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Water quality — Sampling

Part 12: Guidance on sampling of bottom sediments from rivers, lakes and estuarine areas

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National foreword

This British Standard is the UK implementation of ISO 5667-12:2017. It supersedes BS 6068-6.12:1996, which is withdrawn.

The UK participation in its preparation was entrusted to Technical Committee EH/3/6, Sampling (of technical committee EH/3 - Water quality).

A list of organizations represented on this committee can be obtained on request to its secretary.

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Water quality — Sampling —

Part 12: **Guidance on sampling of bottom sediments from rivers, lakes and estuarine areas**

Qualité de l'eau — Échantillonnage —

Partie 12: Recommandations concernant l'échantillonnage des sédiments dans les rivières, les lacs et les estuaires

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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).

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For an explanation on the voluntary nature of standards, 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 147, *Water quality*, Subcommittee SC 6, *Sampling (general methods)*.

This second edition cancels and replaces the first edition (ISO 5667-12:1995), which has been technically revised.

A list of all parts in the ISO 5667 series can be found on the ISO website.

Introduction

This document should be read in conjunction with ISO 5667-1 and ISO 5667-15.

The general terminology used is in accordance with the various parts of ISO 6107, and more particularly, with the terminology on sampling given in ISO 6107-2.

Water quality — Sampling —

Part 12:
Guidance on sampling of bottom sediments from rivers, lakes and estuarine areas

1 Scope

This document provides guidance on the sampling of unconsolidated sediments for the determination of their geological, physical and chemical properties, as well as the determination of biological, microbiological and chemical properties at the water and sediment interface. Guidance on achieving sediment cores is given specifically for the measurement of rates of deposition and detailed strata delineation. The main emphasis of this document is to provide methods that achieve sediment samples.

The environments considered are

— limnic (rivers, streams and lakes, natural and man-made), and

— estuarine, including harbours.

Industrial and sewage works for sludges, paleolimnological sampling and sampling of open ocean sediments are specifically excluded from this document (and are addressed in ISO 5667-15), although some techniques may apply to these situations. Sampling of suspended solids is outside the scope of this document and reference can be made to ISO 5667-17 for such guidance.

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 5667-1, *Water quality — Sampling — Part 1: Guidance on the design of sampling programmes and sampling techniques*

ISO 5667-15, *Water quality — Sampling — Part 15: Guidance on the preservation and handling of sludge and sediment samples*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

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

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

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

3.1
composite sample
two or more samples or subsamples mixed together in appropriate known proportions, from which the average result of a designed characteristic may be obtained

Note 1 to entry: The individual portions may be derived from the same unit (stratum) or at the same sediment depth below a certain interface. The use of subsamples from the same stratum is limited to situations where a natural mixing of strata is unlikely to have occurred or where the depth of the sediment stratum is sufficient to allow subsampling without artificial mixing during sample operations. Therefore, subsampling from different strata is allowed in relation to the objective of the investigation.

3.2
pile-working core compression
blockage
phenomenon which occurs when the sample rising up the inside of a piston corer meets a resistance due to its own friction, a blockage by a large piece of stone, or the tube being full

3.3
descriptive mapping
description of the *sediment* (3.5) present in terms of its nature, variation and extent

Note 1 to entry: The exercise is carried out by precise marking of sample location and general recording of site conditions. Pre-established conditions may be a requirement of the exercise.

3.4
monitoring
establishment of variation of the *sediment* (3.5) characteristics with time and location

3.5
sediment
solid material, both mineral and organic, deposited in the bottom of a water body

3.6
sediment quality
chemical nature, as well as the physical properties of the *sediment* (3.5) being sampled, e.g. in relation to assessment of harbour sediment due to be dredged to determine disposal process

3.7
sampling site
sampling station
well-delimited area, where sampling operations take place

3.8
sampling point
precise position within a *sampling site* (3.7) from which samples are taken

3.9
uncertainty arising from sampling
part of the total uncertainty of a measured value attributable to sampling

3.10
unconsolidated sediments
sediments (3.5) that are loose so that individual particles are able to move easily relative to each other

4 Sampling strategy

4.1 General

Sampling of sediments from estuarine and inland water bodies can be completed to address the following:

— temporal and spatial monitoring of the environment;

— as part of environmental impact assessment informing future construction developments (e.g. increasing of harbour depth so that vessels can access harbours, and installation of renewable energy applications such as wind farms);

— sediment distribution mapping of an area to enable, for example, sediment transport or intrusion of fine inorganic particles and organic material to be determined;

— examining the sediment quality (physical and chemical) so, for example, sediment disposal method can be determined prior to dredging of harbours or rivers;

— spatial and temporal patterns of sediment-dwelling organisms;

— fundamental research.

4.2 Type of investigation

4.2.1 General

The sampling strategy will vary depending on the aims of the work being completed. Three common types of investigation can be distinguished:

a) chemical investigation;

b) physical investigation;

c) biological and microbiological investigation.

4.2.2 Chemical investigation

In this type of investigation, the nature and amounts of the substances which are bound to the sediment or are associated with pore water may be determined. Some chemical species become bonded in preference to small mineral particles and organic matter while some are incorporated in residual pore water. It should be noted that where the sampling device is made of metal then abrasion and chemical action, for example from sulfides and phosphates, may lead to specific contamination. In cases where sample equipment made from plastics are used, chemical residues may leach from the material into the sample, for example dispersants, or chemicals from the sediment may adsorb into the plastics. Quality control measures should be undertaken in full consultation with the receiving laboratory in order to establish the degree of influence of such effects on the survey results. Some study parameters (e.g. sulfides) may require to be maintained in an oxygen-free atmosphere. In such circumstances, storage and handling under an inert gas atmosphere may be needed. If it is necessary to maintain anaerobic conditions while handling samples, tools such as a glove box should be used. For samples whose measurements can be affected by exposure to oxygen, analysis should be performed as quickly as possible.

4.2.3 Physical investigation

In this type of investigation, the structure, texture, particle size and layer formation of the sediment bed are determined and the strata delineation is important for geographical, morphological and, in some cases, geotechnical investigations.

4.2.4 Biological and microbiological investigation

A biological investigation generally involves classifying the species and numbers of flora and/or fauna present on and in the sediment bed. In many cases, sampling is carried out in the habitat layer, with most species present in the top 10 cm. However, this might extend to several decimetres. For specific details regarding biological investigations, references should be made to specific ISO standards already in existence or under development, including ISO 16665 for methods involving quantitative sampling and sample processing of marine sub-bottom macrofauna and ISO 10870 for selection of sampling methods and devices for benthic macroinvertebrates in fresh waters. In some cases, microbial processes may also be of interest, such as denitrification, phosphate release, methylation of metals such as mercury or tin.

4.3 Choice of sampling site

In choosing the exact point from which samples are required, two aspects are generally involved:

a) the selection of the sampling site (e.g. the location of the sampling cross-section on the base of the seabed);

b) the identification of the precise point at the sampling site.

The purpose of sampling is often at a precisely defined sampling site (as is the case when studying deposition from a particular discharge point), but sometimes the purpose is only to lead to a general definition of the sampling site as in the characterization of the quality and type of material.

The choice of sampling sites for a single sampling station is usually relatively easy. For example, a monitoring station for a baseline record of sediment quality may be chosen to permit the use of a convenient bridge or to allow an upstream effluent discharge or tributary to be well mixed laterally before the station.

Remote sensing methods, such as use of echosounders, including multibeam, or side scan sonars, should be considered to assist in checking sediment bed status for rock, or other obstacles such as protected wrecks and unexploded ordnance, prior to sampling. Refer to EN 16260 for advice regarding completion of visual seabed surveys using remotely operated and/or towed observation gear for collection of environmental data.

To establish locations for sediment sampling, and to register the exact sampling point locations, it is recommended to use Global Positioning System (GPS) technology.

The criteria for sample site choice can include:

— the presence of good sedimentation conditions (e.g. reduced flow rate);

— ease of repeated access to the location, for example a tidal influence;

— seasonal accessibility;

— the influence of marine traffic;

— heterogeneity of the stream bed (roughness, particle size, etc.) across a river transect or within an area of interest.

4.4 Choice of sampling point

This will be influenced by physical constraints such as boat size or water depth but the precise point will largely depend upon the purpose of the investigation. For example, if descriptive sediment mapping is the sole purpose then choice may be the function of flow and current conditions only, whereas if chemical contamination is being studied, the sampling point will depend largely on the conditions present at the sediment bed.

NOTE For instance, it would not be expected to find contamination caused by anthropogenic metal inputs in a riffle area of a stream compared with a pool area.

Consideration of local conditions and features in the monitoring of harbours, such as proximity to outfalls, the influence of stream mixing and other factors such as plant growth, may be important. Further guidance is given in 4.7 and ISO 5667-1.

The choice of sampling point will be a desirable pre-qualification for the programme, but exact locations will inevitably be revised in the field. The number of sampling points required needs to be statistically representative relevant to address the purpose of the investigation. In rivers and estuaries, it needs to be considered that the sediments are turned over in several deposition and re-suspension cycles. Thus, the sediment layers may not be representative for historical deposition scenarios. In this case, age determination by radiological or limnological analysis is recommended. Statistical guidance is given in ISO 5667-1. Composite samples may be produced to reduce analysis costs and assist deriving average regional concentrations as indicated in 6.2. Because of the often patchy distribution of organisms, for biological samples, it could be necessary to choose multiple random sample sites or to conduct stratified random sampling[23].

4.5 Choice of sampling method

4.5.1 General

The choice of sampling method will largely be restricted by the two following factors:

a) the requirement for a largely undisturbed sample for delineation and the preservation of water and sediment interface (further details are given in Clause 5);

b) the acceptance of a disturbed sample taken near the bed surface for a general morphological or chemical examination.

Certain types of chemical parameter may necessitate the use of inert liners in piston or tube type recovery devices, for example polytetrafluoroethylene linings if low-level pesticides are being examined. Reference should be made to ISO 5667-15 for guidance on the preservation and handling of sediment samples.

The remaining factor affecting the choice of sampling method will be the applicability of the proposed device to the sediment bed conditions. Ideally, consistent sampling methods are used throughout the survey, although if sediment bed conditions vary within the area being sampled, this may not be possible. Sampling regimes are summarized in Table 1. More detail about samplers is given in Clause 5.

Table 1 — Sediment type and recommended sampler

Sediment type	Sampler[a]
Gravel	Grab systems; large particle size may require heavier grabs.
Sand	Both grab and corer systems can be used. A sand bed can be hard to penetrate and thus prove difficult for lightweight grabs and manually operated corer systems. Grabs of larger mass and heavy mechanical corers may be required.
Clay	It may be necessary to use a corer because grab systems often cannot penetrate easily into the clay.
Mud	Both grab and corer systems can be used but care should be taken to avoid over penetration (see 4.5.3).
Peat	A difficult medium to sample but it is sometimes possible to use a manually operated corer system or a special peat borer.

[a] Sampler type versus sediment type may have to be determined by experimentation.

4.5.2 Consolidated bottom sediment

For consolidated bottom sediment, both grab and corer systems can be used. If a grab is used, it may be difficult to determine the penetration depth of the sampling.

4.5.3 Unconsolidated bottom sediment

For unconsolidated bottom sediment, grab systems are not suitable as they are prone to sinking through the soft layer. Corer systems are better but, when a frame is used at greater depth, care is essential to prevent the frame from sinking through the soft layer. More support can usually be given to prevent this by adding large plates to the feet of the frame. Samplers which depend on the free-fall principle are not suitable for this bed type.

4.6 Frequency and time of sampling

Results from a sampling programme need to provide data with an acceptable uncertainty defined in the objectives of the programme. If the objectives do not include a definition of the tolerable error, a statistically-based sampling programme is impossible. It should be remembered that changes with time of sediment composition may require a much longer period of observation to detect than changes observed for water. For example, diurnal variation in concentration of metals may be detected in estuarine water but the respective sediments may only show fluctuation over a much longer sampling period. When using systematic sampling, it is essential to ensure that the frequency of sampling does not coincide with a natural cycle present in the system. In the case of sediments, this may be seasonal variation, yet it should also be considered that flow extremes, especially flooding, result in bed transport and altered sediment structure and lead to intrusion or washout of inorganic and organic fine material. It may be necessary to increase the sampling frequency in order to observe any variation in some cases, for example when monitoring pore water nutrients. The frequency of sediment sampling is only likely to have a major influence on the interpretation of results when rapid deposition rates are expected, for example weekly sampling of a river bed downstream of a discharge point is not likely to reveal any data that is different from that demonstrated from sampling at half yearly intervals other than the inherent variability of the sediment. The reasons for sampling are constrained by the needs of a particular project which will themselves define the frequency of sampling. For details of the application of statistics to sampling frequency, refer to ISO 5667-1.

4.7 Site conditions

4.7.1 General

Conditions at the sampling position are of vital importance to achieve correct sampling. A number of these conditions will usually be known before sampling takes place and should be taken into account when preparing the operation and also when choosing the apparatus to be employed.

The following conditions are important:

— meteorological and climatic (e.g. temperature, precipitation, solar radiation);

— hydrological (e.g. discharge, water depth, current, velocity);

— geological (e.g. characteristics/composition/stratification of sediments, erosion);

— nautical;

— biological (e.g. with reference to macrophyte accumulation).

4.7.2 Meteorological and climatic conditions

Temperature, wind direction and force can be restricting factors when carrying out sampling. For example, if the sampling location is situated in an area which is strongly affected by wave movements, then this should be taken into account when planning the operation and when using the apparatus. The restrictions related to climates are covered specifically for each type of instrument in the annexes.

In countries with cold climates, it may be practical to work on ice surfaces of lakes. However, safety should always be a priority and local regulations should apply. Equipment and samples can be protected from freezing in heated tents.

The need for sampling should be judged against the safety factors influenced by climatic conditions. In addition, storm conditions may disturb sediment beds so that sampling can become impractical or meaningless.

4.7.3 Hydrological conditions

4.7.3.1 Tidal areas

In tidal areas, attention should be paid to variations in the depth of water, current speeds and directions. Variable currents, in particular, are often a restrictive factor in the choice of apparatus to be used. Many instruments cannot be used where fast currents are present. Sampling using these instruments should be restricted, due to the effect on the sampling vessel, to periods of low flow rates.

Since the depth of water in tidal areas varies, it is often advisable to carry out sampling at low tide, for example on dried-out sandbanks, where manual sampling using conventional spades and similar tools is possible, giving due regard to relevant safety precautions. Each sampling occasion should be judged against local conditions and experience of local tides. With a budget supported sufficiently onboard, sampling at high tide could be considered at the expense of precise location and site observation in order to guarantee the safe field operation. In this case, sampling equipment should be adjusted with grab systems or a corer of heavier weight.

The sampling of tidal river beds and mud flats may be approached in a similar manner to that employed for the sampling of soil. Refer to ISO 18400-102.

4.7.3.2 Rivers

Account should be taken of high flow rates in rivers. If the project allows, it may be advisable to restrict sampling to periods of low water level with low flow rates, where sampling equipment is less likely to be affected. Other local hydrographical conditions may occur, for example the operation of locks, which will require investigation before sampling.

4.7.3.3 Standing bodies of water

In lakes, harbour areas and some sedimentation ponds, the currents are often negligible so that the hydrographical conditions have very little effect on the choice of sampling equipment. When choosing the equipment to be used, the water depth at the sampling point is important in all three water systems mentioned here. If the depth is less than 4 m, then manually operated equipment is advisable. At depths of greater than 4 m, sampling systems operated by lifting or guidance mechanisms are recommended because of possible vessel disturbance of the sediment surface layer. In the case of the grab systems, the size of the equipment will determine whether this can be manually operated or not. Further guidance is given in Table 2.

4.7.3.4 Geological conditions

The general nature of the sediment layer is important when choosing the apparatus to be employed. If no prior knowledge is available then it is advisable to carry out a preliminary investigation using geological maps, coastal charts, visual investigations, as well as remote sensing techniques, or even an inspection via diving, thus preventing many problems arising during the actual sampling. Recommendations for various combinations of sampler type and sediment bed material are summarized in Table 2 and Table 3.

4.7.3.5 Nautical conditions

Due to certain nautical conditions, it is not usually possible to carry out sediment sampling from an anchored vessel in harbour entrances or busy waterways. In these cases, the sampling equipment should be able to be used quickly to compensate for these conditions and hand-operated systems are preferable. In all cases, compliance with local safety regulations is essential.

4.7.3.6 Biological conditions

The use of all types of sampling device may be severely hindered by heavy macrophyte growth; on-site decisions will be constrained by the conditions found. Clearing an area with a dragline is worth trying before sampling, but it is not successful for all types of plant growth and it limits the sample to physical examination. Clearing stands of rooted macrophytes will cause disturbance of the sediment and water interface as well as the upper centimetres of the sediment. This may influence, for example, measurements of sediment pore water nutrient concentrations or sediment phosphorus fractions.

4.7.3.7 Statistical considerations

The design of sediment sampling programmes is project-specific and generalizations cannot be made. Some guidance is given in ISO 5667-1 and it is essential to consider prior to completion of programme to ensure results are robust and fit for purpose desired. The statistical interpretation of data obtained can be dealt with using the principles detailed in ISO 2602 and ISO 2854.

5 Sampling equipment

5.1 General

Sampling of bottom sediments can be broadly split into two methods: grab devices (see Table 2) and coring systems (see Table 3). Samplers presented focus on obtaining undisturbed sediment sample, mainly in finer sediment types. In the case of small depths, where an operator can enter directly on foot into the water, it is possible to use a scoop to collect sediment. If a scoop is used, care should be taken not to mix different layers of sediment.

When a grab system is not used, the criteria for selection of sampling apparatus may also be required to meet the following conditions:

— storage of the sediment in order to minimize changes from *in situ* conditions;

— allow the selection of a layer;

— allow sampling at the required water depth.

5.2 Grab systems

Many samples are collected using bed grabbers. The most well-known is the scissor grab, sometimes known as the van Veen type grab sampler. There are, however, a large number of variations. In general, grab systems consist of one or more hinged buckets which close as it is raised. During closing, sediment is enclosed by the buckets providing disturbed samples, especially for the van Veen grabber type. This can be avoided by using other grab systems, such as the Ekman type, which provides relatively undisturbed samples compared with van Veen type. Probe depths vary from 5 cm to several decimetres, depending upon the size and mass of the sampler and the structure of the bed material. Due to the grab construction, there is a large chance of losing part of the finer fraction and/or the top layer, although Ekman grab systems have shown to be less prone to such losses. Generally, grab systems are not suitable for sampling peat, clays or gravel beds in fast-flowing areas. Grabs are available in a variety of designs and examples are given in Table 2. Since generally all grab systems have the same sampling characteristics, only the van Veen type is described in detail in Annex A. Detailed operating instructions of grab systems are provided by the manufacturer.

Table 2 — Grab samplers

Type	Examples	Sampler penetration depth	Pore water sampling	Water depth (guide)	Accuracy of sample	Sediment type (geological conditions)	Nautical conditions
Manually operated grab (smaller versions of bucket grabs)	Hand-held van Veen grab, petite Ponar grab sampler, mini-Shipek sampler, Sediment snapper, Telescopic sample with stainless beaker	0 cm to 10 cm	No	0 m to 20 m	Need to make sure sampler is sampling perpendicular to the bed. Inaccuracies arise because of washing away of fine fractions.	Unconsolidated sediments (muds and sands); petite Ponar grab is good for sampling coarse and consolidated bottom sediments.	Both shallow and deep water and in areas of slow and fast currents. However, the construction and mass should be adapted to suit the conditions. For mechanical devices, it is recommended, that a secondary line carrying a marker float be attached as a security measure, in case the main line needs to be abandoned for safety reasons.
Mechanical bucket grab – hinged bucket/s that shut together when reaching sediment surface	van Veen (scissor grab) – see Annex A, Clamshell, Day grab, Smith MacIntyre grab, Birge-Ekman sampler, Ponar grab, Lafond and Deitz mud snapper grab	0 cm to 30 cm		5 m to 200 m	Relatively undisturbed sediments. Inaccuracies arise because of washing away of fine fractions.	Unconsolidated sediments (muds and sands); Ponar grab is good for sampling coarse and consolidated bottom sediments.	
Mechanical grab – bucket rotates under spring-loaded mechanism into the sediment upon reaching the sediment surface	Shipek grab	0 cm to 10 cm		5 m to 200 m		Unconsolidated sediments (muds; sands and gravels). Sensitive trigger mechanism – never pull out trapped particles directly.	

NOTE Additional equipment, which emulates or compliments the advantages of that discussed in this document, may also be available commercially. The scope for inclusion in future revisions will be considered at the appropriate time.

5.3 Corer systems

Sampling using a corer system depends on the principle of driving a hollow tube into the bed so that the sediment is pushed into it. A sample is obtained by pulling the tube out of the bed. This sampling principle is used in many different ways and there are a great variety of corer systems available as summarized in Table 3. It is possible to distinguish between systems in which the tube, where necessary extended by rods, is pushed into a bed manually and systems in which the tube is inserted by means of its weight or a vibration mechanism.

When using a boat, it is important that it remains stationary so that, when the core tube is pushed into the sediment, the vessel is not pushed away. There is a possibility of the vessel being moved against the rods by wind or currents. This should be prevented in order to avoid damage to the sampling equipment and boat.

A core cutter can be used to aid penetration of the corer into the sediment bed. Core catchers can be used to maintain retention of sediment when the core is retrieved from the sediment bed. However, they can disturb the sediments during sediment collection as the sediment passes through it.

Pile-working core compression or blockage can occur with corer systems. The amount of compression varies depending on factors such as the diameter of the tube, the composition of the bed and the penetration speed. It is difficult to judge when this phenomenon is recurring, as each location is different, and interpretations should be made with caution. The chance of “pile-working” is high in consolidated silt. In this case, the penetration depth is greater than the compressed strata depth of the sample in the core tube. This should be borne in mind during the sampling operation and when interpreting the core.

Evidence can be found by observing distortions in the strata indicating compression at the centre of the core and a lack of movement at the core periphery during sampling. In general, a concave appearance will predominate from the bottom of the sample up. The consequences of this occurring vary depending on the reason for occurrence and the end use of the sample. Stratification studies can be acutely hampered by this phenomenon. It is possible that the only way to overcome the problem may be to use a different technique, for example a core tube with a larger diameter. Lubrication of the inside of the sample tube should only be used with the agreement of the laboratory carrying out subsequent testing.

A cored sediment sample frequently requires dimensionally accurate subsampling in order to take full advantage of subsequent laboratory analysis and interpretation. Some sampling requirements may mean that division by slicing a core is carried out on-site before storage. The subsampling procedure should include the removal of the sediment proximal to the core barrel or liner. The extrusion device can be a simple piston or a variety of fixtures using a stationary vertical piston over which the core tube is placed; systems with a thread bar allow to slice a core more precisely. The extruded material can be sectioned with a device, which can be put on the top of the sampling tube. The cored sediment sample can be split longitudinally to show sediment horizons. The sample can be simply removed with a spoon or, if the sediment is solid enough, a spatula. The material of the corer or sectioning devices should be chosen so as not to conflict with any chemical analysis. Subsampling should target sediment in the centre of the core, away from the edges, to avoid contamination. If there are clear sediment horizons present, and these have been photographed and logged, it is possible to subsample each of these horizons rather than at regular intervals down the core.

Table 3 — Corer samplers

Type	Examples of sampling system and type	Sampler penetration depth	Pore water extraction possible	Water depth (guide)	Accuracy of sample	Sediment type (geological conditions)	Nautical conditions
Box corers	Ekman box corer, Reineck box corer, Nioz corer	0 cm to 50 cm	Yes	5 m to 200 m	Sediment can be subsampled by inserting core tubes into the sediment. Possible to collect undisturbed sediment with overlying water for microcosm experiments.	Soft sediments (muds, muddy sands, sands). Not gravelly or mixed sediments, especially if interested in pore water sampling.	Hand-operated devices are prone to nautical constraints such as fast flow or high winds in small boats. Mechanical devices can be used remotely from boats and are more suitable for use in rough weather. They are not recommended for use from bankside or bridges. The large weight and size of some of these corers require heavy-duty cranes and experienced operators, these corers are used on larger vessels.
Hand (push) corers	Hand corers, corer system involving a diver (see Annex C), Vrjwit drill or wedge corer (see Annex F), peat borer (see Annex K)	0 cm to 200 cm	No	0 m to 20 m	Relatively undisturbed – surface layers can be disturbed with standard corers. May be used to define sediment strata.	Peat borers have a specific application.	
Single-gravity corer featuring a core barrel penetrating the sediment by gravity	Gravity corer (see Annex G), Craib corer[a] (see Annex I), Jenkins mud sampler[a] (see Annex H), Kajak-Brinkhurst (K-B) corer, Phleger corer, Benthos gravity corer, Alpine Gravity corer, Limnos-segmented gravity corer (see Annex M), Slo-corer (modified gravity corer preserving sediment-water interface), Boomerang corer, Uwitec corer	Varied, depends on sampling system (0 m to 2 m)	No	5 m to 200 m		Soft sediments (muds, muddy sands, sands).	

Table 3 *(continued)*

Type	Examples of sampling system and type	Sampler penetration depth	Pore water extraction possible	Water depth (guide)	Accuracy of sample	Sediment type (geological conditions)	Nautical conditions
Multiple gravity corers, featuring two to four core barrels	Barnett multicorer, Bowers and Connelly mulitcorer, Benthos gravity triple corer	0 cm to 50 cm	No	5 m to 200 m		Soft sediments (muds, muddy sands, sands).	
Piston corers featuring a core barrel with a liner and piston for collecting cores up to 20 m and longer in deep water	Piston drill (see Annex B), Piston corer (see Annex J), Beeker core sampler[a] (see Annex D), sealed core sample (see Annex E), Livingston piston corer, Uwitec piston corer	Varies depending on specific model, up to 20 000 cm	No	5 m to 200 m		Suitable for use in sampling beds consisting of consolidated silt and/or in peat. It is not recommended where the sediment bed consists of fine sandy or silty material as there is a possibility that the sample will be lost from the bottom of the core tube because it is not closed off underneath.	
Vibracorers featuring a vibrating device and a stationary piston for collecting samples from hard clays, etc.	Vibracorer	0 cm to 600 cm	No	5 m to 200 m		Most sediment types. Not generally used for contamination studies.	
Freeze coring	Wedge freeze corer (see Annex L), “lollipop” freeze corer	0 cm to 200 cm	Yes	0 m to 1 000 m	Depth stratified sample.	Undisturbed sediments; (high) watery sediments.	Wedge freeze corers can be deployed from boat. Use of agents for freezing (e.g. dry ice, liquid nitrogen) require setting up of safety procedures.

[a] Rarely used corers.

NOTE Additional equipment, which emulates or complements the advantages of that discussed in this document, may also be available commercially. The scope for inclusion in future revisions will be considered at the appropriate time.

6 Sampling procedure

6.1 Sampling container materials and types

Polyethylene, polypropylene, polycarbonate and glass containers are recommended for most sampling situations, although glass jars have the advantage that the condition of their internal surface is easier to check visually as glass has smooth surfaces and they can be sterilized more easily than most plastic materials prior to use in microbiological sampling situations.

Glass containers should also be used when organic constituents are to be determined, whereas polyethylene containers are preferable for sampling those elements that are major constituents of glass (e.g. sodium, potassium, boron and silicon) and for sampling of trace metallic moieties (e.g. lead). Stainless steel containers maybe used to transport and store freeze cores in frozen condition. These containers should only be used if preliminary tests indicate acceptable levels of contamination for elements being considered. For analysis of light-sensitive substances, opaque glass jars, into which light cannot penetrate, may be useful.

If glass containers are used for storing sediments with pore waters which are weakly buffered, borosilicate rather than soda glass containers should be chosen. Special attention should also be paid to the material from which caps are made, which should be adapted to the parameters to be analysed.

Reference should always be made to both the standard analytical procedure for detailed guidance on the type of sample container to be used and the receiving laboratory. For guidance on container type and cleaning of sample containers, reference should be made to ISO 5667-15. In all cases, consultation with the receiving laboratory should be regarded as mandatory practice.

6.2 Composite samples

Depending on the aim of the investigation, in order to avoid conflicting results and obtain an average picture, a single composite sample per location can be prepared. For a large site, composite samples from at least two or three locations may be used to establish sample representativeness.

A composite sample consists of two or more single samples or subsamples and should be prepared as follows.

a) The individual single samples should be homogenized.

b) Equal volumes of each sample should be taken, combined and homogenized.

Subsamples from equivalent penetration depths should be used.

A composite sample should not be made from samples taken from sediments beds different in nature. The nature of the bed should always be visually checked first to ensure that the sediment beds are geologically compatible.

When samples have been taken by means of a core tube, the length of the sample will vary. In order to make a composite sample, it is preferable for the sample lengths to be the same. Therefore, the sample with the shortest length should be used.

When a grab system is used, the penetration depth can vary with each sample. Since this depth cannot be easily determined, such samples may not be suitable for making a composite sample. The sediment surface is checked to confirm undisturbed and washout has not occurred.

There is a high risk of contamination when making a composite sample. It is therefore recommended that this activity be carried out in a separate location, away from the area where the samples are taken, so that conditions are more easily controlled than, for example, on the deck of a small boat. Obvious foreign matter (e.g. pieces of wood, scrap metal, plastic parts) should be rejected in sampling. Depending on the task, it may be advisable in these cases to discard the sample and to take a new sample (e.g. parts of scrap metal by analysis of heavy metals). If, while sampling, water is taken, the overlaying clear water should be separated. Handling which could cause a change in the sample (e.g. changing the water content, liberation of volatile substances, oxidation of sulfide or organic constituents) should be kept to a minimum. Individual samples for a variety of analyses should be divided on-site, according to the purpose of the investigation, into suitable sample containers.

Preparation of composite samples should be undertaken with the use of nitrile gloves.

7 Storage, transport and stabilization of samples

In practice, it has become apparent that every project or investigation sets its own particular demands in the field of sample treatment. The investigation plan prepared for the field sampling should include a section on the treatment of the samples. This plan should take account of the particular aim of the project and the requirements for sample treatment given by the receiving analyst. This plan should also include details of requirements for sample transportation.

When transferring samples from the collection equipment to the storage container, care should be taken to ensure the continuance of *in situ* conditions, if appropriate to the planned analysis. The maintenance of anaerobic conditions will, to a large extent, depend on the equipment being used. A practice run may be found useful to refine any techniques developed. In addition, if trace organics are to be studied, the use of some plastic implements during subsampling may contribute to interference. Similarly, the use of a metal spatula should be avoided if trace metals are of interest. The type and composition of sample transfer tools should be noted in the field report.

Under certain circumstances, it may be appropriate to remove macroinvertebrates from a sample where decay may occur and bias the results of the tests.

Sediment samples should generally be stored and transported in accordance with ISO 5667-15. Freeze cores should be transported in frozen condition (below −20 °C in a battery-powered freezer or in a portable nitrogen vapour freezer). If it is necessary to keep them longer than 1 month, this should be done in a deep-freezer giving due regard to the physicochemical changes that can affect colloids on freezing. For example, changes in de-watering characteristics may be observed when specific laboratory sample preparations are used. Sediments for microbiological analysis need not be frozen in order of the disturbance of the microbes community. There may be a requirement for composite sampling when

— baseline data after dredging are required, and

— an estimate of sediment quality is required in order to describe level of contamination and therefore how it can be disposed after dredging.

Changes in stratification can be avoided if frozen cores are divided before thawing. This can be done on-site or in the laboratory. In all cases, sample containers should be delivered to the laboratory tightly sealed and protected from excessive heat and where necessary, light, because the sample may change rapidly due to gas exchange, chemical reactions and the metabolism of organisms. The build-up of gas pressures in the sample container, due to anaerobic digestion, should not be overlooked and it may therefore be necessary periodically to release pressure from the container. This may become necessary if temperature regulation cannot be provided in warm climates. If freezing the sample is chosen as the preferred method of preservation, as defined by the sampling programme and specified analytical method, notice should be taken of the following. When various items are analysed, care should be taken of those in which thawing frozen sediment samples could affect measurement values.

a) It is essential for the sample to be completely thawed before use, as the freezing process may have the effect of concentrating some components in the pore water of the inner part of the sample which substantially freezes last. The freezing of samples can lead to a loss of material of interest from pore water solution by absorption/adsorption on the precipitating compounds (e.g. calcium phosphate and sulfate). When the sample thaws, dissolution may be incomplete and thus erroneous results for pore water parameters, such as phosphates, may be produced.

b) Chemical preservation techniques should only be used after careful assessment of the project needs, the requirements of the analytical method and with the specific guidance of the receiving laboratory on the techniques required for homogenization of the sample with the preservative. For example, mineral acid may be added in an attempt to arrest or inhibit anaerobic digestion of organic matter if a study of organic acids is being made. Therefore, separate subsamples may be required prior to freezing. Additional guidance can be found in ISO 5667-15 and will depend on specific project needs.

All preservation steps should be recorded in a field report and the temperature measured and recorded on-site. If appropriate, other physical and chemical parameters (e.g. description, pH, redox potential) should be determined on-site or as soon as possible after sample collection.

Further guidance on the handling and storage of aerobic samples may be found in ISO 18400-102.

Performing a site sieving immediately after the elaboration of the composite sample may be appropriate, for example to ensure the availability of sufficient quantity of exploitable sample (i.e. with sufficient amount of small size particles, for example when sampling from riffles).

8 Safety

WARNING — Where there is a risk of drowning, single-person sampling should not take place and appropriate safety measures should be applied, e.g. use of life jackets. Special caution should be taken around waterfalls, strong currents and deep waters. To access deep-water locations, use safer means such as boats, rather than entering the water directly. A life jacket needs to be worn in all cases when working on boats.

For general safety precautions, refer to ISO 5667-1. However, particular attention should be paid to the following safety aspects.

Safe access to routine sampling sites in all weathers is particularly important; failure to satisfy this criterion will normally rule out a given site, even where it is preferred from the point of view of satisfying the technical objectives of the sampling programme.

In swamps and shallow waters, some safety benefit may be gained if the ground is frozen. However, caution should always be exercised and the durability of frozen surfaces assessed. When samples are to be taken by wading into a river or stream, account should be taken of the possible presence of soft mud, quicksand, deep holes and swift currents. A wading rod or similar probing instrument is essential to ensure safe wading. By probing ahead, the person sampling can estimate the current and locate holes, benches, soft mud and quicksand. If in doubt, a safety line should be attached to a secure object on the bank or shore for support. The increased volume of chest waders (as compared with thigh waders) can be an impairment to rescue should total immersion occur.

It should be recognized that there may be chemical, bacteriological, virological and zoological hazards in many aquatic sampling situations.

The use of nitrile gloves is necessary in order to prevent chemical and/or microbiological hazards.

9 Sample identification and records

When a sample has been collected, a number of steps should be taken before it is sent to the laboratory for analysis in order to achieve as good an interpretation of the analytical results as possible. The sample and its location should first be described and this report should be made as soon as the sample has been obtained. An example of the type of form, which is recommended, is given in Table 4 (see ISO 5667-6).

Table 4 — Example of a sample report form

Example: Ohio EPA Sediment Data Collection Sheet
Project:____
Collection date:______________________ Collection time:_________________
Collector(s):____
Weather conditions: ____
Sample location description (provide diagram of sampling location(s) on opposite side):
Waterbody name: ______________________________
River mile location: _______________
Lake location: _______________
Pond location: _______________
Latitude: ______________________________
Longitude: ______________________________
Sample site description: ____
Ambient site information (water):
Conductivity ______________
Dissolved oxygen ________________
pH _____________
Temperature ______________
Current velocity ________________
Sediment collection information:
Water depth above sample: ______________
Sediment sample depth: ____________________
Collection device: Scoop ______ Ekman dredge ______ Corer ______ Other ______
Sample type: grab ______ Composite: ______
Sample replicate collected? YES or NO Sample duplicate collected? YES or NO
Replicate ID/name: ______________________
Duplicate ID/name: ________________________
Sample information: ______________
Sediment pH (undisturbed) ____________
Sediment pH (post-homogenization) ___________
Colour (Munsell soil colour chart number): _______________________________
Texture (particle size description): _____________________________________
Odour: ____
Sample photograph identification ____________________________
Information on sediment components (seashells, animals, peat, wood, tar, stones, waste, plastics, etc.) ____
Additional comments: ____

Annex A
(informative)

Description of the scissor-grab system (van Veen type)

A.1 Apparatus

See Figure A.1.

The system consists of two open-topped mutually hinged buckets which close while the sample is being taken. The opened grab is placed overboard. When the bed is reached, a catch is released (usually under gravity) so that the buckets can be shut. When this happens, a surface sample of sediment is collected. Small models can be operated manually without requiring a winch.

A.2 Types in use

Several types of scissor grab are in use; their main difference is the mass (1 kg to 100 kg) and capacity of the buckets (0,5 l to 25 l). Most grabs are manufactured from galvanized or stainless steel. Modifications for various purposes have been made such as:

a) addition of a top valve for sampling the surface of the sample;

b) side walls to prevent the top layer being washed out;

c) extra weights.

A.3 Method of operation

The grab is locked into an open position and then lowered into the water by means of a davit and winch or manually depending on its size. The locking device is released on contact with the bed. The grab then shuts itself as it is raised and while this happens, sample material is collected in the buckets. The grab is placed in a receiving tray on the deck to allow the sample to be dealt with, for example by tipping it into the collection bin or by subsampling via top valves. The way in which samples are taken from the collected material depends on the aim of the investigation and should be recorded in the sampling report. After cleansing by brushing or with a high pressure hose, the grab can be prepared for the next sample.

A.4 Screen top sediment sampler

The screen top sediment sampler differs from the conventional grab in that it has two plates on the side which shut off the opening between the hinged buckets so that no sediment can escape. (Sediment can escape through the sides while shutting the buckets of the scissor-grab type.)

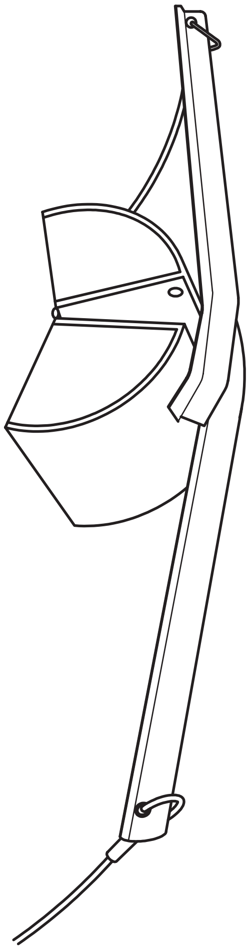


Figure A.1 — Scissor grab

Annex B
(informative)

Description of the piston drill system

B.1 Apparatus

See Figure B.1.

A tube, of stainless steel, or occasionally (transparent) plastics containing a piston is pushed into the bed. The piston is withdrawn while inserting the tube in the bed, which allows the sediment to enter the tube more easily.

B.2 Nature of the sample

In general, all samples will be somewhat compressed due to the influence of pile-working.

B.3 Location conditions

The use of extension rods allows accurate working from the bank in water up to 3 m deep. Samples can also be taken from a well-anchored vessel in water up to a maximum of 3 m deep.

B.4 Nautical conditions

When working from a vessel, there is always a possibility that wind or current will push the vessel up against the piston drill rods. This will affect the accuracy of the sampling and may compromise operator safety.

B.5 Method of operation

The depth of water at the sampling site is determined. The required number of extension rods are then fixed to the core tube. The core tube is then lowered to the sediment bed and the rod attached to the piston is fastened or held tightly. The core tube is pushed in as far as required. Pressure under the piston is reduced by lifting, which will reduce pile-working to some extent, so that the material can enter the core tube more easily. When withdrawing the core tube, the piston needs to be held in the same relative position within the tube in order to retain the sample. The piston can be used to push out the contents of the tube after which the pediment can be subsampled.

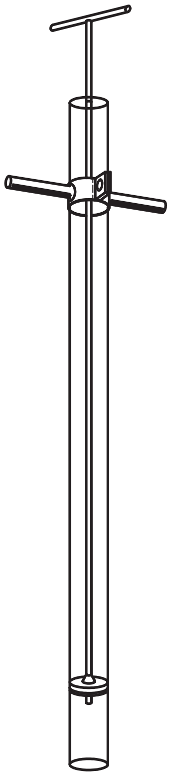


Figure B.1 — Piston drill

Annex C
(informative)

Description of the corer system involving a diver

C.1 General

Facilities for diving and experienced divers are necessary. A plastics core tube is pushed into the bed by a diver. If necessary, a pump is used to reduce the pressure in the tube so that the sample experiences less resistance when entering the tube.

C.2 Apparatus

C.2.1 Core tube, made of clear plastic, with decimal gradation. External diameter: 70 mm and internal diameter: 66 mm. The tube can vary in length from 1 m to 3 m. The material used for the tube may also vary in wall thickness and in composition.

C.2.2 Adjustable handle, with quick shutting clamp.

C.2.3 Rubber stoppers, for core tube.

C.2.4 Geared pump, operated by an electric or petrol motor.

C.2.5 Vacuum pump hose.

C.3 Nautical conditions

WARNING — At all times, when it is necessary to use a diver to operate equipment, consideration should be given to good diving safety practice and in particular to the need for decompression requirements.

The surroundings should allow diving. Restricting factors include current speeds, wave and shipping movements and clarity of water. In certain locations, possible hazards may arise from sharks, etc.

C.4 Method of operation

The core tube (C.2.1) is pushed into the water sediment bed at the sample site by the diver. If the resistance to this is too great, the diver may fit the vacuum pump hose (C.2.5). Reduced pressure provided by the pump (C.2.4) on board the vessel or bank allows the diver to insert the core tube more easily. To do this, the diver turns or vibrates the tube using the handle (C.2.2). When the desired penetration has been reached, the valve to the pump is closed, the tube is withdrawn and closed off underneath with a stopper (C.2.3).

Annex D
(informative)

Description of the Beeker sampler system

D.1 Apparatus

See Figure D.1.

The Beeker sampler consists of a cutter head fitted to a transparent polyvinylchloride (PVC) tube which is forced into the sediment by means of extension rods or a frame construction. A piston in the core tube causes the pressure in the tube to be reduced so that the sample can slide into the plastic sample tube more easily. When the core tube has penetrated to the required depth, a rubber gland in the cutter head is blown up so that the bottom is closed off. The sample tube can then be withdrawn; the tube removed and closed. The sample is now ready for transport or for the preparation of a description and subsamples. It can be used either with extension rods or in a frame. The sample tube lengths can vary by up to 2 m. The dimensions are summarized in Table D.1.

Table D.1 — Dimensions of the Beeker Sampler

Type	Dimensions	Mass kg	Sampling depth m
Beeker sampler with extension rods	Length: 2 m to 6 m Internal diameter of tube: 63 mm	5 to 15	Up to 2
Beeker sampler in a frame	Height: 1,80 m Base: 2,00 m Internal diameter of tube: 63 mm	50 to 100	Up to 2

D.2 Application

The Beeker sampler is suitable for physical, chemical and limited biological investigations.

The use of a transparent tube allows a description of the sample to be made, for a limited morphological investigation. The PVC tube can, if desired, be replaced by a thin-walled stainless steel tube when a chemical investigation is being carried out in order to avoid interference by the plastics and associated materials. The Beeker sampler can be used with extension rods from the bank or from a vessel. Sampling in this manner is difficult at water depths greater than 3 m.

The Beeker sampler in the frame requires the use of a lift or davit with a lifting capacity of 150 kg. When working from a vessel, the deck space needs to be big enough for the frame, an equilateral triangle of sides 2 m, and the lift height sufficient for a frame 1,80 m high.

D.3 Type of bed

The sampler is suitable for unconsolidated and consolidated silt beds.

D.4 Accuracy of sample

It is possible to obtain an almost undisturbed sample by using the piston and, at greater depths, the frame as well.

D.5 Nautical conditions

When working with extension rods, any vessel needs to be stationary in calm conditions. Due to its light weight, the Beeker sampler in a frame is affected by currents, particularly at great depth, and cannot be used where the current speed is greater than 50 cm/s.

The vessel needs to remain stationary so that the lift remains above the sampling position; otherwise, the core tube could break when it is raised. Too much wave movement makes it difficult to collect an undisturbed sample and could make working from a vessel dangerous. The Beeker sampler is thus best suited for in land or very shallow waters.

D.6 Sediment conditions

The Beeker sampler with extension rods is suitable for soft sediment beds. Due to the vessel movement, it is difficult to sample a top layer without disturbance at water depths of 3 m. The Beeker sampler in the frame can be used at much greater depths. By using an echo-sounder attached to a guide box, a controlled sample of the top layer can also be obtained. It does not sink into soft beds due to its large bottom plate and the relatively light weight of the frame. The piston, which is attached to the frame, can then reduce pressure in the tube at the same time as this penetrates the bed. The Beeker sampler is less suitable for sand beds.

D.7 Methods of operation

D.7.1 Use of the Beeker sampler with extension rods

The sample tube is clamped between the sample tube holder and the cutter head. The depth of water at the sample location is determined and the required number of extension rods fixed to the core tube. The rubber gland in the cutter head is evacuated so that it lies against the inside of the cutter head. The core tube is lowered to just above the sediment. The piston in the core is arranged so that, when the tube is pushed into the sediment bed, the pressure in the tube is reduced. The sample can now enter the tube easily.

When the tube has reached the required depth, the rubber gland in the cutter head is inflated so that the sample cannot slide out of the tube. The Beeker sampler is then withdrawn. The sample tube is then removed and sealed underneath with a stopper. The top is already sealed by the piston. The sample is now ready for transport or further treatment.

D.7.2 Use of the Beeker sampler in a frame

The frame is set up to the required height for the length of sample tube to be used. The echo-sounder (if available) is mounted onto the guide box. The sample tube is clamped between the cutter head and the sample tube holder and fixed to the guide box in the frame. The piston at the bottom of the tube is fixed to the frame with a steel wire. A pump is used to evacuate the rubber gland so that it lies against the inside of the cutter head. The frame is lowered into the water, to just above the bottom, with the help of the echo-sounder. The sampler is set on the bed gently and the line let out further so that the core tube penetrates the bed.

The piston attached to the frame causes reduced pressure in the tube so that the sample slides into it easily. The tube is pushed into the bed because the guide box is weighted in accordance with how deep the penetration is to be. It is also possible to attach a vibration motor inside the guide box to use vibrations to lessen the tendency of the sediment to stick to the tube, thus making it easier to push in the core tube. The echo-sounder may be used to determine the penetration depth.

When the tube has reached the required depth, the rubber gland in the cutter head is inflated so that the sample cannot slide out of the tube. The Beeker sampler is then raised. The core tube is removed from the guide box. The sample tube is then removed and sealed underneath with a stopper. The top is already sealed by the piston. The sample is now ready for transport or further treatment.

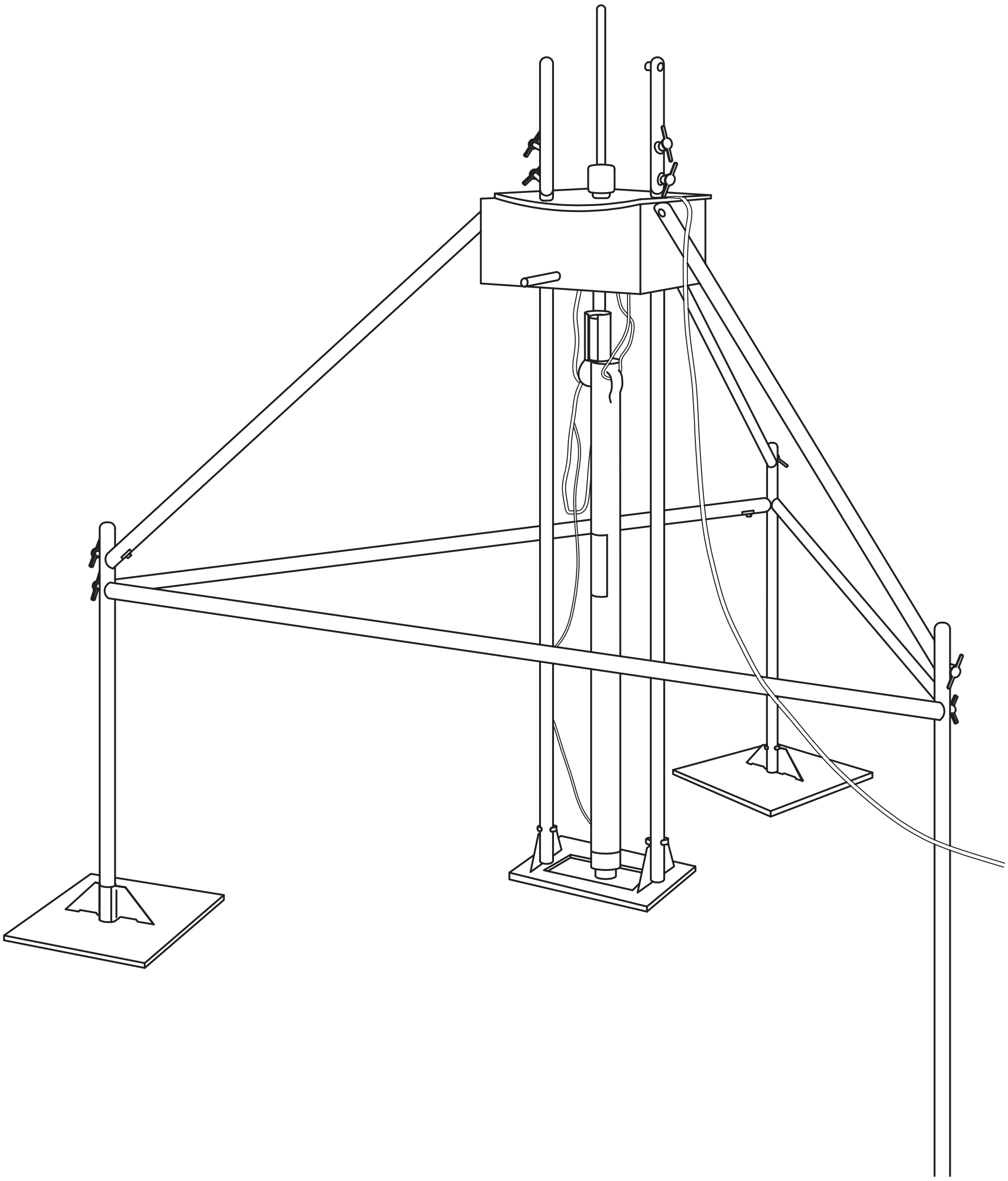


Figure D.1 — Beeker sampler

Annex E
(informative)

Description of the sealed core sampler system

E.1 Apparatus

See Figure E.1.

The sampler consists of a stainless steel tube with a polymethyl methacrylate liner. The top and bottom of the core tube can be shut off with a rubber bellows so that the sample cannot fall out and also cannot be disturbed at the top.

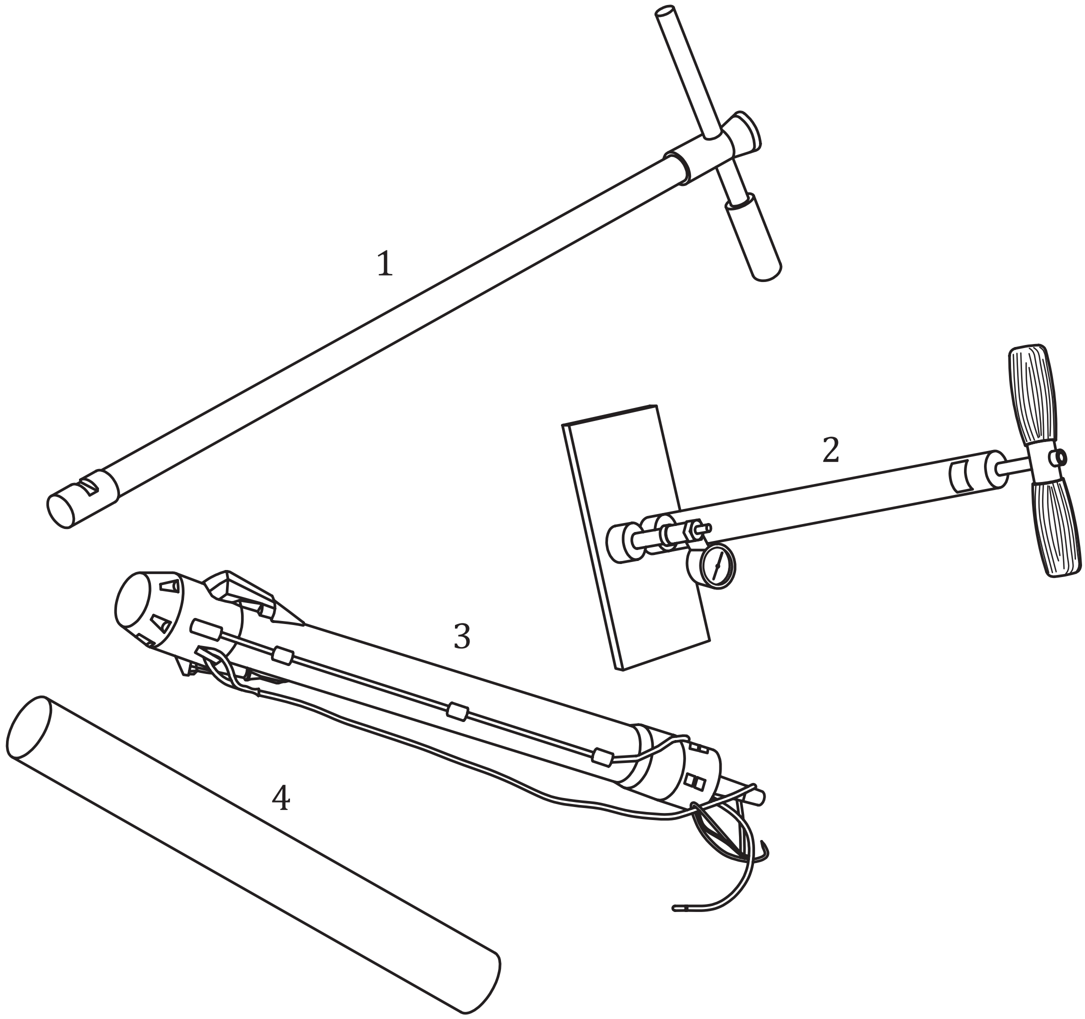
The core tube is pushed into the bed by means of rods; the rubber bellows are opened and closed by inflating or deflating with a manually operated pump. There is only one type in use, the following are its dimensions:

length:	700 mm;
diameter:	nominally 58 mm, but may vary;
mass:	approximately 15 kg;
penetration:	600 mm.

E.2 Method of operation

The depth of water at the sampling position should be determined and the appropriate number of rods fitted. The tube is lowered to the bed with the rubber bellows at the top and bottom evacuated. After the desired or maximum possible penetration has been achieved, the rubber bellows are inflated, shutting off the core tube at the top and bottom. It is then withdrawn. The cutter head containing the rubber bellows is removed, allowing the polymethyl methacrylate liner containing the sediment to be taken out of the core tube.

The sediment is extruded from the top, allowing the sample to be analysed layer by layer from the top.



Key

1 push rod
2 manually operated pressurization pump
3 core tube (incorporating rubber bellows)
4 polymethyl methacrylate core liner

Figure E.1 — Sealed core sampler

Annex F
(informative)

Description of the wedge core or Vrijwit drill system

F.1 Apparatus

See Figure F.1.

The Vrijwit drill is a wedge-shaped, stainless steel core tube. The tube can be opened on one side with a slider. The opened drill is pushed into the bed by means of extension rods. Because one side of the wedge remains open when it is pushed into the sediment, there is a little friction on the surrounding material, thus reducing the tendency of compaction when collecting the sample. When the desired penetration depth has been reached, the Vrijwit drill is shut off with the slider. This can be removed after the tube has been raised, allowing the sample to be taken out. There are a variety of types in use with penetration depths up to 1,5 m.

F.2 Method of operation

The water depth at the sampling position should be determined and the required number of extension rods attached to the core tube. The tube is then pushed into the bed to the required depth and the slider is pushed down with extension rods so that the sample is enclosed in the wedge. The drill is raised and laid horizontally on a receiving tray. The slider is removed and the sample is available for a description and subsampling as required.

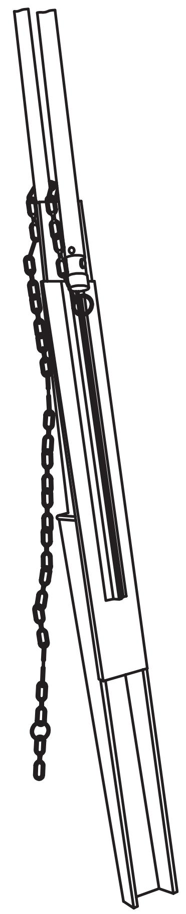


Figure F.1 — Vrijwit drill

Annex G
(informative)

Description of the gravity corer system

G.1 Apparatus

See Figure G.1.

The falling bomb consists of a graduated polymethyl methacrylate sample tube fitted in a weighted tube holder which is dropped in free fall from a davit on a vessel. Due to its own weight and speed, the sample tube penetrates the bed. The apparatus is then withdrawn and a rubber ball shuts off the tube from above. Formation of a vacuum in ascent prevents material from falling out of the bottom. Once the tube is above the water level, the vacuum is released by raising the rubber ball slightly and the sample can be collected in an appropriate container after first siphoning off water held above the sediment.

There are various types which differ largely in the length and diameter of the core tube as well as their total weight.

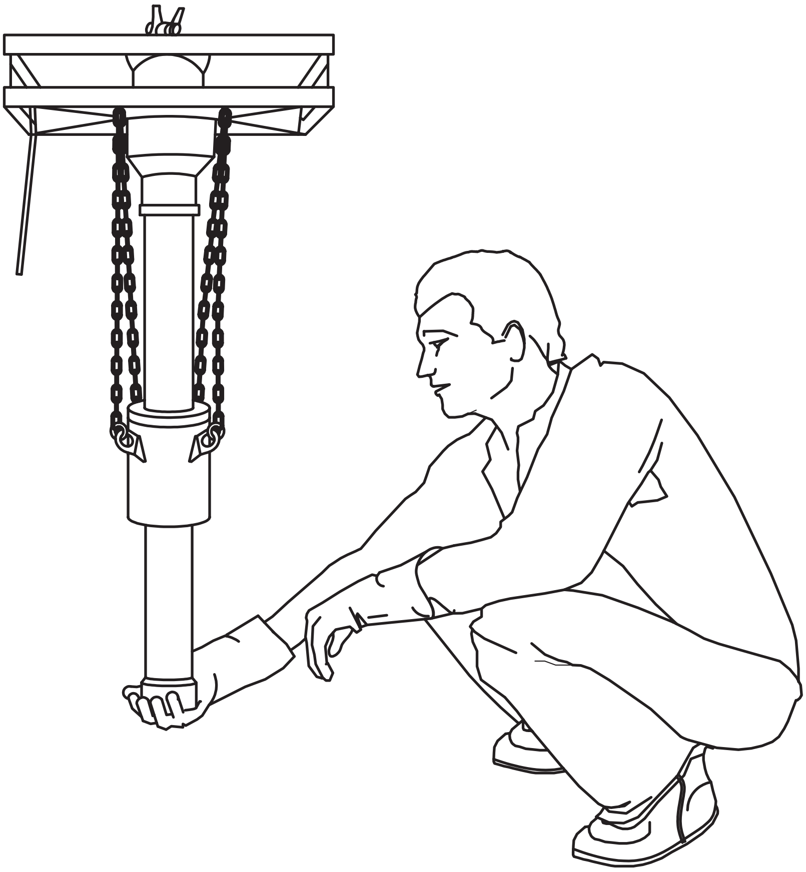


Figure G.1 — Gravity corer

G.2 Application

The falling bomb can be used for physical, chemical, and limited biological investigations in the top layer of the sediment.

G.3 Type of sediment bed

To make the best use of the falling bomb, the sediment bed should ideally consist of a mixture of sand and silt, possibly with some organic matter. Due to its limited penetration, the falling bomb is not suitable for coarse, sandy or gravel beds or hard sand beds. Where the sediment bed is not properly consolidated, problems with interpretation of the results can arise because of disturbance of the top layer on impact.

G.4 Accuracy of sampling

With the exception of very soft beds, sampling with minimal disturbance of the layer structure is possible. It should be noted that penetration of the bed is not always equal to the length of the sample in the core tube due to compression and angle of attack.

G.5 Operation

The vessel needs to be fitted with a davit and preferably a free-fall winch. It is also possible to work manually but a pulley system for lifting will be a minimal requirement; only a small working space on deck is required for the falling bomb and its sample tubes.

G.6 Nautical conditions

The falling bomb can be used for sampling sediment layers with a penetration depth up to 2 m in areas where the depth of water is 3 m. Where the difficulty of holding the vessel stationary makes the use of other systems difficult, this technique can prove a useful alternative.

G.7 Method of operation

The falling bomb is held in a davit and allowed to fall freely into the sediment bed. It is then raised at once and brought back on deck. While this is done, it may be necessary for someone to hold their hand underneath the tube to prevent the sample from dropping out.

Next, the water above the sample can be sucked with a small pump or syphoned away, taking into account relevant safety precautions. This needs to be done very carefully, particularly if the water is very turbid, to prevent solids being removed. In such cases, it is recommended to wait until the solids have settled and that a consistent procedure be adopted.

The layer strata of the sample in the polymethyl methacrylate core tube can then be described prior to subsampling and any further treatment.

Annex H
(informative)

Description of the Jenkins mud sampler system

H.1 Apparatus

See Figure H.1.

The Jenkins mud sampler consists of a metal stand supporting a sample tube. The sample tube can be shut off at both ends by valves. The valves and their closing mechanism are made from aluminium while the stand is steel. The valves are covered with rubber to ensure that a proper seal is made. The sample tube is 50 cm long and made from polymethyl methacrylate. The stand is in the form of a pyramid, of base 70 cm and height 90 cm. The total mass is 15 kg. The frame and core tube penetrate into the sediment due to their weight.

H.2 Operation

Due to its relatively light weight, the apparatus can be operated manually or with a davit from the bank or vessel. Only a small working space on deck is necessary for operating this apparatus.

H.3 Nautical conditions

When working from a vessel, the conditions should be calm to ensure that the samples are undisturbed and that the work can be carried out safely.

H.4 Method of operation

A tube together with the valves is mounted in the frame. The valves are locked open mechanically and fixed by springs. The water depth is determined and the sampler set carefully on the water bed. The core tube penetrates into the bed due to its weight. When the line is slackened sufficiently, the valves are gently closed by means of the mechanical arms which are operated by a hydraulic “brake” cylinder. The sample can now be recovered for transport or treatment.

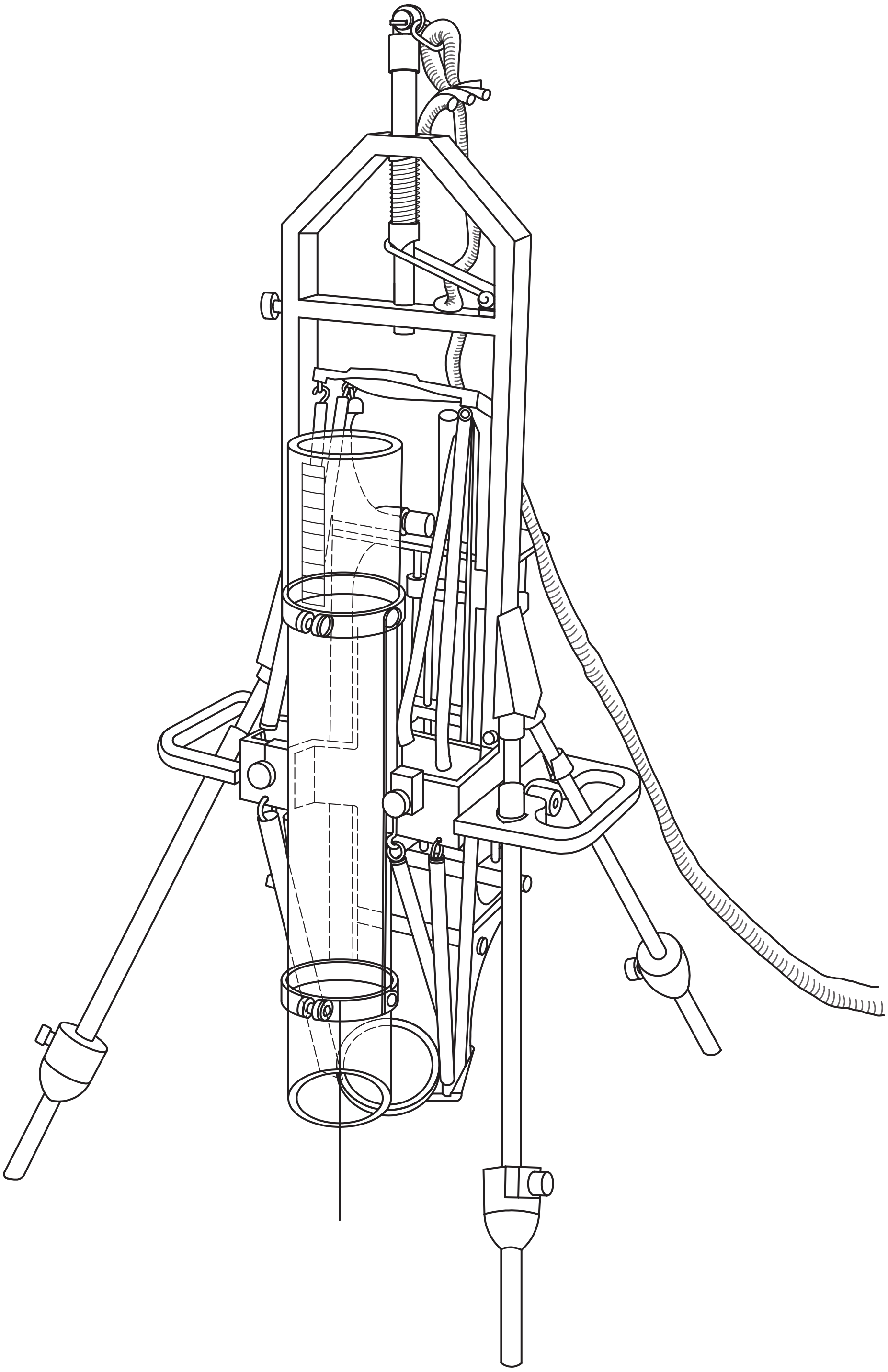


Figure H.1 — Jenkins mud sampler

Annex I
(informative)

Description of the Craib corer system

I.1 Apparatus

See Figure I.1.

The Craib corer consists of a corer which is free to move within a frame and has exchangeable, plastic core tubes. The corer is made from brass and the frame is galvanized.

I.2 Application

The Craib corer can be used for physical, chemical and limited biological investigations. Its only limitations are the diameter and length of the samples. The top layer remains undisturbed. A davit with a minimum lifting capacity of 150 kg is necessary.

NOTE Brass fittings can contribute to contamination of the samples by topper and zinc.

I.3 Nautical conditions

It is not advisable to work with a Craib corer from the deck of a tossing vessel. Not only is it unsafe but it is also not possible to control the placing of the apparatus on the sediment bed. If the current is strong, the Craib corer will hang crookedly. Therefore, lowering to the sediment bed should be done carefully and it may be necessary to choose an alternative sampling location.

I.4 Sediment bed conditions

The Craib corer does not work well on a very soft bed as the frame also penetrates it. Modifications to the frame can prevent this to some extent. There is little penetration of the frame into hard beds.

I.5 Method of operation

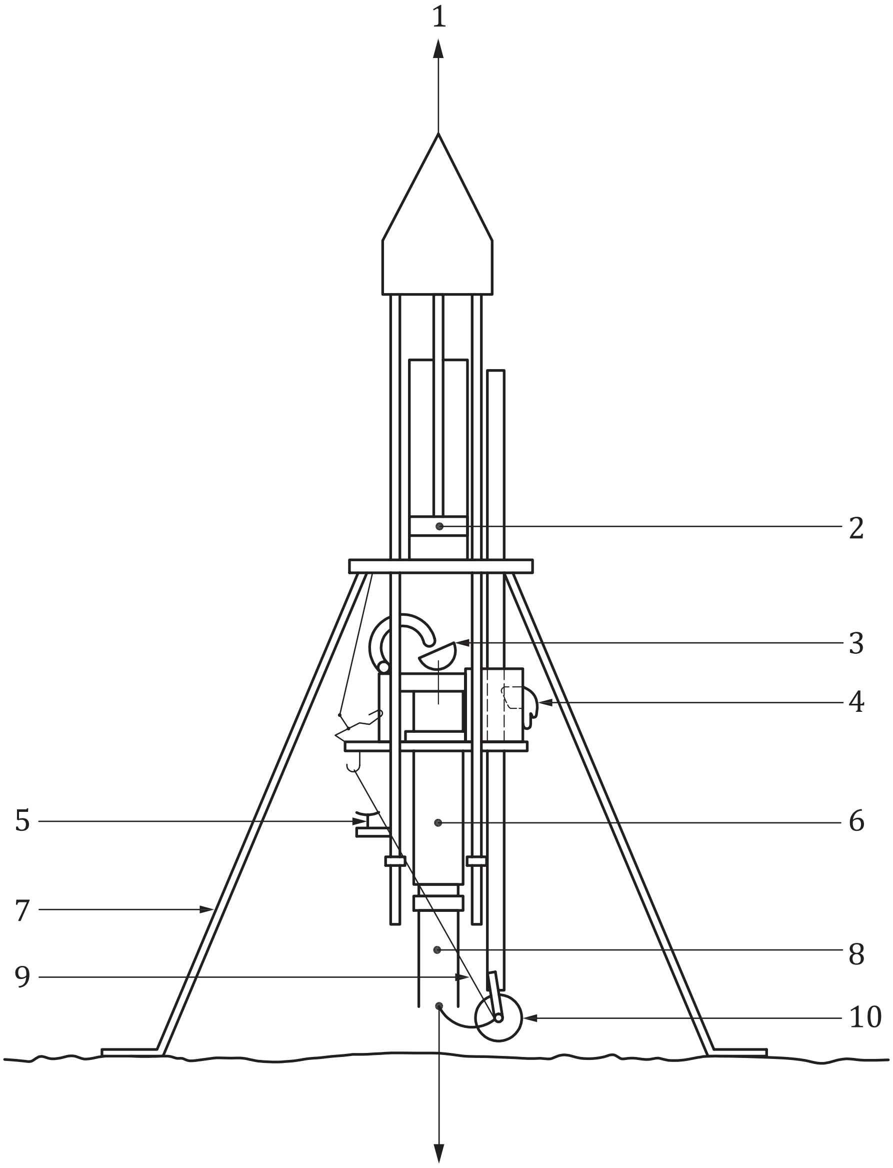
Once the corer has been prepared, the piston in the hydraulic damper is at the highest point of its stroke and the core tube is about 15 cm above the base level of the frame. The ball for closing the bottom is held against the side of the core tube, about 5 cm from the bottom, by an automatic catch. This ball is mounted on the end of a freely moving vertical rod. The spherical-shaped shutting valve is also kept open by an automatic catch. It is necessary to fill the piston with water before the first sample is taken. This is easily done by taking a preliminary test sample. When the corer is raised, the piston fills with water.

When the apparatus has been lowered, the frame rests on the sediment bed. The lifting cable should have some slack to prevent movement of the vessel from affecting the corer.

The weighted core tube holder then sinks slowly down, dampened by the hydraulic piston and is pushed into the sediment. This takes about 30 s. When the tube has penetrated 5 cm, both locking catches are released. The spherical top valve closes the top of the core tube but allows water to escape. The ball now lies on the bed next to the core tube. When the corer is withdrawn, the weight of the rod holds the ball on the bed. As the core tube comes out, two rubber bands pull the ball under the tube, thus closing it.

While the core tube is being pulled out of the sediment, the top valve causes reduced pressure in the core tube. As the apparatus is being raised, the hydraulic piston refills with water.

The core tube is removed from the holder while the apparatus hangs in the davit alongside the vessel. In order to do this, the ball needs to be pushed to one side and the bottom of the tube shut off with a stopper. Water can be run out of the holder by opening a tap situated level with the top of the core tube. The ring holding the tube in the holder can then be loosened and the tube, containing the sample plus a little water on the top, can be removed from the holder. The locking catches are then reset for taking a new sample.



Key

1	winch	6	sample tube
2	hydraulic piston	7	frame
3	top valve	8	removable sample tube
4	locking device bottom ball	9	rubber bands
5	drainage tap	10	ball

Figure I.1 — Craib corer

Annex J
(informative)

Description of a piston corer

J.1 Apparatus

See Figure J.1.

The piston corer consists of a core tube weighted at the top and possibly with added vanes for extra stability. The method relies on free fall commencing at a predetermined height above the bed. There is a piston in the core tube which can be fixed at a constant height above the bed during sampling. A second tube can be enclosed in the core tube, allowing tube and sample to be removed together. The core tube can be made of various metals with lead weights attached and the inner tube can be of metal or plastics.

J.2 Types in use

The diameter, mass and length of the core tube can be varied according to requirements. The free-fall mechanism of piston corers is generally activated by a trigger weight touching the bed. This can cause problems where the bed is very soft or has a thick drifting layer. There are also models available where the free-fall mechanism is activated by a photocell. The mechanism is activated as soon as the photocell registers a change from water to drifting layer.

J.3 Application

The piston can be used for physical and chemical investigations of the topmost layer of the sediment bed.

J.4 Type of sediment bed

The piston corer is not suitable for beds consisting of hard sand or stones. It can be used effectively for the other types.

J.5 Accuracy of sample

The risk of pile-working is limited because a piston is used[12]. Apart from the sides, the sample is practically undisturbed.

J.6 Operation

Operation is simple and can be carried out from a vessel. The smaller version can even be used from a bridge or quay. Since the core tube can be lifted over the rail of a vessel horizontally, no davit is required.

J.7 Nautical conditions

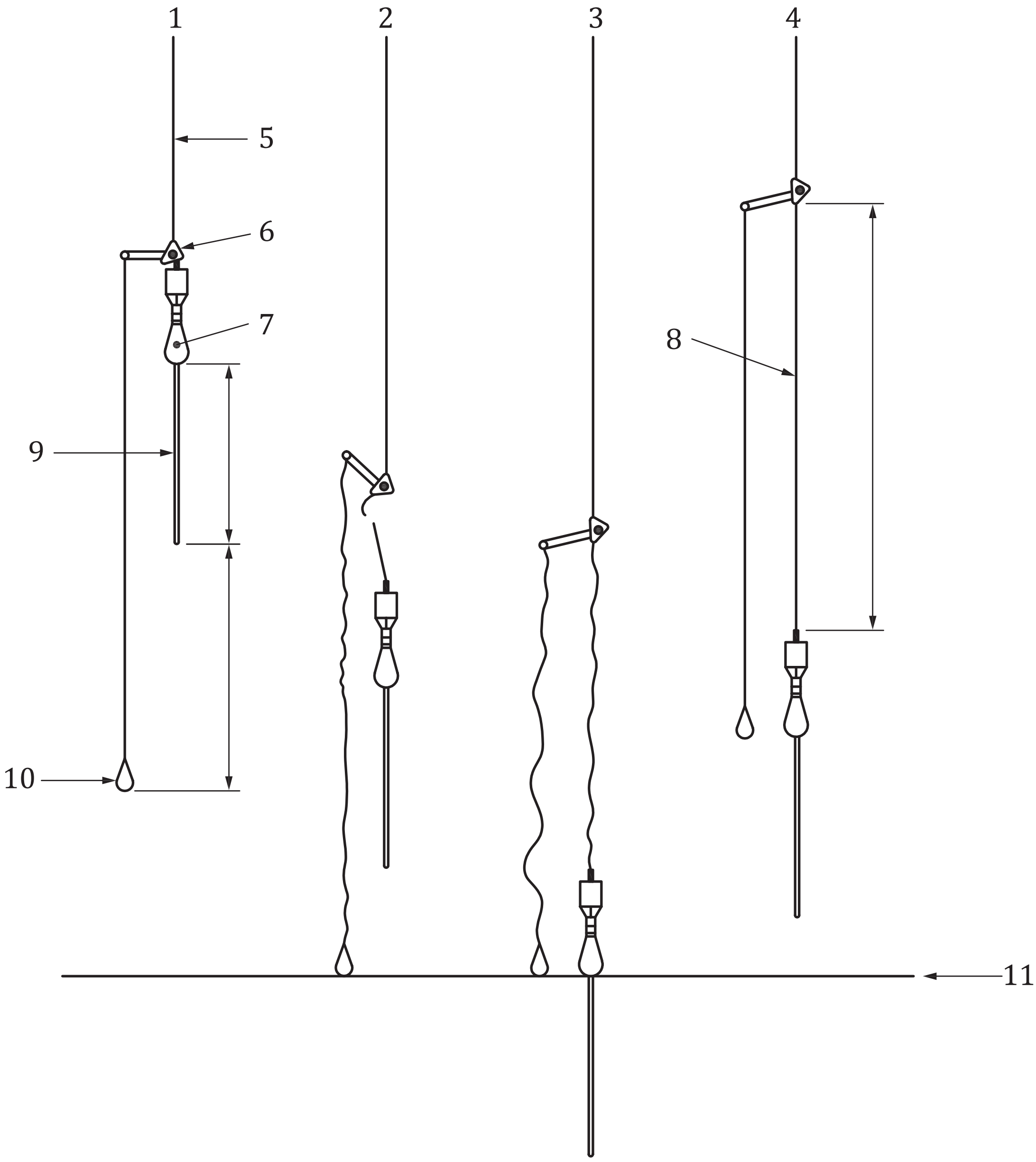
It is not advisable to work with this apparatus from a tossing vessel but, once the corer is in the water, the movement of the vessel has little effect on the quality of the sample, since once free fall has started the corer goes its own way. Due to the self-righting characteristics of the corer, currents have little effect on it. The piston corer is used for sampling beds in areas where the use of other sampling techniques causes problems, i.e. where the water is too deep and/or it is difficult to hold the vessel stationary due to currents or the wind. The piston corer can be used on sandy or silt beds.

J.8 Method of operation

The piston corer consists of three main parts: the core tube, the core tube holder and the “no-load” mechanism. The “no-load” mechanism is fixed to the operating cable. The core tube is fitted to one side of this and the counterweight to the other. This counterweight is suspended on a chain of adjustable length attached to a lever. The length of this chain minus the length of the core tube and weight determines the free-fall height. As soon as the counterweight touches the bottom while the apparatus is being lowered, the lever goes up and the core tube slides off and falls to the bed. The length of sample depends on the free-fall speed, resistance of the sediment and the diameter of the core tube.

In order to prevent pile-working, a piston can be fitted inside the core tube. This is attached to the “no-load” mechanism via a cable passing through the tube. This line should be a little shorter than the counterweight chain. In this way, the piston remains just above the bed level.

It is possible to include fittings on the inside of the penetration head to prevent the sample from dropping out or being washed out, but this will depend on the manufacturer.



Key

1 lowering
2 release
3 sampling
4 withdrawal
5 main
6 release cable
7 lead weight
8 chain
9 core tube
10 pilot weight
11 bed surface

Figure J.1 — Piston corer

Annex K
(informative)

Description of peat borers

K.1 Description of the Peat Institute peat drill model 1

See Figure K.1.

The main working piece of the Peat Institute drill (later referred to as the P.I. drill) is its container which is made up of a part with cutting edge “scoop”, a core and a penetrating blade. The scoop has the shape of a hollow semi-cylinder tapering at both ends into truncated cones. Both edges of the scoop are sharp and function as cutters. The containers capacity is 150 cm^3.

When in operation, the P.I. drill is inserted forcibly into the deposit, with its container closed, to a depth of 30 cm shorter than the depth from which the peat sample is to be taken. As the drill sinks deeper, successive rod sections are fastened on, but never more than two of them at the same time. After the drill reaches the required depth within the deposit (30 cm shorter than the depth from which the peat sample is to be taken), the container is forced open by turning the handle 180° clockwise. It is then pushed deeper down to the depth from which the sample is to be taken. An anticlockwise 180° turn of the handle closes the container. Having performed a semi-circular movement, the “scoop” adheres closely to a comb on the core, slicing a peat sample from the deposit without disturbing its structure. The peat-filled drill is pulled up from the deposit.

K.2 Peat Institute drill (year 1939 model)

The container of the new model of the P.I. drill also consists of a scoop and a core, the difference being that the core is fitted with a lateral fin instead of a blade to prevent turning of the container core in the deposit (see Figure K.1). The capacity of the container is 76,5 cm^3. Operation of the drill is the same as in the case of the P.I. drill model 1.

During the taking of peat samples, the smaller capacity of the 1939 drill model container is a disadvantage. In most cases, large peat samples are needed and so the drill needs to be reinserted into the deposit several times.

K.3 Sounding-rod drill

The container consists of two hollow cylinders. The inner cylinder, which has about a third (its width) of its circumference removed lengthwise, fits closely into the outer cylinder. The wall of the outer cylinder is slit lengthwise and bent away at an angle of 45°. This bent-out wall is sharpened like a knife. The outer cylinder rotates round the internal one by less than a full circle. When the container is open, the openings in both cylinders are aligned. When it is closed, the opening in the internal cylinder is covered by the wall of the outer one. At its lower end, the container is fitted with a drill; its upper end is connected with a rod. The container of the sounding-rod drill, like the container of the P.I. drill, comes with a set of rod sections, a handle, a key and spare couplings. There are two sounding-rod drills: large and small. The dimensions and masses of both are given in Table K.1 for comparison.

Table K.1 — Dimensions and masses of large and small drills

Drill	Length of individual rods m	Container capacity cm^3	Mass of drill with a full set of rods kg
Large	1,5	140	13,2
Small	1,0	90	4,2

It is recommended to use the lightweight, easily transportable, small sounding-rod drill during reconnaissance sounding of peat deposits, when a team of workmen has to cover large distances during one workday. The additional advantage of this drill model is the small diameter of its container, which is more or less easily inserted through mineral layers overlying the peat deposit.

The advantage of the P.I. drill is that it is the only drill suitable for taking peat samples with undisturbed structure and natural moisture content, and as such should be used when determining moisture content. Its disadvantage is that, with a relatively large container diameter, it requires the application of somewhat more force when it is pushed down into the deposit (especially when the deposit is highly compacted). Because of this, it may not always be used for taking samples from the substrate.

The P.I. drill model from 1939 is more convenient for stratigraphic studies.

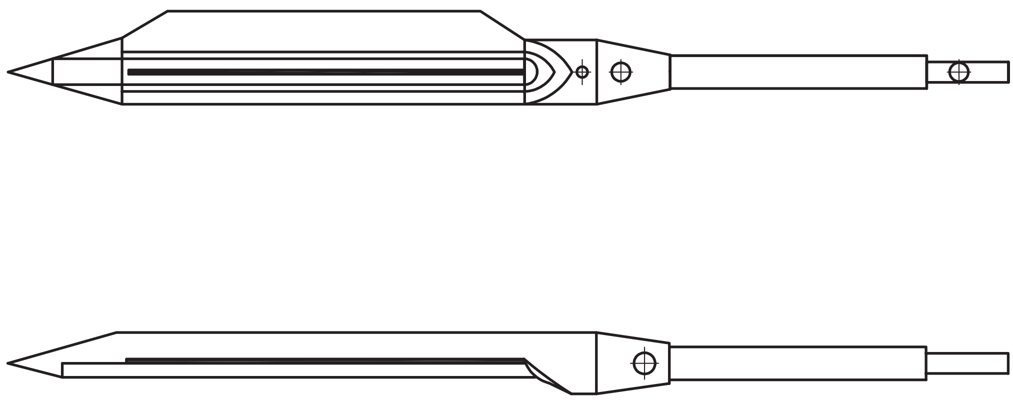


Figure K.1 — Peat Institute drill

Annex L
(informative)

Freeze coring

L.1 Apparatus and types in use

The freeze corers[21] are commonly from wedge- or tube-shaped type and made from aluminium or stainless steel. In general, a cooling agent such as dry ice or liquid is needed to run the freezing process. In case of the use of dry ice, alcohol is used to develop a freezing mixture in order to accelerate the freezing process. Free fall types are operated with a rope and could be used in up to a water depth of 1 000 m with remote control of the freezing process[13]. Flange connected types[14][20][21] are operated from the water surface by pressing liquid nitrogen down to the corer (see Figure L.1) up to a water depth of 10 m to obtain cores with a length of maximum 2 m[14][20]. In the latter case, the placement of the corer is under full control of the operator. The rope type corer may need adjustable landing legs and plates to stabilize the corer in the sediment in order of vertical operation[13].

L.2 Application

Freeze corers were developed for chemical and for (limited) physical investigations of the topmost layer of the sediment bed.

L.3 Type of sediment bed

The freeze corers are used for the undisturbed sampling of high watery and soft sediments such as sapropel or gyttja[20]. However, they are likewise used for gravel, for example in case of river bed investigations[15].

L.4 Accuracy of sample

The risk of pile-working is limited and considered as negligible[20]. Rope-operated corers may push the sediment horizontally[17]. In the inner and outer shells of the core, some mixing or smearing of the layers may occur and thus should be disposed.

L.5 Operation

Smaller rope-operated freeze corer can easily be used from a rubber boat or a bridge. The flange connected type or bigger rope type should be operated from a pontoon or vessel equipped with a tripod or davit to retrieve the core.

L.6 Nautical conditions

The rope-operated type is not influenced by a tossing vessel or boat after placing the corer in the sediment. It is obviously that the vessel or pontoon should be fixed in position if the flange-type corer is used to obtain undisturbed cores. In areas with difficult nautical conditions (i.e. the water is too deep and/or it is difficult to hold the vessel stationary due to currents or the wind), the rope-type corers are the preference.

L.7 Method of operation

L.7.1 Wedge-type freeze corer

The wedge-type freeze corer was introduced in the early 1970s[19]. The wedge-shaped design enhances the ability of the corer to penetrate the sediment with low disturbance. The corer is typically filled with solid CO_2 (dry ice) mixed with a liquid of low freezing point such as butanol, ethanol or iso-propanol to develop a freezing mixture. The CO_2 gas releases through a gas or check valve on the top of the corer. Furthermore, the valve prevents water to flow into the corer.

The simple wedge-freeze corer has the advantage that is robust, relatively light weight and easy to use. The disadvantage is that the freezing begins immediately after filling of the corer and thus an ice cover arises during descent of the corer. At sampling points with a deep water layer, this may cause a decreased capacity of the corer to freeze the sediment.

To overcome this drawback, an enhanced version of the wedge-type freeze corer was developed[17] (see Figure L.1). The dry ice and the solvent are stored in a thermos chamber. After placement of the corer in the sediment, a battery-driven fuel pump is switched on remotely and the cooling agent is pumped through the wedge in a circuit. The advantage is the freezing process is under full control of the operator and no loss of the cooling agent occurs while lowering down the device to the sediment. Hence, no sampling of deep sea sediments would be possible using a freeze corer.

The cooling capacity of a dry ice freeze corer holds for approximately 30 min to 70 min with consumption of ~10 kg dry ice and 1,5 l alcohol[17][18]. Thus, the cores are relatively thin and thus only small amounts of sediment material are available for analysis.

L.7.2 Tube-type freeze corer

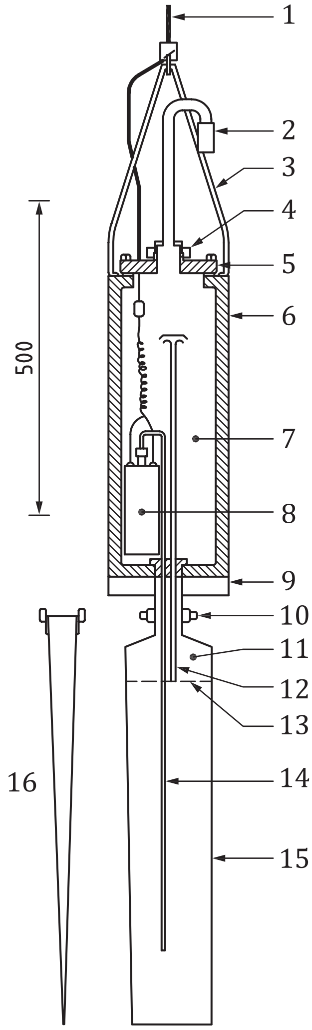
The tube-type freeze corer is used both with dry ice and liquid nitrogen as freezing agents. The tube-type dry ice freezer corer is in principle constructed and operated similar to the wedge-type freeze corer[18][20][21][22].

The second type of tube freeze corers are operated using liquid nitrogen as a freezing agent. The nitrogen freeze corer was firstly described by Leschber and Pernak[14]. The corer is a simple cylindrical steel lance with a conical head (see Figure L.2). The liquid nitrogen flows through an internal pipe into the lance and vaporizes. The liquid nitrogen is stored in a Dewar and typically technical nitrogen gas is used to press it out from the Dewar into the pipe. The temperate of the lance is below −150 °C (the temperature of gaseous nitrogen near the condensation point and thus cores with a diameter of 10 cm to 20 cm can be obtained[14][20]). The corer tube is typically extended with tubes to bridge water layers up to 10 m.

The disadvantage of the firstly described, simple nitrogen freeze corer is that probably a larger swamp of liquid nitrogen exists on the bottom of the corer. In consequence, the corers might have a more conical shape due to a steep temperature gradient from the bottom (liquid nitrogen, −196 °C) to the top of the lance (gaseous nitrogen near the condensation point, −150 °C).

For this reason, a corer with an internal cooper-tube-helix was developed in order to ensure a better chilling of the whole corer tube (see Figure L.3)[20]. The latter device makes it possible to obtain concentric cores of 10 cm to 20 cm diameter and of a length up to 120 cm within 0,5 h to 2 h[20]. The tube extensions equipped with vacuum QF vacuum flanges and the flexible liquid nitrogen piping made from perfluoroalkoxy makes it easy to receive cores from water depths up to 10 m.

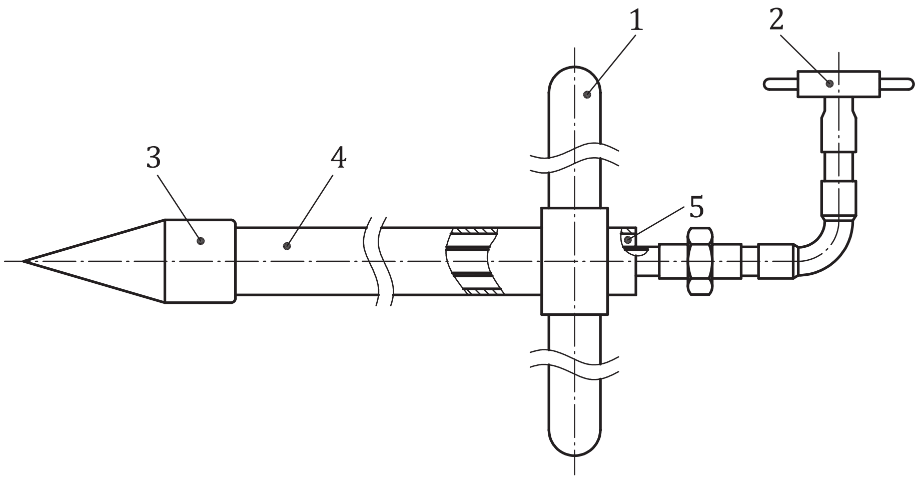
Dimensions in millimetres



Key

1	wire-reinforced
2	gas valve screw
3	frame
4	small lid
5	large lid
6	thermos
7	dry ice and alcohol
8	pump
9	cable weight
10	coupling
11	gas pocket
12	return tube
13	alcohol level
14	inlet tube
15	freeze wedge
16	side view

Figure L.1 — Scheme of the wedge-type pump freeze corer[17]



Key

1 holder

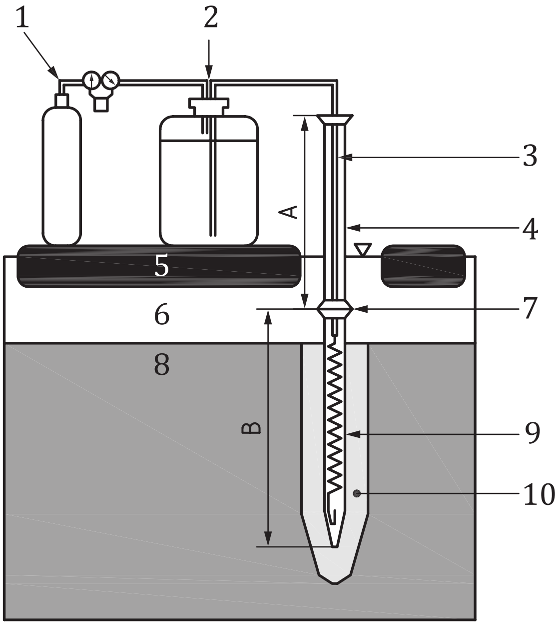
2 liquid nitrogen supply

3 icing point

4 lance

5 degassing device

Figure L.2 — Scheme of the simple tube-type liquid nitrogen freeze corer[14]



Key

1 nitrogen gas

2 Dewar with liquid nitrogen (LN_2)

3 perfluoroalkoxy (PFA) tube (isolated)

4 stainless steel extension tube

5 drilling platform

6 water column

7 vacuum QF-flange with centring ring and clamp

8 sediment

9 stainless steel lance with LN_2 evaporator

10 frozen sediment

A 1 m

B 1,2 m

Figure L.3 — Scheme of the tube-type nitrogen freeze corer[20]

Annex M
(informative)

Description of sediment sampler with slicing mechanism

See Figure M.1.

A Limnos sediment sampler with sediment slicing mechanism provides a way to take samples from soft sediments and to slice the sample in layers. The Limnos sampler also provides a method for taking undisturbed samples directly into the incubation tubes for studies in the laboratory (see http://www.gwm-engineering.fi/fi/tuoteryhmat/limnologia-sedimentti/limnos-viipaloiva-sedimenttinaytteenotin/ or http://www.limnos.pl/?switchlang=en)

The sampler allows free water passage, preventing any pressure impact which could disturb the sediment surface. The bottom of the sampler closes within the sediment. It is the weight of the device which keeps the valve closed. The container tube of the sampler consists of a series of rings (60) placed on top of one another. Slicing is performed by rotating the ring round its other axle so that it cuts a sediment layer of similar thickness. The method concerned is quick and accurate and does not disturb the natural layering of the sediment.

The tube is easily changeable and it is possible to use an unsectioned tube in the sampler. This is suitable for use in taking samples of benthic organisms as well as for studying the water layers above the sediment. A Limnos sampler offers a good method to take undisturbed samples directly into the incubation tubes for longer laboratory studies.

The metal parts of the sampler are made of stainless steel, the slicing tube rings of impact-resistant polycarbonate plastic.

The sampler can be lowered beneath ice through a borehole.

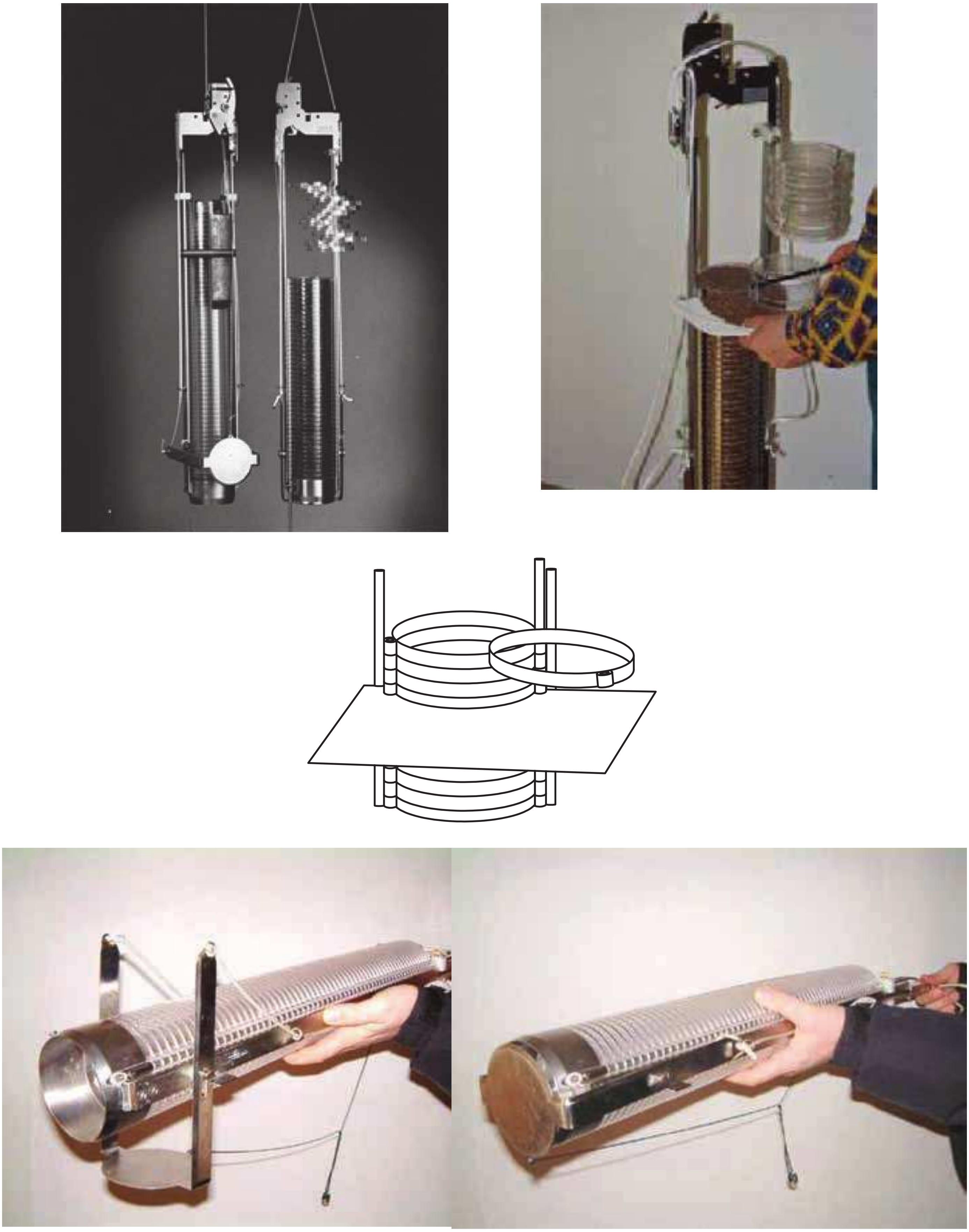


Figure M.1 — Sediment sampler with slicing mechanism

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