions — General aspects

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:

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

— emphasize 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 subcontracted personnel and to the general public;

— require competency to be demonstrated and the evidence for this to be recorded;

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

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.

NOTE Employing organisations (i.e. clients) sometimes enforce their own safety policies through contractual requirements on the organization(s) carrying out the investigation.

1) Under preparation.

6.2 Planning and managing for safety

To ensure 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 should include as appropriate (see also Table 2):

— compliance with company safety policy (see 6.1);

— preparation of a safety plan;

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

— clear assignment of responsibilities;

— provision of information to all concerned;

— provision of training;

— identification and assessment of the hazards arising from the site (see 5.3 and 5.4);

— avoidance of hazards where possible;

— selection of sampling methods with safety in mind;

— provision and use of personal protection equipment (see 6.4 and Table 2);

— provision of equipment for the detection of hazardous environments (see Table 2);

— adoption of appropriate working procedures and provision of supporting facilities as listed in Table 2;

— health surveillance;

— consultation with managers of the site where works are to be undertaken regarding site conditions, site works within the area for sampling and other issues which could be relevant to the general safety of those undertaking the works (e.g. activities beyond the site boundary which could compromise the site works, ground conditions, unreported incidents within the area of study).

Requirements and systems for controlling the exposure of workers to substances hazardous to health shall be complied with. Precise requirements might differ, but often include a framework requiring:

— avoidance of exposure to potential physical, chemical and biological hazards;

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

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

They could also require:

— the provision of information and training;

— health surveillance programmes;

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

NOTE 1 The above provides a useful framework for a policy to protect personnel from hazardous substances.

When establishing suitable safety procedures, not only should the hazard be considered, but also the way the hazard is likely to be encountered by the investigator or sampler and the consequences of the exposure to the hazard which might vary from skin irritation and simple physical injury to death.

NOTE 2 In most cases, chemicals are likely to be considered hazardous because they can cause acute toxic effects, but chronic effects could also be of concern in respect of regular investigators and samplers.

NOTE 3 Annex A describes how investigators could be exposed to the hazards that might occur in different situations and some of the consequences of such exposures.

6.3 Personnel

There are various roles that need to be performed by one or a number of persons during an investigation, including project leader, field manager, field investigator and skilled operatives (e.g. drillers). Tasks to be carried out include direction, planning and execution; supervision in the field; sampling and measurement, formation of exploratory holes and logging of excavations and boreholes, etc. Whoever performs these roles and tasks has responsibility to ensure safe working and that health is protected. They should therefore be appropriately knowledgeable, qualified, trained, experienced and able to communicate with other members of the team. The prescription of the qualifications, etc. required by those performing these roles is outside the scope of this standard. However, the provisions in national, international and European geotechnical standards might be useful by analogy regarding the roles to be performed and appropriate levels of qualification, etc.

NOTE 1 Those performing the various roles and tasks mentioned above could work for the client, a consultant or a contractor.

The lead driller in charge of an individual drilling rig should be skilled in the practice of exploration of the ground by means of boreholes, simple sampling and testing, making groundwater observations in boreholes, and properly recording the information obtained. In some jurisdictions, all boring and drilling operatives are required to hold specific qualifications.

Operators of excavating plant should be skilled and experienced in the safe use for digging trial pits and trenches and have any relevant specific qualifications required in the jurisdiction in which they are operating.

Physical support to ensure safety on site should be installed by skilled operatives who should have any relevant specific qualifications required in the jurisdiction in which they are operating.

NOTE 2 ISO/TS 22475-2[4] provides guidance on qualification criteria for enterprises and personnel including for “qualified operators” and ISO/TS 22475-3[5] provides guidance on conformity assessment of enterprises and personnel by a third party.

6.4 Safety equipment

Appropriate safety equipment including personal protective clothing and equipment and monitoring equipment should be provided and operatives trained in their proper use by their employer.

The selection of appropriate safety equipment can be a complex process, because of the range of conditions that might be encountered and the range of equipment available. The project manager and/or safety manager should always obtain specialist advice if there is any doubt about the type of equipment required.

The aim should always be to take precautions aimed at preventing hazards or reducing risks at source. However, such measures, will seldom completely remove a risk and thus use of personal protective equipment (PPE) will usually be necessary. Even in situations where chemical or similar hazards are negligible, there will remain a need to provide protection against physical hazards and adverse weather conditions. The selection of PPE can be made more difficult because of the availability in some markets of counterfeit PPE.

For those forms of personal protective equipment (PPE) where several classes of protection are available, it is important to select the right level of protection for the risk involved. For example,

respiratory protective equipment (RPE) shall be selected to provide the right type of protection (dusts or vapours and gases need different forms of filter) and the right level of protection (high concentrations of a substance will need a higher performance filter).

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 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 and supervising personnel.

When PPE has been selected, it should always be readily available. Some forms of PPE are relatively robust and long-lasting. Others, however, might be designed for limited use only (e.g. disposable RPE) or might be easily soiled and made unsuitable. For example, gloves which have been heavily contaminated by whatever they are protecting from might no longer provide suitable protection. Replacement supplies shall be readily and easily available or any efforts to ensure compliance will be undermined.

Safety helmets are relatively robust and long-lasting but can deteriorate due to exposure to heat, sunlight, or chemicals. They commonly are marked with a maximum product life after which they should be changed.

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

The equipment listed in Table 2 should be provided as necessary taking into account the anticipated working environment, hazards likely to be encountered, and local legislation and regulations that may exist.

NOTE 1 Guidance on the selection of PPE to provide protection against particular types of hazard is provided in Table 3.

Project managers should:

— oversee inductions, documentation of the RAMS (risk analysis management system), proof of competency, preparation of health and safety plan, etc.;

— make sure anyone using protective clothing is aware of why it is needed, when it is to be used, repaired or replaced — and its limitations;

— train and instruct people how to use PPE properly and make sure they are doing so;

— check regularly that protective work wear is being worn all the time workers are exposed to the risk, and never allow exemptions for those exposed for only a short time;

— if PPE is not being worn, or not being worn correctly, investigate the reasons why not and record the incident as a “near-miss”;

— provide facilities to keep clean clothing and dirty work clothing apart and check that workers use, clean and store protective clothing and other PPE properly;

— make sure workers avoid contaminating the skin when removing PPE;

— not permit chemically contaminated protective coveralls to be washed at home;

— ensure that PPE is checked for any damage before and after use;

— ensure disposable PPE is used only once and disposed of safely after use, and in a suitable approved method;

— keep abreast of national and international best practices.

Table 2 — Health and safety measures that might be required for site investigations

Protective clothing and equipment[b]	Monitoring equipment	Safety procedures and facilities
— Overalls (water or chemical proof if necessary); — safety boots (not laced) with steel toe and sole protection and chemically resistant where necessary; — gloves offering protection in relation to the hazards likely to be encountered (physical, chemical, biological); — protective helmet; — eye protection such as glasses, goggles or face shield; — ear protection; — face masks and filters; — breathing apparatus; — safety harness and lanyards; — protection against strong sunlight including eyes and skin; — high visibility vest or jacket; — safety torches; — fire extinguishers; — first aid equipment including eyewash.	— Hand-held gas monitors; — automatic gas detectors; — personal monitors; — environmental monitoring; — radiation monitors; — services monitoring/detection equipment.	— Training; — procedure for recording "incidents" and "possible exposures"; — permit to work systems; — notification to emergency services; — access to telephone contact; — decontamination facilities for plant to prevent transport of contamination from site; — decontamination facilities for personnel[a]; — safe sampling procedures; — safe sample-handling procedures; — access for emergency vehicles.

[a] Washing and toilet facilities 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.

[b] See also Table 3.

Table 3 — Personal protective equipment required for different hazards

Hazard	Requirements for personal protective equipment (PPE)
7.3 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. They should be appropriate to the task in hand and meet relevant health and safety standards for PPE. Gloves should be worn to avoid contact between hands and any contamination. The gloves should be of a suitably chemical-resistant material appropriate for the materials expected to be encountered. Contamination of the face and eyes from hands should be avoided by removing gloves and washing hands. — Wearing a suitable overall reduces the risk of contact of the remainder of the body. Overalls should be made of at least strong cotton material. When appropriate, impervious overalls should be worn. — 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 should be considered a standard prudent procedure. — Subject to the nature of the hazard it could be appropriate to use masks fitted with appropriate filters rather than an independent air supply. — Use of disposable protective clothing should be considered as a means of avoiding dispersal of contamination from the site, but the protective clothing shall then be disposed by a suitable approved method.
7.4 Gases[a]	— Personal monitors for toxic and other gases. — In some cases, provision of an independent external source of air for breathing could be necessary, for example, by use of a breathing apparatus. This, however, requires specialist instruction and training before use.
7.5 Biological hazards	— The precautions in relation to chemical hazards (see 7.3) apply equally to bacterial hazards. However, one additional problem is the possibility of contracting Weil's disease (*Leptospira*) through contact with water that has been infected by rodent urine. If such a situation is possible, appropriate waterproof clothing should be worn. Cuts and abrasions should be protected with waterproof plasters, etc. Regard should also be paid to the possible presence of faecal bacteria, fungi (e.g. Aspergillus), anthrax and other possibly infective agents (see also A.1, B.1.3 and B.2.4).
7.9 Machines	— High visibility clothing should be worn in line with site-specific requirements. — 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. — 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.

NOTE Information provided above is not exhaustive. Each situation needs to be judged individually following an appropriate risk assessment. All equipment should comply with relevant standards. Regulations could exist and may need to be taken into account.

[a] "Gases" here embraces all gaseous substances including vapours and fumes.

7 Safety precautions in relation to particular hazards

7.1 General

On all sites irrespective of their history, the locations of any below-ground services (utilities) or other vulnerable features should be identified before on-site work starts to prevent inadvertent and possibly dangerous damage. Overhead power lines should also be identified. Further guidance is given in 8.3.

When using specialized sampling techniques, for instance, involving explosives, specialized personnel should be employed.

Preliminary investigation in accordance with ISO 18400-202 should identify whether unexploded ordnance might be present, e.g. munitions from former warfare or military training exercises. In which case, an appropriate survey and removal action should be undertaken. Even when this has been done, however, vigilance should be maintained at all times for the presence of suspicious articles, especially when forming excavations. The relevant authorities should be called to site if suspicious articles are seen.

NOTE 1 In general, safety precautions against a particular hazard are independent of the type or location of investigation being carried out. Some precautions might however need to be more extensive, for instance those relating to machinery, depending on the size and the nature of the machinery to be used.

NOTE 2 Further guidance in relation to particular hazards is provided in Annex B.

NOTE 3 Reference [14] provides useful guidance on investigations, etc. for unexploded ordnance.

7.2 Personal protective equipment

Personal protective equipment (PPE) and other safety equipment should be supplied and used as appropriate for each of the hazards listed below in adherence with the guidance in 6.4 and Table 3.

7.3 Chemicals

There are usually two potential sources of hazardous substances: those that exist on site (contaminated land) and those used to enable the works to be carried out (cement, bentonite (in powder form), fuels, etc.). All substances used in the planned works should be the subject of a formal assessment in relation to hazards to health and appropriate data sheets provided.

In the case of a potentially contaminated site, the risk assessment should list the likely substances to be encountered and hence enable requirements for PPE to be identified (see 6.4, Tables 2 and 3).

In the case of purchased materials, appropriate hazard assessments should be carried out.

NOTE 1 Regulations often require the contractor using the materials to consider each individual site, to prepare an assessment for each hazardous substance and to provide guidance on the procedures to be adopted to control the hazardous substance including, for example, how they are to be stored (e.g. fuels so that any leaks are captured). Where products such as cement, bentonite, fuel, etc. are used daily on various investigation sites, these substances may be dealt with by using general assessments that are provided on site and by ensuring all site staff and operatives are aware of the existence of these assessments.

Some people are allergic/sensitive to some chemicals and this should be taken into account in the risk assessment and risk management measures adopted.

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 prohibited on suspect sites and on sites known as likely to be contaminated. In all other cases, smoking, eating and drinking should be banned except in designated areas.

Those carrying out excavations should routinely have available protection against nuisance dusts or aerosols liberated during the investigation or sampling and when necessary against specific potential hazards that have been identified before the work is started. In some cases, full protective clothing

with an independent air supply should be provided. When it is known or suspected that asbestos might be present, protective clothing shall be provided and working methods shall be adopted, in accordance with applicable requirements.

There could be occasions when dusts or aerosols occur unexpectedly. The immediate hazard can usually be avoided by moving away from the area and allowing the problem to subside. Consideration shall then be given as to how best to proceed, taking advice form the project leader and a health and safety specialist as necessary. It might be possible to reduce the risk sufficiently by damping the material with a water spray, but in other cases the following actions should be taken, as appropriate:

— cease work until the dust or aerosol has been identified;

— backfill the excavation (avoiding as far as possible dispersion of dust) to prevent further dispersion of the offending material and contact by site workers;

— adopt a different sampling technique that will limit dispersal of the dust and exposure of the work force;

— employ appropriate PPE;

— abandon the sampling location altogether as being too hazardous to disturb further.

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.[14]

7.4 Gases

WARNING — Some people are allergic/sensitive to traces of some gasses and are liable to collapse and require assistance if affected. Although unlikely, work on sites where ground gas is suspected or known to be present should be conducted with this possibility in mind. This warning refers to work in the open and should not be confused with the requirements for work in enclosed spaces.

There should be regard to both the safety of workers as described below and to occupiers and neighbours of the site being investigated (see 8.4.3).

In most cases, adequate dilution of any gases liberated is sufficiently protective; 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, and if working with machinery, they should stand so that they do not inhale the exhaust emissions.

All machines should be located on the upwind side of the investigation location where possible so that any fumes or gases are blown away from the operators. Depending on the results of the risk assessment, machine operators should ensure sufficient air ventilation so that there can be no accumulation of gas or work in pressurized cabs for which the air is appropriately filtered prior to entering the cabin or provided from a compressed-air supply.

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 about 1 m below ground level and is also necessary in any situation where gases can be released by the investigation work or might have built up.

Records of gas concentrations before and during exposure should be recorded and assessed against appropriate thresholds for occupational exposure.

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 casualties rather than a single casualty).

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

It is not normal to enter deep excavations as part of a sampling exercise or site investigation (see 7.8), 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 or an oxygen-deficient atmosphere.

Personnel entering old buildings should consider rooms entered as potential confined spaces (see 7.10).

7.5 Biological hazards (bacteria and viruses)

The precautions in relation to chemical hazards (see 7.3) apply equally to bacterial hazards. However one additional problem is the possibility of contracting Weil's disease (*Leptospira*) in particular, but also other illnesses through contact with water that has been infected by rodent urine (see B.1.3). If such a situation is possible, appropriate waterproof clothing should be worn. Other potential biological hazards include, but are not limited to, faecal bacteria, fungi (e.g. Aspergillus), anthrax bacillus (*Bacillus anthracis*), tetanus (*Clostridium tetani*), "foot and mouth disease" (*Aphthovirus picornaviridae*).

In old buildings, where there has been unauthorised occupation or use, there could be a risk of encountering hypodermic needles used for injection of drugs, faeces and other infective materials.

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

NOTE 1 Contact with some plants can be harmful, for example:

— giant hogweed (*Heracleum mantegazzianum*), the sap of which causes severe, recurring blistering in sunlight;

— common hogweed which can cause mild allergic skin allergies;

— spurge which can cause skin irritations;

— members of the primrose family which can cause skin rashes in some people.

NOTE 2 Blue-green algal blooms are hazardous to humans and other animals. In humans, illness can include skin rashes, vomiting, eye irritation, diarrhoea, fever and pains in the muscles. The illnesses can be severe but are not usually life threatening.

7.6 Radiation

Where radiation hazard is possible, dose-monitoring badges should be worn as a 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 advice should also be obtained.

7.7 Asbestos

The presence of asbestos fibres or asbestos-containing materials (e.g. fragments of asbestos cement sheeting) in the ground can present risks to health and requires particular care in the selection of appropriate sampling techniques and design of sampling procedures. Contingency plans should always be in place so that investigation personnel know how to proceed if asbestos is unexpectedly encountered.[9]

7.8 Topography

Many of the safety requirements for the avoidance of topographical 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 shall 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 inspection chambers, corroded underground artefacts such as pipelines and tanks, poorly secured mine shafts and filled-in areas, in case these are not capable of supporting a mass or are unstable.

Except in the case of an emergency, 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 surface water samples are to be taken, the exercise should be properly planned having regard to the need for the site of sampling to be safe and secure, and to provide as appropriate a life-line to prevent the sampler falling into the water, buoyancy aids, life jacket and to plan for rescue should it be necessary.

When excavating trial pits, it is not uncommon for the sides to be unstable and collapse. This might 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 and signs posted warning of the hazard. The hazard increases with increasing depth and decreasing stability of the ground. Instability can be exacerbated by rainfall, a rising water table and proximity of arising to the edge. When necessary, the sides of the trial pit should be supported.

Entry to trial pits should be avoided whenever possible. They should not be entered unless it is safe to do so, e.g. if relatively shallow or shored by a competent person when necessary. Other potential hazards (e.g. possible exposure to hazardous chemicals) should also be taken into account.

NOTE 1 There is no generic safe depth. However, some jurisdictions permit entry to unsupported excavations of no more than a specific depth (e.g. 1,2 m). Others require formal risk assessments for each trial pit concerning whether it is safe to enter the trial pit and other hazards that might be encountered.

NOTE 2 For detailed advice about safety and trial pits, see Reference [10].

Below-ground excavations which are to be entered should be only shored by those with appropriate training, experience and specific qualifications where these exist.

Trial pits should be backfilled as soon as possible and should not normally 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.

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

7.9 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 risk of injury.

All moving parts on machinery, especially drilling and boring equipment, shall be properly guarded. Manufacturer's operating instructions shall be followed.

NOTE Some relevant guidance can be found in the EN 16228 series.[1]

PPE should be provided in line with risk assessment and control procedures. In general, boots with steel toe-caps and sole-plates and safety helmets should be worn to reduce risks of physical injury from crushing, sharp objects and overhead hazards including moving parts of excavators, etc., together with ear and eye protection as necessary.

Care should always be 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 should be taken to ensure that body strains do not result. When using motor-powered, augers care should be taken 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.

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 operates at a safe voltage. 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.

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.

7.10 Buildings and other structures

Care should be exercised while on site in relation to the physical state of buildings. 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 (e.g. glass, sharp metal objects). 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).

Personnel entering old buildings should consider rooms entered as potential confined spaces. Closing doors can create a "confined space" where gases previously vented could build up creating a hazard to the personnel entering the room and creating the confined space, as well as to other persons who might later enter the property.

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

NOTE For detailed useful guidance, see Reference [26].

7.11 Unexploded ordnance and other explosive hazards

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

NOTE The presence of unexploded bombs and mines, etc. from former wartime activities or, for example, on military proofing grounds can present a hazard. Hazards due to explosives residues and munitions are also likely to exist at sites which have produced and handled explosives and munitions. For some relevant guidance, see Reference [14].

7.12 Extreme weather conditions

Extreme weather conditions (e.g. very hot or cold climate) can present significant hazards. These need to be taken into account when planning work and selecting protective equipment.

NOTE 1 Even in fairly temperate climates, prolonged unprotected exposure to sun can be injurious. In addition, the risks of heat fatigue for those wearing heavy protective gear is enhanced.

NOTE 2 In addition to the direct effects of low temperatures, wet or icy ground conditions increase the risk of injury due to slipping. Wet sticky conditions can make it difficult for workers to get out of the way of moving machinery.

NOTE 3 Dehydration is a particular hazard for those with pre-existing medical conditions such as diabetes.

8 Safety procedures — Specific activities

8.1 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 might 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 after the end of contact with potentially harmful substances and always before eating or leaving the site.

Sample equipment should be cleansed and any contaminants contained to prevent their spread (see Reference [15]). 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, and in accordance with the testing laboratory's sample safety requirements.

National regulations and legislation regarding packaging and transport of hazardous materials and wastes could exist and may need to be taken into account.

8.2 Protection of buildings and installations including underground utilities

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

On all sites irrespective of their history, the locations of any below-ground services (utilities) should be identified to prevent damage before commencement of the site work. This can sometimes be done by consultation with the land owner and the service/utilities suppliers/companies. However, it could be necessary to carry out a survey for services by physical tracing and geophysical techniques (see Reference [12]).

Even when the service locations have been identified, the sample location should be checked with a service monitor before commencement (see for example, References [11] and [12]). 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 or vacuum excavation. Even when this has been done, all excavations should be carefully observed for signs of buried services irrespective of whether utility surveys have been carried out or starter pits employed.

In agricultural surveys, features such as irrigation and drainage lines should be identified and care taken to identify water, gas and fuel oil distribution lines which often cross fields and other open land.

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.

8.3 Safety on agricultural sites (see also 6.4 and B.2)

Care should be exercised on ploughed fields and fields which are 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 might 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.

8.4 Safety on contaminated sites (see also 6.4 and B.3)

8.4.1 Preliminary investigation and site reconnaissance

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

A full desk study as described in ISO 18400-202 should be carried out before the site reconnaissance visit, so that potential chemical, physical (e.g. below-ground cavities), biological and other hazards can be identified and any necessary protective measures identified.

Equipment should be brought to site with the necessary provision for cleaning, (see Reference [15]).

Care should be exercised while on site in relation to the physical state of buildings (see 7.10).

Personnel entering old buildings should consider rooms entered as potential confined spaces (see 7.10).

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

If during the site reconnaissance carried out as part of a preliminary investigation (see ISO 18400-202) anything is seen that is considered likely to pose an immediate threat to human health and safety or the environment, this should be reported immediately to whoever is in control of the site so that any essential urgent action can be taken.

NOTE There might be a duty under the health and safety legislation and/or a professional code of conduct to do this.

8.4.2 Field investigations — General

The desk study and site reconnaissance carried out prior to the on-site work should, among other things, indicate:

— potential for below ground cavities, voids and storage tanks;

— existence and location of services;

— locations of unsafe buildings;

— location of neighbours;

— location of party walls (i.e. walls shared with other buildings or land holdings);

— location of surface water features;

— location of asbestos requiring precautions.

On seriously contaminated sites, it could 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.

It is essential to avoid damage to any mains services, if necessary by using hand or vacuum 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 and appropriate confined space training. 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 (see Reference [15]).

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 using a combination of:

— restricted access for vehicles;

— provision of dedicated haul roads formed from imported aggregate;

— a traffic management plan.

NOTE Guidance on safe drilling and investigation practices is given in a number of industry documents (see References [16] to[24]).

8.4.3 Field investigations — Soil gas

The guidance provided in 8.4.2 should be followed as appropriate.

For reasons of safety, water flushing should be used when drilling in productive coal measures (see Reference [16]).

NOTE 1 Guidance on safe drilling and investigation practices is given in a number of industry documents (see References [16] to[24]).

NOTE 2 Injudicious choice of drilling method can cause risks to drillers due to gas coming out of boreholes and also cause risks to the public (e.g. the occupants and users of neighbouring buildings due to displacement of gas from the location where drilling is taking place (see Reference [16]).

a) A number of serious incidents have occurred as a result of surface emissions of toxic gases into houses during the investigation and treatment of nearby former coal mine workings. Of particular concern are incidents where carbon monoxide has been measured or inferred as entering houses from the mine workings below. Mine workings can also contain methane, hydrogen sulfide, carbon dioxide and oxygen-deficient-air, all of which can be hazardous to health if emitted at the surface (see References [16] and[25]). For guidance on the general procedures to be adopted when drilling or piling into former coal mine workings (including mine entries) and unworked coal, see Reference [16]. Following the advice contained in the guidance will greatly reduce the likelihood of a dangerous incident happening.

b) Following a reported leak of petrol (over 60 000 l) at a service station, exploratory investigations were undertaken to assess the extent and severity of the associated contamination. The petrol vapours present in the subsurface had migrated beneath a neighbouring residential property, accumulated and ignited, resulting in an explosion. Later investigations into the incident suggested that the use of air-flush drilling techniques could have exacerbated the potential for the migration of the vapours and then explosion (see Reference [25]).

NOTE 3 Radon occurs naturally at varying concentrations in many parts of the world. It is commonly present in mine gas and can also be released from groundwater when it is extracted from the ground. It can also arise from deposited wastes such as those from the nuclear industry, phosphorus slags, and coal ash. Appropriate safety precautions are required when it is considered that radon could be encountered at high enough levels and for sufficient duration to pose a hazard. Radon exposure in the open air around a small diameter borehole is not likely to be significant.

Annex A
(informative)

Routes of exposure to hazard

A.1 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 could result.

Some chemicals are potentially carcinogenic, mutagenic and/or teratogenic through skin contact. Other chemicals are allergenic or sensitizing agents.

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 also 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 might clear up as a result of bathing, but particulate matter might cause scratching and solvents can cause permanent damage.

A.2 Exposure through ingestion

Contaminants from a site can be ingested by eating food, smoking, taking refreshment, or 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.

A.3 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 can 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.

Some people are allergic/sensitive to traces of some gases and are liable to collapse and require assistance if affected.

A.4 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, can present a particular hazard (see 7.8).

NOTE See also B.1.5.

A.5 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 when underground tanks are present can pose a hazard, particularly if some form of ignition is inadvertently provided.

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

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

A.6 Extreme weather conditions

Extreme weather conditions (e.g. very hot or cold climate) can present significant hazards that need to be taken into account when planning work and selecting protective equipment. Personnel might need protection against exposure to excessive UV.

NOTE 1 Even in fairly temperate climate, prolonged unprotected exposure to sun can be injurious. In addition, the risks of heat fatigue for those wearing heavy protective gear is enhanced.

NOTE 2 In addition to the direct effects of lows temperatures, wet or icy ground conditions increase the risk of injury due to slipping. Wet sticky conditions can make it difficult for workers to get out of the way of moving machinery.

NOTE 3 Dehydration is a particular hazard for those with pre-existing medical conditions such as diabetes.

Annex B
(informative)

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

B.1 General hazard

B.1.1 Hazards due to solid and liquid chemicals

Hazards due to solid and liquid chemicals might be very obvious (as in the case of chemicals remaining on a former industrial site) or might not be immediately apparent (for instance, in the case of pesticides in a field). When devising a safe method of investigation and sampling, both situations should be considered and appropriate precautions taken.

The hazard could 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.

B.1.2 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. In addition, some people are allergic/sensitive to traces of some gases and are liable to collapse and require assistance if affected.

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 and 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.

B.1.3 Hazards due to biological agents (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 might 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 could present and also taking precautions to prevent any adverse effects from them, however mild. One of the main causes of infection from soil is breaks in the skin.

Some biological hazards are not site-specific [e.g. tetanus (C*lostridium tetani*), *Clostridium difficile* and *Clostridium perfingens* (the main causative agent of Gangrene), typhoid (*typhus*) and Weil's disease (*Leptospira*)] and require appropriate general precautions in addition to any local prevention. *Clostridium* spores, like those of *Bacillus anthracis* can remain dormant in soil for many years.

Weil's disease (*Leptospira* jaundice) occurs as a result of contact with water which has been contaminated by rodent urine. The disease is notifiable (in some jurisdictions) and requires hospital treatment. It can quickly lead to kidney or liver failure which can be fatal (about one in 20 dies after infection). Symptoms appear about 3 to 20 days after exposure and are flu-like. Early diagnosis is essential — there is a specific blood test that can yield results in a few hours.

Any outdoor body of water might therefore be a source of hazard, as can areas where there has been a high rat population, for instance landfill sites. Weil's disease can be transmitted through breaks in the skin but the causative organism (*Leptospira*) can also penetrate the skin if it is softened by prolonged exposure to water. To reduce the risks, appropriate waterproof clothing should be worn, all injuries or skin lesions should be covered with waterproof plasters or similar, and food should not be eaten without first washing the hands.

Anthrax spores (*Bacillus anthracis*) can also present a hazard. These might be encountered, among other places, on sites associated with the tanning industry.

"Foot and mouth disease" (*Apthovirus picornaviridae*) is among animal diseases that can also sometimes affect humans.

In the tropics in particular, "jiggers" and hookworm can be spread by contact with infected soil.

NOTE See also B.2.4 with particular reference to agricultural sites.

B.1.4 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.

B.1.5 Hazards due to topography, etc.

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 could 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 might 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.

Personnel working at the base of slopes or cliff faces could be at risk from rock/soil falls/slides. Personnel must be fully vigilant of the condition of the feature, as well as works within the near vicinity which could promote instability prior to surveying or sampling the slope or face. Consultation should always be made with quarry managers and land owners prior to attending slopes/faces.

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 tall machinery (backhoe excavators, drilling rigs), which can short-circuit, causing electrocution.

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 high risk and 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, can undermine other services (e.g. gas and electricity) and the sides of excavations, and consequently sometimes site investigation personnel.

B.1.6 Hazards due to machines

Any machinery can be hazardous if not operated correctly with regard to the manufacturer's instructions and the safety requirements 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, particularly when using concrete-breakers and heavy machinery.

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.

All moving parts on machinery, especially drilling and boring equipment, shall be properly guarded.

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, and 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.

B.2 Particular hazards on agricultural sites

B.2.1 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.

Hazards can also arise due to use of farm buildings for non-agricultural purposes, e.g. when buildings are rented out for such activities as vehicle servicing and painting (see also ISO 18400-202[2)] and ISO 18400-205[2)]).

B.2.2 Hazards due to chemicals (see also B.1.1)

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,

2) Under preparation.

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 and soil amendment materials such as sewage sludge 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.

B.2.3 Hazards due to gases (see also B.1.2)

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 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.

B.2.4 Hazards due to biological agents (bacteria and viruses) (see also B.1.3)

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 about one year 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.

In some jurisdictions, “foot and mouth disease” (*Aphthovirus picornaviridae*) and other animal disease have been controlled by slaughter followed by burning and mass burial of carcases on agricultural land. Such pits present significant hazards. Not only could there be exposure to disease organism if they are disturbed but the ground could be unstable and hazardous gases being generated. In some jurisdictions, it is illegal to open such pits.

NOTE For guidance on the construction of burial pits, see Reference [6].

B.2.5 Hazards due to radiation (see also B.1.4)

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

B.2.6 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.

B.2.7 Hazards due to machines (see also B.1.6)

While there are few hazards involved when hand-tools are used provided these are of an appropriate size and weight for the operator, flints can be shattered by augers, picks, spades, etc. giving very sharp edges which are a distinct hazard.

Sampling for agricultural purposes is carried out in most cases using hand augers down to approximately 1,2 mbgl (though this can be increased in suitable ground by using extendable augers), or by a wheeled, or tracked vehicle with a mechanical auger or probe.

When hand-augering down to approximately 1,2 mbgl, there are usually few hazards when normal physical exertion is applied. The use of machines presents a greater hazard, since they could fall over and cause crushing if placed in an unstable situation, and carelessness or uncontrolled movement could result in similar injuries.

All moving parts on machinery, especially drilling and boring equipment, shall be properly guarded.

B.2.8 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 that could be at risk from the site works.

B.3 Particular hazards in contamination investigations

B.3.1 General

An essential preliminary to visiting a site, whether for reconnaissance or sampling, is the desk study (see ISO 18400-202). This will give some guidance on the chemical, physical and biological hazards which could be present; enable an appreciation of the problems these might cause and help to identify what precautionary measures are appropriate.

B.3.2 Hazards due to chemicals (see also B.1.1)

Knowledge of the former uses of the site will give some indication of the chemicals that might 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 and that many will have used hydrocarbon fuels.

B.3.3 Hazards due to gases (see also B.1.2)

Various toxic gases, including in particular hydrogen sulfide and hydrogen cyanide, might 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 deep 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 or an oxygen-deficient atmosphere.

Any excavation that is to be entered shall be properly shored by competent persons.

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 might 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 % to volume fraction in air).

B.3.4 Hazards due to biological causes (bacteria and viruses) (see also B.1.3)

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.

B.3.5 Hazards due to radiation (see also 7.6)

In addition to possible fall-out hazard as covered in B.1.4, it is also possible that the former industrial operations used radioactive material. Such usage or the possibility of such usage will usually be revealed by 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.

B.3.6 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 covers to inspection chambers and other covers which lack the strength to support the passage of pedestrian or machinery traffic.

Personnel entering old buildings should consider rooms entered as potential confined spaces. Closing doors can create a “confined space” where gases previously vented could build up creating a hazard to the personnel entering the room, as well as to other persons who might later enter the property.

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

B.3.7 Hazards due to topography

Hazards due to physical structures such as kerbs or foundations are normally self-evident but could 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 might not have been properly compacted and could be unstable.

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

B.3.8 Hazards due to machines (see also B.1.6)

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.

All moving parts on machinery, especially drilling and boring equipment, shall be properly guarded.

If a machine is used for breaking through obstructions, there is a hazard 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, can undermine other services (e.g. gas and electricity) and the sides of excavations, and consequently sometimes 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.

B.4 Hazards when sampling stockpiles

The same hazards are likely to be encountered when sampling stockpiles as when in other situations (see B.1 to B.3).

Where (large) stockpiles are part of the (industrial) activities, heavy mechanical equipment can pose an additional threat to the sampler. Operational personnel should be informed about the presence of the sampler on the site.

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

Annex C
(informative)

Example of risk assessment

Table C.1 — Driven probe sampling (windowless sampling)

Activity	Hazards	Whom at risk	Precautions and controls	Residual risk if precautions and controls are applied
Moving equipment	Incorrect lifting	Drilling staff	Comply with manual handling safety requirements Staff training Split loads if possible	Low
Boring and sampling	Incorrect handling of tooling and equipment Finger, hand and limb injuries	Drilling staff	Regular staff training Experienced operators All moving parts on equipment appropriately guarded	Low
	Sudden break or mal-function of equipment	Drilling staff	Regular inspection and servicing of equipment	Low
		Engineering supervising staff	To stay at reasonable distance from operating crew	Low
	Noise	Drilling staff Engineering staff	Wear appropriate ear protection	Low
Personnel movement	Tripping or falling	Drilling staff Engineering staff	Full awareness of site hazards Keep working areas tidy	Low

NOTE 1 The on-site work is being undertaken by a drilling contractor under the supervision of a consulting engineer. The risk assessment has been prepared jointly by the two organizations.

NOTE 2 Windowless sampling (Track mounted rig): The “windowless” sampling system drives an open-ended sampling tube into the ground using a drop-hammer system mounted on a small tracked drill rig. The sample diameter obtained typically ranges from 82 mm to 50 mm in size. The sample tube is provided with a disposable internal plastic sleeve which retains the soil sample for inspection and testing. Using extension drive rods, the sample tubes are used to form investigation boreholes to a typical depth of 5 m to 6 m, or to the depth capable of being reached by the sampling tools. The particular technique used is also capable of driving a temporary casing for hole support through unstable ground. This feature will be used as necessary to penetrate the anticipated superficial sand and gravel deposits.

The machine is petrol powered and uses a 63,5 kg hammer dropping through 0,75 m.

Some noise and vibration are inevitable with this equipment. Levels are commensurate with a small petrol engine and a 63,5 kg drop hammer.

NOTE 3 Table C.1 might also include an indication of the risks before precautions are taken and whether these are acceptable or need to be mitigated, thus providing a record of the decision making process.

NOTE 4 Risk assessments are usually signed and dated and referenced to the site to be investigated although they might make use of generic elements.

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