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Water quality — Sampling —

Part 4: Guidance on sampling from lakes, natural and man-made

Qualité de l'eau — Échantillonnage —

Partie 4: Lignes directrices pour l'échantillonnage des eaux des lacs naturels et des lacs artificiels

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Contents

Page

Foreword

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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 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.

The committee responsible for this document is ISO/TC 147, *Water quality*, Subcommittee SC 6, *Sampling (general methods)*.

This second edition cancels and replaces the first edition (ISO 5667-4:1987), which has been technically revised.

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

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

— *Part 3: Preservation and handling of water samples*

— *Part 4: Guidance on sampling from lakes, natural and man-made*

— *Part 5: Guidance on sampling of drinking water from treatment works and piped distribution systems*

— *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 sludges*

— *Part 14: Guidance on quality assurance and quality control of environmental water sampling and handling*

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

— *Part 16: Guidance on biotesting of samples*

— *Part 17: Guidance on sampling of bulk suspended solids*

— *Part 19: Guidance on sampling of marine sediments*

— *Part 20: Guidance on the use of sampling data for decision making — Compliance with thresholds and classification systems*

— *Part 21: Guidance on sampling of drinking water distributed by tankers or means other than distribution pipes*

— *Part 22: Guidance on the design and installation of groundwater monitoring points*

— *Part 23: Guidance on passive sampling in surface waters*

— *Part 24: Guidelines for the auditing of water quality sampling*

Water quality — Sampling —

Part 4: Guidance on sampling from lakes, natural and man-made

1 Scope

This part of ISO 5667 gives guidelines for the design of sampling programmes, techniques and the handling and preservation of samples of water, from natural and man-made lakes during open-water and ice-covered conditions. This part of ISO 5667 is applicable to lakes with and without aquatic vegetation.

Guidance on sampling for microbiological examination is not included.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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 5667-3, *Water quality — Sampling — Part 3: Preservation and handling of water samples*

ISO 5667-14, *Water quality — Sampling — Part 14: Guidance on quality assurance and quality control of environmental water sampling and handling*

ISO 7027, *Water quality — Determination of turbidity*

3 Terms and definitions

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

3.1
grab sample
single discrete sample collected from a body of water at a specific time, location and depth

3.2
depth profile samples
two or more discrete samples collected at two or more depths at a specific time and location on a lake

3.3
area profile samples
two or more discrete samples collected from the same depth at two or more locations on a lake

3.4
composite sample
two or more *depth profile* (3.2) or *area profile samples* (3.3) that are combined to form a single sample prior to measurement of water quality parameters

3.5
integrated sample
single sample collected by a tube or similar sampler that collects a water sample across a range of depths

3.6
***in-situ* measurement**
measurement of a water quality parameter made within a body of water, not requiring collection of a water sample

Note 1 to entry: The measurement is generally taken by use of an electronic probe.

3.7
***ex-situ* measurement**
measurement of a water quality parameter made outside a body of water, and requiring collection and possibly transport of a water sample prior to measurement

3.8
open sampling device
open-mouthed vessel, including beakers, buckets, containers or tubes, used for sampling at or near the water surface (<1 m depth)

Note 1 to entry: Open sampling devices are not suitable for sampling for volatile parameters or dissolved gases.

3.9
closed sampling device
vertically or horizontally aligned hollow-bodied tube, pipe, box or container fitted with shutters, valves, stoppers or other devices that prevent entry of air into and/or enclosure of air with the water sample and the exchange of water between the collected sample and the surrounding water column

Note 1 to entry: Closed sampling devices are used for collecting water samples from deeper waters or for collection of water samples for the analysis of volatile parameters and dissolved gases.

3.10
sampling pole
pole or rod with a terminal apparatus that accepts an open or *closed sampling device* (3.9) and that is used to extend the reach of samplers

3.11
sampling iron
weighted container holder attached to a line and used to extend the reach of samplers or to submerse a sample container to a specific depth

3.12
pumping device
hand or motor operated suction or submersible pumps, or pneumatic ejection samplers used for collection of samples from defined depths or a series of depths

3.13
filling device
funnel, ladle, churn sample splitter or other device used to transfer sample water from a sampling device to a sampling container

3.14
negative control
quality control sample that is used to ensure a negative response

4 Sampling equipment

4.1 Material selection

Sampling probes, devices and other equipment should be chosen, as far as possible, which do not give rise to any interaction between the water and the material composition. The equipment and devices to be used should be checked at random for the presence of emission, absorption and adsorption of substances or influence of properties that are to be determined in the samples to be taken. Examples of

common sampling equipment are summarized in Annex A. Advantages and disadvantages of sampling equipment are provided in Annex B. If a boat, marine vessel or any floatation device is used, care shall be taken so that it does not result in contamination of the samples. Additional details regarding sampling from a vessel are summarized in Annex C. A winch with steel rope and counter is advisable for deeper lakes. This ensures the required sinking and resurfacing velocity of the sampling devices. Any solvents, chemicals or fuels should be stored in sealed non-permeable containers. For example, the use of electric motors on small boats can be of value in eliminating the risk of contamination by combustion exhaust and engine lubricants. ISO 5667-14 provides guidance for checking the uptake and emission of the substances to be measured by equipment and devices that are used for sampling.

4.2 Cleaning

A proper quality assurance and quality control (QA/QC) system should be in place to prevent contamination and detect any contamination that could affect analytical results. All equipment and devices should be regularly mechanically and, if appropriate, chemically cleaned, both internally and externally, to prevent contamination of water samples.

4.3 Maintenance

Where equipment uses mechanical or other triggering devices, these mechanisms should be regularly tested. Electronic devices and probes should be tested and calibrated according to the manufacturer's recommendations. A log of testing and calibration dates and results should be maintained.

5 Design of the sampling programme

Proper sampling is critical to ensure the quality of the investigation and resulting data. Developing a detailed sampling strategy prior to collecting samples will minimize any sampling errors and will provide the most representative sample for analysis. General aspects that should be considered in a sampling programme are summarized in ISO 5667-1. These include, but are not limited to, the following:

a) purpose of the investigation;

b) parameters to be analysed for each sampling point;

c) measurements to be carried out at the sampling point as specified in the analytical method, e.g. temperature, dissolved oxygen, pH, turbidity, conductivity;

d) frequency and times of sampling and type of sample;

e) sampling site and the number and locations of sampling points;

f) sampling equipment;

g) quality assurance procedures to be followed;

h) transport preservation and storage of samples;

i) hydrodynamic and morphologic characteristics of the water sampled;

j) local circumstances such as water depth, vegetation, accessibility of location and other potential obstacles such as floating layers or sludge layers present;

k) sampling depth(s);

l) composition and quantity of the water to be sampled;

m) safety considerations.

6 Sampling procedure

6.1 General

As recommended in ISO 5667-1, an investigation plan should be established before a sampling program is initiated. The plan should include: the purpose of the investigation; parameters to be analysed for each sampling site; frequency and times of sampling; the type of collection gear and containers; the number and locations of sampling points; sample preservation requirements; access and safety concerns; hydrodynamic, morphological and biological characteristics of the sampling site(s); the sampling depth(s); and quantity of water to be collected.

Phytoplankton and/or chlorophyll, as well nutrients for water protection issues, should be sampled in the euphotic zone or mixed layer, respectively. The decision down to which depth an integrated sample has to be taken should be done according to EN 16698. The decision depends on lake type, stratification and phytoplankton turbidity. That means before the sampling procedure, the current probe measurement data and Secchi disk readings have to be available.

6.2 Sampling location

6.2.1 General

General guidance is given in ISO 5667-1.

Samples from surface layers containing floating material should be taken with special surface samplers.

The spatial distribution of sampling locations can be properly decided only after detailed preliminary work using a large number of sampling locations to provide information to which statistical techniques may be applied.

6.2.2 Horizontal distribution of sampling positions

6.2.2.1 Sampling point for characterization of water quality

Morphologically complex lakes, those either consisting of several basins or having a complicated shoreline can show significant heterogeneities in a horizontal direction. In order to evaluate the extent of such heterogeneities, it is necessary to set up several sampling points to carry out preliminary investigations. The data gathered then enable the necessary number of sampling points to be fixed effectively. One sampling point above the deepest part of the lake is generally sufficient for lakes showing no significant heterogeneities in a horizontal direction. Sampling points should be defined clearly, and if possible, marked with buoys. Use navigation devices to identify the sampling points if the surface area is too large to allow the fixing of buoys. If appropriate to the sampling purpose, samples can be collected from the lake shore, ideally at or near the outflow, or jetty or promontory, using a device such as a sampling iron or sampling pole.

6.2.2.2 Sampling point for quality control

Negative control samples should be taken such that they are not influenced by potential sources of contamination. These could include other nearby non-impacted areas or other nearby bodies of water that are representative of the body of water being sampled.

6.2.2.3 Sampling point for special investigations

Samples should be taken as single or replicate samples where unusual phenomena have been observed. The sites should be clearly identified in the report, with a map or sketch where possible.

6.2.3 Vertical distribution of sampling points

The water quality in natural and man-made lakes can show large vertical heterogeneities due to stratification. The reasons for these are influences from the water surface (changes of the water quality by photosynthesis in the euphotic zone and changes in water temperature by heating) and influences arising from the sediment (dissolution or resuspension of substances from the sediment). Furthermore, vertical heterogeneities can arise from sedimentation of suspended matter. Large differences in water quality are also frequently observed at the thermocline. For these reasons, the distance between grab sample depths in heterogeneous zones should be minimized. The exact arrangement of sampling levels depends on the information required and the local circumstances. It is therefore advisable to carry out preliminary investigations using measuring probes (for measurement of temperature, if possible, as well as dissolved oxygen concentration, pH value, conductivity, turbidity and chlorophyll fluorescence), which allow either continuous monitoring or monitoring at short intervals. In such cases, stagger the sampling depth to allow the recording of all vertical heterogeneity. Once a sampling programme has been defined, it should be carried out to completion, since if it is altered during sampling, the data gathered will be incompatible. In large and deep bodies of water where internal movement of water can occur, the use of a series of samplers, which all take samples simultaneously, is recommended.

6.3 Frequency and timing of sampling

Detailed guidance, including statistical considerations, is given in ISO 5667-1.

The water quality of natural and man-made lakes varies seasonally. Consequently, the frequency of sampling will depend on the information required.

In general, for lentic waters, an interval of 1 month or longer between the collection of consecutive samples is acceptable for water quality characterization over a long period of time. For the purpose of quality control measurement, a minimum interval of one week is necessary. If rapid changes in water quality are apparent, daily or even continuous sampling can be necessary.

Lake sampling four times a year will allow an acceptable water quality characterization over a long period of time. For the purpose of quality control measurement, a higher frequency may be required.

In addition, quality can vary significantly during a day. Samples should be taken at about the same time of the day. If daily variation is of special interest, sampling every 2 h or 3 h is recommended.

6.4 Choice of sampling method

The choice of sampling method depends on the objective of the sampling programme. Samples taken for special reasons or for quality control purposes will, in most cases, be grab samples. For monitoring water quality, a series of grab samples is used, but composite samples can be useful. The analysis of a series of grab samples can be costly and these are often combined to reduce analytical costs; however, composite samples will indicate only mean values and will not reveal details of extreme conditions or the extent of quality variation. Both methods may be combined by taking composite samples at short intervals and a series of samples at longer intervals.

6.5 Choice of the sampling device

The choice of the sampling device depends on the objective of the sampling program. Samples taken for special reasons or for quality control purposes will, in most cases, be grab samples (see Annex A for examples of sampling devices). For monitoring water quality, a series of grab samples is often used, but composite samples may be useful, especially for the investigation of defined water layers, e.g. the epilimnion or the euphotic zone. However, composite samples will indicate only mean values and will not reveal details of extreme conditions or the extent of quality variation.

Immersion probes may used for a continuous measurement of pH or dissolved oxygen in unstable water samples (Annex E).

6.6 Aids for recovery of lost sampling equipment

When handing sampling devices in small boats, there is an increased risk of losing equipment overboard. It is recommended that the trailing end of the tether line comprises of "floating rope" to aid recovery should the equipment be lost in shallow waters. Floating ropes are designed as safety products that remain near the surface for easy capture and recovery of objects to which they are attached. They are readily available for a range of safety applications and load ratings.

6.7 Blank sample

When collecting and processing water samples, it is necessary to include blank samples such as field blanks, travel blanks and filter blanks to measure the degree of contamination that may have been introduced into the samples as a result of sampling related activities. Detailed guidance on the use of blanks and other quality control samples is given in ISO 5667-14.

6.8 Transport, stabilization and keeping of samples

ISO 5667-3 gives general guidance on sample handling and preservation.

Ensure that sample containers are delivered to the laboratory tightly sealed and protected from the effects of light and excessive heat, because the quality may change rapidly due to gas exchange, chemical reactions and the metabolism of organisms. Ensure that samples which cannot be analysed quickly are filtered (if required by specific analytical method) and stabilized or preserved if required. The method of preservation shall be chosen to avoid interference with the parameters of interest and does not interfere with the subsequent examination or influence the results. Where particles or biological activity in the sample may be expected to influence parameters of interest, the sample may be filtered on site to remove particles or organisms and the filter held separately for analysis. For storage over short periods, cooling to 5 °C ± 3 °C may be applied; for keeping over longer periods, freezing to –18 °C is advisable. In the latter case, ensure the sample is completely thawed before use as the freezing process can have the effect concentrating some components of the inner part of the sample which freezes last. Samples may be preserved by the addition of chemicals. Record all preservation steps in the report. Measure and record the temperature on site. Ideally, other physical parameters (pH, for example) should be determined on site. If free carbon dioxide is present, measure the pH *in situ*.

7 Occupational health and safety

ISO 5667-1 specifies safety precautions including, but not limited to, sampling from boats and ice-covered waters.

NOTE The user's attention is drawn to the existence of national and/or local health and safety regulations.

8 Sample containers

Sample containers should be selected on the basis of the parameters to be analysed and be made of materials that do not lead to contamination of samples. ISO 5667-3 provides further guidance on the selection of sample containers. Depending on parameters to be analysed, sample containers can require laboratory pre-treatment, including acid-washing, cleaning or quality assurance/quality control procedures or on-site rinsing to be performed prior to use. Guidance should be sought from the analytical laboratory with respect to the selection and use of sampling containers and the volume of sample required to be collected. This guidance should be documented in formal, written protocols. Where containers are pre-treated, precautions should be taken to avoid exposure to chemicals used in the pre-treatment process.

9 Priority of procedure

Prior to taking samples, it is important to take the UTM-coordinates and water depth to ensure samples were collected in the correct location. This is typically the deepest point of the lake.

In order to reduce the risk of contamination of water samples, choose methods that reduce the number of water transfers between sample collection devices, filling devices and sample containers. In order of preference (see Table 1),

— conduct *in situ* measurement of parameters of interest,

— collect water samples using direct filling of sampling containers for *ex-situ* analysis without the use of sampling devices, funnels or other equipment,

— conduct indirect filling of sampling containers for *ex-situ* analysis where sampling devices are used to collect water samples that are later distributed directly into one or more sample containers, and

— conduct indirect collection of samples for *ex-situ* measurement, whereby sampling devices collect water samples that are later distributed into one or more sample containers.

In situ water quality measurements including dissolved oxygen, pH, water temperature, conductivity, turbidity and light penetration, by Secchi disk depth or light probe, can guide depth stratified sampling of thermally or chemically stratified waters by permitting pre-sampling assessment of the chemical and physical structure of the water column and therefore should be completed before the collection of physical water samples occurs. Depth measurements should be consistently repeated in stratified waters to ensure depth sensitive parameters such as pH and dissolved oxygen are sampled correctly.

Secchi disks can take a number of different forms including 30 cm diameter white and 20 cm diameter with every quarter of the disk alternating between black and white. Details of the disks and procedure are summarized in ISO 7027. A brief description is listed as follows.

a) Lower the Secchi disk to the point of disappearance.

b) Raise the disk until it reappears and then lower it until it disappears a second time.

c) Note the depth.

d) Repeat the procedure until a constant result is obtained.

Measurements should be taken such that environmental conditions, e.g. wind and glare from the sun, are minimized. Care shall be taken as to not disturb the sampling area (the use of an underwater viewscope can be desirable). If a motorized vessel with propeller is used, the engine should be shut off at least 10 m from the sampling area. Position and anchor the motorized vessel so that vessel does not contaminate the sampling area.