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Water quality — Sampling —

Part 12:
Guidance on sampling of bottom sediments

Qualité de l'eau — Échantillonnage —

Partie 12: Guide général pour l'échantillonnage des sédiments

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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.

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

International Standard ISO 5667-12 was prepared by Technical Committee ISO/TC 147, *Water quality*, Subcommittee SC 6, *Sampling (general methods)*.

ISO 5667 consists of the following parts, under the general title *Water quality — Sampling*:

- *Part 1: Guidance on the design of sampling programmes*
- *Part 2: Guidance on sampling techniques*
- *Part 3: Guidance on the preservation and handling of samples*
- *Part 4: Guidance on sampling from lakes, natural and man-made*
- *Part 5: Guidance on sampling of drinking water and water used for food and beverage processing*
- *Part 6: Guidance on sampling of rivers and streams*
- *Part 7: Guidance on sampling of water and steam in boiler plants*
- *Part 8: Guidance on the sampling of wet deposition*
- *Part 9: Guidance on sampling from marine waters*
- *Part 10: Guidance on sampling of waste waters*
- *Part 11: Guidance on sampling of groundwaters*
- *Part 12: Guidance on sampling of bottom sediments*
- *Part 13: Guidance on sampling of sewage, waterworks and related sludges*

— *Part 14: Guidance on monitoring the quality of sampling procedures*

— *Part 15: Guidance on the preservation and handling of sludge and sediment samples*

— *Part 16: Sampling and pretreatment of samples for biotesting*

Annexes A, B, C, D, E, F, G, H, J, K, L and M of this part of ISO 5667 are for information only.

Introduction

This part of ISO 5667 should be read in conjunction with ISO 5667-1, ISO 5667-2 and ISO 5667-3.

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.

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Water quality — Sampling —

Part 12:
Guidance on sampling of bottom sediments

1 Scope

This part of ISO 5667 provides guidance on the sampling of sedimentary materials from

— inland rivers and streams;

— lakes and similar standing bodies; and

— estuarine and harbour areas.

Industrial and sewage works sludges, palaeolimnology sampling and open ocean sediments are specifically excluded although some techniques may apply to these situations. Sampling specifically for the measurement of rates of deposition, other transport criteria and detailed strata delineation is not within the scope of this part of ISO 5667.

The investigation may have the following objectives:

— the descriptive mapping of an area;

— the monitoring at regular intervals of fixed markers such as buoys;

— examining the quality of dredger spoil; and

— fundamental research.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 5667. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 5667 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 2602:1980, *Statistical interpretation of test results — Estimation of the mean — Confidence interval.*

ISO 2854:1976, *Statistical interpretation of data — Techniques of estimation and tests relating to means and variances.*

ISO 5667-1:1980, *Water quality — Sampling — Part 1: Guidance on the design of sampling programmes.*

ISO 5667-3:1994, *Water quality — Sampling — Part 3: Guidance on the preservation and handling of samples.*

ISO 9391:1993, *Water quality — Sampling in deep waters for macro-invertebrates — Guidance on the use of colonization, qualitative and quantitative samplers.*

ISO 10381-6:1993, *Soil quality — Sampling — Part 6: Guidance on the collection, handling and storage of soil for the assessment of aerobic microbial processes in the laboratory.*

3 Definitions

For the purposes of this part of ISO 5667, the following definitions apply.

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. The individual portions may be derived from the same stratum or at the same sediment thickness. The sample components are taken and pretreated with the same equipment and under the same conditions.

3.2 pile-working: The 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: A description of the sediment present, in terms of its nature, variation and extent. The exercise is carried out by precise marking of sample locations and recording of site conditions. Pre-established conditions may be a requirement of the exercise.

3.4 monitoring: Establishment of variation with time of the physico-chemical and descriptive characteristics of the sediment.

3.5 quality of dredger spoil: To establish the chemical nature and, in the case of sandbank dredging, the physical properties of the sediment layer removed by the dredging process and disposed of off-site.

4 Sampling equipment

4.1 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 more readily apparent and they can be sterilized more easily than most plastics 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. mercury). These containers should only be used if preliminary tests indicate acceptable levels of contamination.

If glass containers are used for storing sediments with pore waters which are weakly buffered, borosilicate rather than soda glass containers should be chosen.

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 the cleaning of sample containers, reference should be made to ISO 5667-3. In all cases, consultation with the receiving laboratory should be regarded as mandatory practice.

4.2 Criteria for selection of apparatus

4.2.1 Type of investigation

Three types of investigation can be distinguished:

a) chemical investigation;

b) physical investigation; and

c) biological investigation exclusive of colonization samplers, traps or nets.

When a grab system (4.3.1) is not used, the criteria for selection of sampling apparatus may also be required to meet the following conditions:

— storage of the sediment without changing the stratigraphy;

— allow the selection of a layer; and

— allow sampling at the required water depth.

4.2.1.1 Chemical investigation

In this type of investigation, the nature and amounts of the substances which have become bonded to the sediment may be determined. Some chemical species bond 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. Appropriate 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 may require to be maintained in an oxygen-free atmosphere (e.g. sulfides) and storage and handling under pressure of an inert gas may be needed. In all cases analysis should be performed as quickly as possible.

4.2.1.2 Physical investigation

In this type of investigation the structure, texture and layer formation of the water bed are determined. These details are particularly important for sand, clay and shell production and for geographical, morphological and, in some cases, geotechnical investigations.

4.2.1.3 Biological investigation

A biological investigation generally involves classifying the species and numbers of flora and/or fauna present on and in the sediment bed. In nearly all cases sampling is carried out in the habitat layer. The probe depth is generally a maximum of 50 cm. For specific details, reference should be made to ISO 9391 for methods involving colonization traps or net sampling. In some cases microbiological action may also be of interest, such as denitrification, phosphate release, methylization of metals such as mercury or tin.

4.3 Types of apparatus

NOTE 1 Additional equipment, which emulates or compliments the advantages of that discussed in this part of ISO 5667, may also be available commercially. The scope for inclusion in future revisions will be considered at the appropriate time.

4.3.1 Grab systems

4.3.1.1 General

Many samples are collected using bed grabbers. The most well-known is the scissor-grab, sometimes known as the van Veenhapper type. There are, however, a large number of variations. In general, grab systems consist of one or more hinged buckets which close whilst being raised. During closing, sediment is enclosed by the buckets providing disturbed samples. Probe depths vary from 5 cm to 50 cm, 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. Grabs are available in a variety of designs. Since all grab systems have the same sampling characteristics, only the van Veenhapper type is described in detail in annex A. In general, detailed operating instructions are provided by the manufacturer.

4.3.1.2 Scissor grab or clam-shell buckets

4.3.1.2.1 Application

The system is recommended for physical, chemical and biological investigations.

4.3.1.2.2 Type of bed

The system is most suitable for sampling sediment beds consisting of silt and/or sand and gravel. It is not suitable for sampling peat, clays or gravel beds in riffle areas.

4.3.1.2.3 Accuracy of sample

A sample taken with a scissor grab will always be disturbed. Inaccuracies arise because of washing away of the fine fractions. The depth of penetration is unknown and dependent on the nature of the bed for any particular instrument, for example, the grab can sink through a thin silt layer so that it will not be known at what depth the sample has been taken from within the bottom sediment.

4.3.1.2.4 Nautical conditions

The scissor grab can be used in both shallow and deep water and in areas of slow and fast currents. However, the construction and mass need to be adapted to suit the conditions. It is recommended that trials using objects of a similar mass be carried out; this indicates whether strong currents affect the position of the samples. Additional weights can then be added if it is found necessary. It is recommended that a secondary line carrying a marker float be attached as a security measure, in case the main line has to be abandoned for safety reasons. This will aid recovery.

4.3.2 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. 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.

4.3.2.1 Application

The systems described are recommended for physical, chemical and limited biological investigations.

4.3.2.2 Type of bed

Some sandy beds may be suitable but trials will need to be undertaken first. Clay types and soft peaty materials are also suited to corers. Peat borers have a specific application.

4.3.2.3 Accuracy of sample

Most corer samples are relatively undisturbed and may be used to define strata.

4.3.2.4 Nautical conditions

Hand-operated types are prone to nautical constraints such as fast flow or high winds in small boats. They are usually confined to use at shallow depths unless a diver is employed.

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.

4.3.2.5 Other information

So-called "pile-working" (3.2) can occur with corer systems. The amount of pile-working depends on such variables 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.

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. 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. The extruded material can be sectioned with a device, which can be put on the top of the sampling tube. 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.

4.3.2.6 Manually operated sampling apparatus

In this apparatus the tube is pushed into the bed by means of rods. Penetration is generally up to a maximum of 2 m, depending on the nature of the bed materials. Gravels are unlikely to be suited to this sampling method. Because extension rods are used, there can be problems in obtaining samples when working from the bank where a distance of more than 4 m must be bridged by rods. Due to movement of a vessel, it is often difficult to obtain good samples from a boat. However, it is possible to obtain reliable samples in a water depth of approximately 2 m; beyond this a diver may need to be employed.

Various types of manually operated corers with a multitude of modifications, all based on the same principle, are in use. The characteristics of a number of types of corer systems and recommended typical applications are described in 4.3.2.6.1 to 4.3.2.6.5.

4.3.2.6.1 Piston drill

The piston drill is recommended for chemical, physical and biological investigations. It is 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.

4.3.2.6.2 Corer system involving a diver

In this system a corer tube is pushed into the sediment by a diver. If necessary, the tube can be coupled to a vacuum pump so that the sample can be taken up into the tube more easily. Maximum penetration is 2 m.

The diver core tube is applicable to chemical, physical and limited biological investigations.

4.3.2.6.3 Beeker core sampler (see annex D)

The tube is mounted on a cutter head containing an inflatable bellows which prevents the sample from falling out of the tube when it is withdrawn from the sediment.

4.3.2.6.4 Sealed core sampler (see annex E)

The stainless steel tube containing a plastics inner sleeve is closed off by inflating two small bellows, one at the top of the tube and one in the cutter head, so that when the tube is removed from the sediment the sample does not fall out.

As long as its limitations are taken into account, the sealed core sampler can be used for physical, chemical and limited biological investigations. It is suitable for silty and fairly soft water beds and can be operated from a (small) vessel or from shore (for example from a pier, quay or bridge).

NOTE 2 The terms hard and soft (as used in this part of ISO 5667) are largely arbitrary and a certain amount of trial and error will have to be employed when assessing the suitability of certain sampler types to those particular physical sediment characteristics.

Because the top and bottom of the tube can be shut off, the sample can be collected undisturbed. Use of the sample-removal apparatus often supplied with the sealed core sampler can allow various strata to be sampled accurately.

WARNING — 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.

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.

The consistency of the bed largely determines the sampling result. Because of its construction (air and pressure hoses) the apparatus is only usable in silty, fairly soft beds up to a water depth of approximately 3 m.

4.3.2.6.5 Vrijwit drill or wedge corer (see annex F)

The wedge core tube has a maximum penetration of 1,50 m. One side of the wedge remains open whilst it is pushed into the sediment. The open side of the core tube is then closed off with the slider, and the sample is extracted from the sediment.

4.3.3 Mechanically operated sampling apparatus

Many types and modifications are in use. Subclauses 4.3.3.1 to 4.3.3.8 describe the characteristic properties of a number of common types and recommend typical applications and suitability to various types of sediment.

4.3.3.1 Falling bomb core sampler (see annex G)

The core tube is mounted in a weighted holder which is dropped freely from a vessel and penetrates the sediment. The method is fast and efficient because it is not necessary for the vessel to be anchored. This method is not suitable for use in unconsolidated sediments.

4.3.3.2 Jenkins mud sampler core sampler (see annex H)

The corer is mounted in a frame and due to its large mass it sinks into the bed. Once the suspension cable is slackened sufficiently, a closing mechanism is activated which shuts off the sample tube by means of hinged arms.

The Jenkins mud sampler is suitable for physical, chemical and limited biological investigation of the top layer of very soft beds. It is not suitable for hard sediment beds. By shutting the valves gently using an oil pressure device, an undisturbed sample of the soft top layer of sediment can be obtained.

The bed needs to be soft since the valves do not shut properly if the bed is hard, due to the resistance experienced, and the core tube will not penetrate. Samples can be taken in deep water.

4.3.3.3 Craib corer sampler (see annex J)

The Craib corer consists of a core tube mounted in a frame. When it is lifted out of the sediment layer, the core tube is first closed off at the top by a valve. As soon as the bottom is free of the bed, it is closed off by a ball.

4.3.3.4 Easy All core sampler

The Easy All is a corer whose mass can be increased to approximately 110 kg. After the sample has been taken, the core tube is shut off at the top and the bottom by means of valves. The filled core tube can be removed from the holder completely once it is aboard. It is also possible to take readings directly from the core material by inserting electrodes in tiny side openings in the tube wall. Parameters such as temperatures and redox potential can be studied easily.

4.3.3.5 Vibro corer sampler

A casing containing a polyvinylchloride tube is pushed into the bed by means of weights and a vibration mechanism. A piston ensures that the sample can be moved into the tube more easily. When the core tube has reached the required depth, it is removed from the sediment bed. A core catcher and the piston ensure that the sample does not fall out of the tube. Penetration depths of various Vibro corers vary between 1,2 m and 6 m. The total mass is approximately 850 kg. A vessel with a lifting capacity of at least 1 000 kg is necessary if the Vibro corer is to be used. This type of sampler consists of highly specialized equipment and its use is considered to be beyond the scope of this part of ISO 5667.

4.3.3.6 Piston corer sampler (see annex K)

The Piston corer consists of a core tube which is weighted at the top and can have fins for added stability. Its operation depends on the free fall principle.

4.3.3.7 Peat borer

These devices generally comprise hand augers specifically designed to cut cores out of saturated or partially drained peat sediments. Some examples from the Polish Peat Institute are given in annex L.

4.3.3.8 Cold finger techniques

During the preparation of this part of ISO 5667 it was noted that some success has been reported in the literature with the use of "cold finger" sampling of sediments. This involves the insertion of a refrigerated device into the sediment which freezes a portion of its surroundings allowing stratigraphical extraction and separation. Users of this part of ISO 5667 are recommended to refer to the literature sources cited in the bibliography in annex M for more details of the scope of application.

5 Sampling procedure

5.1 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 (i.e. the location of the sampling cross-section on the base of the water body);

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

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

The choice of sampling sites for single sampling stations 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.

Low-frequency echosounders should be considered to assist in locating bed areas of appropriate quality prior to sampling.

The criteria for choice can include:

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

— seasonal availability, for example, affected by safety, problems in spate;

— the influence of marine traffic, for example, sample points may need to be avoided due to traffic.

5.2 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 geophysical mapping is the sole purpose then choice may be the function of flow and current conditions only, whereas if chemical composition/contamination is being studied, the sampling point will depend largely on the geophysical condition of the bed areas. For instance, it would not be expected to find contamination caused by gross metals in a riffle area of a stream compared to a pool area. The choice of sampling point will be a desirable pre-qualification for the programme, but exact locations will inevitably be revised in the field.

Locations will need to reflect the proximity to outfalls, the influence of stream mixing and other factors such as plant growth.

5.3 Choice of sampling method

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

a) The requirement for a largely undisturbed sample for stratigraphical delineation.

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

These factors will be decided upon during the programme design stage. 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.

The remaining factor affecting the choice of sampling method will be the applicability of the proposed device to the sediment conditions. This regime is summarized in table 1.

5.4 Frequency and time of sampling

Analytical results from a sampling programme need to provide estimates of the required information within acceptable tolerance limits 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 an estuary 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. It may be necessary to increase the sampling frequency in order to observe any seasonal 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 dictated by the needs of a particular project will themselves define the frequency of sampling. For details of the application of statistics to sampling frequency refer to ISO 5667-1.

5.5 Site conditions

Conditions at the sampling position are of vital importance to effect 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:

— climatological;

— hydrographical;

— geological;

— shipping/nautical.

Table 1 — Sediment type and recommended sampler

Sediment type	Sampler[1)]
Gravel	Grab systems; large particle size may require heavier grabs
Sand	Both grab and corer systems can be used. A sand bed can be very hard 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
Peat	A difficult medium to sample but it is sometimes possible to use a hand operated corer system, or a special peat borer
Consolidated bottom sediment	Both grab and corer systems can be used. If a grab is used it is not possible to determine the sample penetration depth.
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.

1) Sampler type versus sediment type may have to be determined by experimentation.