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Water quality — Sampling —

Part 6:
Guidance on sampling of rivers and streams

Qualité de l'eau — Echantillonnage —

Partie 6: Guide pour l'échantillonnage des rivières et des cours d'eau

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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 5667-6 was prepared by Technical Committee ISO/TC 147, *Water quality*.

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 sampling of wet deposition*
- *Part 9: Guidance on sampling from marine waters*
- *Part 10: Guidance on sampling of wastewaters*

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— *Part 11: Guidance on sampling of ground water*

— *Part 12: Guidance on sampling of industrial cooling water*

Annex A of this part of ISO 5667 is for information only.

Introduction

This part of ISO 5667 is one of a group of standards dealing with the sampling of specific types of water. It should be read in conjunction particularly with ISO 5667-1, ISO 5667-2 and ISO 5667-3, which deal respectively with the design of sampling programmes, sampling techniques and the preservation and handling of samples. The general terminology used is in accordance with that established by ISO/TC 147, *Water quality*, and more particularly, with the terminology on sampling given in ISO 6107-2.

Water quality — Sampling —

Part 6:
Guidance on sampling of rivers and streams

1 Scope

This part of ISO 5667 sets out the principles to be applied to the design of sampling programmes, sampling techniques and the handling of water samples from rivers and streams for physical, chemical and microbiological assessment. It does not apply to the sampling of estuarine or coastal waters and is of limited applicability to the sampling of canals and other inland waters with restricted flow regimes.

Examinations of sediment and biota require special procedures which are not the subject of this part of ISO 5667. In cases where naturally occurring or artificially constructed dams result in the detention of water for several days or more, it may be better to consider the stretch of the river or stream as a standing water body for sampling purposes. ISO 5667-4 provides guidance for sampling in these circumstances.

A definition of the purpose of sampling is an essential prerequisite to identifying the principles to be applied to a particular sampling problem. Examples of the purposes of sampling programmes commonly devised for rivers and streams are as follows:

a) to assess the quality of water within a river basin;

b) to determine the suitability of a river or stream as a source of drinking water;

c) to determine the suitability of a river or stream for agricultural use (e.g. spray irrigation, livestock watering);

d) to determine the suitability of a river or stream for the maintenance and/or development of fisheries;

e) to determine the suitability of a river or stream for amenity use (e.g. aquatic sports and swimming);

f) to study the effects of waste discharges or accidental spillages on a receiving water;

g) to assess the impact of land use on river or stream quality;

h) to assess the effect of the accumulation and release of substances
   — from bottom deposits on aquatic biota within the water mass, or
   — on bottom deposits;

i) to study the effects of abstraction, river regulation and river-to-river water transfers on the chemical quality of rivers and their aquatic biota;

j) to study the effects of river engineering works on water quality (eg. addition/removal of weirs, changes to channel/bed structure).

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 555-1:1973, *Liquid flow measurement in open channels — Dilution methods for measurement of steady flow — Part 1: Constant-rate injection method.*

ISO 555-2:1987, *Liquid flow measurement in open channels — Dilution methods for the measurement of steady flow — Part 2: Integration method.*

ISO 555-3:1982, *Liquid flow measurement in open channels — Dilution methods for measurement of steady flow — Part 3: Constant rate injection method and integration method using radioactive tracers.*

ISO 748:1979, *Liquid flow measurement in open channels — Velocity-area methods.*

ISO 1070:1973, *Liquid flow measurement in open channels — Slope-area method.*

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

ISO 5667-2:1982, *Water quality — Sampling — Part 2: Guidance on sampling techniques.*

ISO 5667-3:1985, *Water quality — Sampling — Part 3: Guidance on the preservation and handling of samples.*

ISO 5667-4:1987, *Water quality — Sampling — Part 4: Guidance on sampling from lakes, natural and man-made.*

ISO 6107-2:1989, *Water quality — Vocabulary — Part 2.*

ISO 8363:1986, *Liquid flow measurement in open channels — General guidelines for the selection of methods.*

ISO 7828:1985, *Water quality — Methods of biological sampling — Guidance on handnet sampling of aquatic benthic macro-invertebrates.*

ISO 8265:1988, *Water quality — Design and use of quantitative samplers for benthic macro-invertebrates on stony substrata in shallow freshwaters.*

3 Definitions

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

3.1 river: A natural body of water flowing continuously or intermittently along a well-defined course into an ocean, sea, lake, inland depression, marsh or other watercourse. [ISO 6107-2]

3.2 stream: Water flowing continuously or intermittently along a well-defined course, as for a river, but generally on a smaller scale. [ISO 6107-2]

3.3 automatic sampling: A process whereby samples are taken either discretely or continuously, independently of human intervention, and according to a predetermined programme. [ISO 6107-2]

3.4 isokinetic sampling: A technique in which the sample from a water stream passes into the orifice of a sampling probe with a velocity equal to that of the stream in the immediate vicinity of the probe. [ISO 6107-2]

3.5 random sampling: Sampling where the chances of obtaining different concentration values of a determinand are precisely those defined by the probability distribution of the determinand in question.

3.6 systematic sampling: The commonest form of non-random sampling where the samples are taken at predetermined intervals, often equally spaced in time.

3.7 sampling site: The general area within a body of water from which samples are taken. [ISO 6107/2]

3.8 sampling point: The precise position within a sampling location from which samples are taken. [ISO 6107-2]

4 Sampling equipment

4.1 Materials

Polyethylene, polypropylene, polycarbonate and glass containers are satisfactory for most sampling situations, glass bottles having the advantages that the condition of their internal surface is more readily apparent and they may be sterilized prior to use in microbiological sampling situations.

Glass containers should be used when organic constituents are to be determined whereas polyethylene containers are preferable for sampling those determinands that are major constituents of glass (e.g. sodium, potassium, boron and silicon), and for sampling for trace metallic impurities. However, polyethylene containers may not be suitable for collecting samples to be subjected to some trace metallic analyses (e.g. mercury) and these containers should only be used if preliminary tests indicate acceptable levels of contamination.

If glass bottles are used for storing weakly buffered water, borosilicate rather than soda-glass containers should be chosen.

Refer to relevant standard analytical procedures for detailed guidance on the type of sample container to be used. For guidance on the cleaning of sample containers, refer to ISO 5667-3.

4.2 Types of apparatus

4.2.1 Surface samplers

For many applications concerned with the chemical sampling of rivers and streams, it is often sufficient to immerse an open-mouthed vessel (e.g. a bucket or can) just below the surface in order to collect the sample. In situations where it is essential to sample at specified depths below the surface (or where sampling for dissolved gases), it is imperative that other sampling devices are used (see 4.2.2 and 4.2.3).

When sampling surface layers for microbiological (particularly bacteriological) analyses, sampling bottles may be used that are similar to those used for potable water sampling. These usually have a capacity of at least 250 ml and are fitted with a large screw cap, ground glass or other sterilizable stopper, covered with thin aluminium foil. If screw caps are used, silicone rubber liners capable of withstanding autoclaving at 121 °C, or sterilization at 160 °C, should be used inside the cap. If the bacteriological contamination from the hand is a potential problem, a clamp or pole should be attached to the bottle (see 5.3.2).

4.2.2 Sealed immersion devices

These consist of sealed containers filled with air (or an inert gas) which is lowered on a cable to the required depth. The means of sealing (e.g. a ring bung) is then released such that the container is filled with water as the air (or inert gas) is displaced. If a suitable sample bottle is placed within the device, this can be used for dissolved gas sampling. The Dussart Flask[1] is an example of this type of sampling equipment.

4.2.3 Open tube or cylinder devices

This type of device consists of a tube or cylinder open at both ends, with tightly fitting hinged lids or stoppers which are left open during the lowering of the device to the required depth. The device is then activated by means of a weight dropped down a cable so that it releases a spring mechanism which closes the lids or inserts the stoppers. These devices are only effective if a free flow of water is able to pass through the tube or cylinder when unsealed. Examples of this type of device are Rutner[2], Kemmerer[3], Van Dorn[1] and Friedinger[4] sampling equipment.

Whilst these devices are suitable for sampling stagnant or low velocity watercourses, the Zukovsky [5][6] sampling device is more suitable for the sampling of fast flowing rivers and streams, since the open tube system is placed in the horizontal (rather than the vertical) plane, thus facilitating isokinetic sampling. In all other aspects, its operation is similar to the Friedinger sampling equipment.

4.2.4 Pumping devices

Pump systems often provide a convenient method of collecting samples and include submersible, suction and peristaltic devices. The choice of pumping system depends upon the particular sampling situation. Subclause 5.3 gives some advice on pump selection.

4.2.5 Automatic sampling machines

These devices can be used to advantage in many river and stream sampling situations, since they allow a continuous sample or a series of samples to be collected without manual intervention. They are particularly useful in preparing composite samples and studying variations in quality with time.

It is essential to ensure that sample instability does not lead to errors as a result of the longer storage time of samples (see also 5.4).

Automatic sampling devices may be of the discrete or continuous type and may be operated on a time or flow-proportional basis. The choice of the most suitable type of machine will be dependent on the particular sampling situation, for example, sampling in order to estimate the average load of dissolved trace metals in a river or stream may best be carried out using a continuous flow-proportional device, utilizing a peristaltic pumping system. Since automatic sampling machines use a variety of pumping systems, their choice depends upon the particular sampling situation (see 5.3 for guidance).

5 Sampling procedure

5.1 Sampling point selection

5.1.1 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 within the river basin, river or stream);

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

The purpose of sampling often precisely defines sampling sites (as in the case of the determination of the quality of an effluent discharge) but sometimes the purpose only leads to a general idea of the

sampling site, as in the characterization of quality in a river basin.

The choice of sampling sites for single sampling stations is usually relatively easy. For example, a monitoring station for a base-line record of water 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. Stations for monitoring water supply abstraction points may need to be fixed within narrow limits (i.e. in close proximity to the abstractions).

5.1.1.1 Importance of mixing

When the effects of a tributary, or an effluent, on the quality in a particular reach of the main stream are of interest, at least two sites are necessary, one just upstream of the confluence and the other sufficiently far downstream to ensure that mixing is complete.

The physical characteristics of the channels of watercourses largely control distances required for the complete mixing of effluents with stream flow.

Effluents mix in three dimensions in a stream, namely:

a) vertically (from top to bottom);

b) laterally (from one side to the other);

c) longitudinally (levelling out of peaks and troughs in the concentration of effluent constituents as water passes downstream).

The distances over which effluents mix in these three dimensions need to be considered in the selection of sampling sites and points and are affected by the water velocity. Tracer techniques using dyes can be useful in studying mixing processes and conductivity measurements can also be helpful.

Effluents discharged to most streams mix vertically completely within a kilometre. Normally a stream need not be sampled at more than one depth, although stratification may be induced in slow moving rivers and streams by thermal and other density effects. In these cases sampling at several depths may be necessary and preliminary tests should be carried out to assess the degree of stratification (see 5.1.2 for guidance).

The distance for complete lateral mixing is generally dependent on the occurrence of relatively sharp reverse bends, and is measured in kilometres rather than fractions of a kilometre. Therefore, to obtain representative samples a stream should be sampled at two or more points across its width at sites downstream from an effluent or tributary discharge.

Consideration of longitudinal mixing distances can be important in deciding on the frequency of sampling. To give representative results just below an irregular discharge, more frequent sampling will be required than would be necessary some distance downstream where longitudinal mixing has been completed to a greater extent.

It is recommended that the distance for complete mixing to within 1 % of complete homogeneity be calculated approximately using the following formula (see ISO 555-2):

$$l = \frac{0{,}13b^2c\left(0{,}7c + 2\sqrt{g}\right)}{gd}$$

where

l is the length of mixing reach, in metres;

b is the average width of reach, in metres;

c is the Chezy coefficient for reach ($15 < c < 50$);

g is the acceleration due to gravity, in metres per second squared;

d is the mean depth of reach, in metres.

It should be noted that some tests have shown that the above expression can underestimate the mixing length for small streams of about 5 m in width and overestimate the mixing length for rivers of about 50 m in width.

5.1.1.2 Consideration of time of travel

Time-of-travel data may often be of relevance to the choice of sampling location. For example, sampling sites may have to be arranged to allow certain constituents or pollutants to be traced through a system, particularly from a discrete source of pollution. This necessitates a knowledge of the residence time within the system under investigation (i.e. the time of travel). Knowledge of the time of travel is also important in sampling studies to investigate the rate of change of unstable constituents (e.g. in the selfpurification of a water body, the time of travel can provide information on kinetic rate coefficients).

In determining the time of travel one of the three principal methods should be used, namely the use of surface floats (ISO 748), use of tracers (ISO 555, ISO 555-2 and ISO 155-3) or measurement of flow with a knowledge of cross-sectional areas (ISO 748 and ISO 1070).

Measurements should be made at a minimum of five different flow rates and the resulting times of travel plotted against the corresponding flow rates, thereby enabling other travel times to be obtained by extrapolation or interpolation. However, extrapolation outside 10 % of a measured flow rate value may provide inaccurate information on time of travel.

Refer to ISO 5667-1 for general guidance on time of travel and also to ISO 8363 for guidance on the measurement of liquid flow in open channels.

5.1.2 Choice of sampling point

Problems arise in selecting suitable sampling sites whenever the determinands are not homogeneously distributed throughout the water body of interest. In general, such sampling sites are best avoided, except when the sites themselves are of direct interest, as they may not yield representative samples of the major part of the water body. If there is any possibility of a non-homogeneous distribution of the determinands of interest at the chosen site, experimental tests on the nature and magnitude of any heterogeneity in all three dimensions should be made. If such tests show that the determinands are distributed homogeneously, any sampling point will suffice. Otherwise another site should be sought where the determinands are homogeneously distributed. If it is impossible to find such a sampling site, samples should be taken from sufficient points at the chosen site to ensure representative results.

These samples may often be combined as sub-samples to form one single composite sample representative of the quality at the sampling location, so that it is not necessary to analyse individual samples taken from each of the sampling points. However, this provides no information on the variability in quality between the sampling points. In addition, the combination of sub-samples in this way cannot be undertaken when sampling for dissolved gases or other volatile constituents.

5.2 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 magnitude of the tolerable error, a statistically-based sampling programme is impossible. For details of the application of statistics to sampling frequency refer to ISO 5667-1.

Where cyclic or other persistent variations are present, better precision should be sought in estimating mean concentrations by systematic rather than by random sampling (for any given number of samples), provided that the sampling interval is short enough for consecutive samples to reveal the variations.

When using systematic sampling it is essential to ensure that the frequency of sampling does not coincide with any natural cycle present in the system, or with some other time-based effect (e.g. a pump just upstream starting once an hour, a study of the effects of which are not part of the sampling objectives).

In river systems, regular cyclic variations in water quality may occur with, for example, periods of one day, one week and one year. When these occur, sampling times should be carefully chosen to assess the nature of these variations. If these variations are not persistent or if the amplitude is appreciably smaller than random variations, it will usually be adequate to choose the sampling times randomly, or alternatively in a systematic manner with samples evenly distributed throughout the period of interest. Otherwise, the times should be chosen so that different parts of the cycle are sampled, unless the extreme concentrations are of interest, when samples should be taken at the corresponding times of each cycle. Refer to ISO 5667-1 for further guidance.

5.3 Choice of sampling method

5.3.1 Physical chemical sampling

In cases where sub-surface sampling is acceptable (e.g. within 50 cm of the water surface), it is often sufficient to immerse a container (e.g. a bucket or can) in the river or stream of interest. The contents are then poured into appropriate sample bottles. Alternatively, the sample bottles or containers may be directly immersed in the river or stream. However, sampling of surface films should be avoided, unless these are particularly required for analysis.

When sampling from specified depths is required, special sampling equipment, which is lowered into the water to enable a sealed sample from the chosen depth, should be used. (See 4.2.2 and 4.2.3)

Sampling systems for rivers should be carefully selected and installed to avoid blockage of the inlet by debris in the water. The inlet should be protected by surrounding it with both a coarse and a fine mesh; frequent inspection and removal of accumulated debris may be required and these factors should be borne in mind when selecting the sampling point. The sampler inlet should also provide a minimum resistence to flow.

Sampling systems at exposed locations (e.g. on river banks) may need protection from vandalism and effects such as extremes of temperature. When pumps are required, submersible rather than suction-type pumps should be used in situations where dissolved gases are of interest. It should also be noted that dissolved gases will be released and entrain suspended solids on rising to the surface, when subjected to reduced pressure by the suction of a pump. The first part of the sample should, therefore, be run to waste when using such pumping systems. This effect may also occur when a peristaltic pump is used, as in many portable automatic samplers. However, it is recommended that whenever sampling for dissolved gases is of primary