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Water quality — Sampling —

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

Qualité de l'eau — Échantillonnage —

Partie 1: Recommandations relatives à la conception des programmes et des techniques d'échantillonnage

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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).

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For an explanation of 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 www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 147, *Water quality*, Subcommittee SC 6, *Sampling management*.

This third edition cancels and replaces the second edition (ISO 5667-1:2006), which has been technically revised. The main changes compared to the previous edition are as follows:

— incorporation of updated references;

— addition of a section on variation from normal sampling conditions;

— expansion of Clause 7 on sampling from specific types of water;

— introduction of a clause on passive sampling;

— incorporation of sample container provisions in Clause 12;

— expansion of Clause 15 to address data management;

— addition of annexes on field documentation, emerging sampling techniques, preparation of sampling equipment.

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

Any feedback or questions on this document should be directed to the user’s national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Water quality — Sampling —

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

1 Scope

This document sets out the general principles for, and provides guidance on, the design of sampling programmes and sampling techniques for all aspects of sampling of water (including waste waters, sludges, effluents, suspended solids and sediments).

It does not include detailed instructions for specific sampling situations, which are covered in the various other parts of ISO 5667 and in ISO 19458.

2 Normative references

There are no normative references.

3 Terms and definitions

No terms and definitions are listed in this document.

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

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

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

4 General safety precautions

Attention is drawn to the requirements of national and/or regional health and safety regulations.

The following are general examples of safety considerations.

4.1 Safety of Personnel

The enormously wide range of conditions encountered in sampling water bodies and bottom sediments can subject sampling personnel to a variety of safety and health risks. Precautions should be taken to avoid inhalation of toxic gases and ingestion of toxic materials through the nose, mouth and skin. Personnel responsible for the design of sampling programmes and for carrying out sampling operations should ensure that sampling personnel are informed of the necessary precautions to be taken in sampling operations.

Weather conditions should be taken into account in order to ensure the safety of personnel and equipment and it is essential that life jackets and lifelines should be worn when sampling large masses of water. Before sampling from ice-covered waters, the location and extent of weak ice should be carefully checked. If self-contained underwater breathing apparatus or other diving equipment is used, it should always be checked and maintained in accordance with relevant ISO or national standards to ensure reliability.

Boats or platforms used for sampling purposes should be capable of being maintained in a stable condition. In all waters, precautions should be taken in relation to commercial ships and fishing vessels; for example, the correct signal flags should be flown to indicate the nature of the work being undertaken.

Sampling from unsafe sites, such as unstable river banks, should be avoided wherever possible. If this is not possible, the operation should be conducted by a team using appropriate precautions rather than by a single operator. Wherever possible, sampling from bridges should be used as a substitute for bank sampling unless bank conditions are the specific subject of the sampling study.

Safe access to sampling sites in all weather is essential for frequent routine sampling. Where relevant, precautions should be taken where additional natural hazards are present, such as fauna or flora, that can endanger the health or safety of personnel.

Hazardous materials (e.g. bottles containing concentrated acids) should be properly labelled.

If instruments or other items of equipment are to be installed on a river bank for sampling purposes, locations that are susceptible to flooding or vandalism should be avoided or appropriate precautions taken.

Many other situations arise during the sampling of water when special precautions should be taken to avoid accidents. For example, some industrial effluents can be corrosive or can contain toxic or flammable materials. The potential dangers associated with contact with sewage should also not be overlooked; these can be gaseous, microbiological, radiological, virological or zoological, such as from amoebae or helminthes.

Gas protection equipment, breathing apparatus, resuscitation apparatus and other safety equipment should be available when sampling personnel need to enter sampling locations containing hazardous atmospheres. In addition, the concentration of oxygen and of any likely toxic or asphyxiating vapour or gas likely to be present should be measured before personnel enter enclosed spaces.

In the sampling of steam and hot discharges, special care is necessary, and recognized sampling techniques designed to remove hazards should be applied.

The handling of radioactive samples requires special care, and the special techniques required should be strictly applied.

The use of electrically operated sampling equipment in or near water can present special electrocution hazards. Work procedures, site design and equipment maintenance should be planned so as to minimize these hazards. Where appropriate, specific materials and equipment, e.g. 'Atmosphere Explosible' equipment, should be used.

4.2 General environmental considerations

Whilst working in the field environmental protection should be observed. In any sampling activity there should be measures taken to avoid environmental impacts on the sampling site surroundings and the working space.

Measures should be designed to avoid any harm to flora and fauna when installing equipment using machinery (subsoil compaction) or when developing the access and egress form the site.

5 Design of sampling programmes

5.1 General

Whenever a volume of water, suspended solids, bottom sediment or sludge is to be characterized, it is generally impossible to examine the whole and it is therefore necessary to take samples.

Samples are collected and examined primarily for the following reasons:

a) to determine the concentration of associated physical, chemical, microbiological, biological and radiological parameters in space and time;

b) with bottom sediments, to obtain a visual indication of their nature;

c) to estimate the flux of material;

d) to assess trends over time or over space;

e) for conformance with, or attainment of, criteria, standards or objectives.

Sampling programmes, the outcome of which will be estimates of summary statistics and trends, should be designed in full awareness of the issues of statistical sampling error and the techniques by which these errors are quantified and how they are used to take decisions.

The samples collected should be as representative as possible of the whole to be characterized, and all precautions should be taken to ensure that, as far as possible, the samples do not undergo any changes in the interval between sampling and analysis (see ISO 5667-3 for additional guidance). The sampling of multiphase systems, such as water containing suspended solids or immiscible organic liquids, can present special problems and in such cases, specific advice should be sought (see Clause 6).

5.2 Sampling personnel

Attention is drawn to the fact that certification and accreditation of the sampling process and the individuals implementing it may be required or recommended at national level. Also refer to 7.1.6, ISO 5667-14 and ISO 5667-24.

5.3 Broad objectives for the design of sampling programmes

Before any sampling programme is devised, it is very important that the objectives of the programme are carefully established since they are the major factors in determining the position of sampling sites, frequency of sampling, duration of sampling, sampling procedures, subsequent treatment of samples and analytical requirements. The degree of accuracy and precision necessary for the estimation of water quality concentrations sought should also be taken into account, as should the manner in which the results are to be expressed and presented, for example, as concentrations or mass loads, maximum and/or minimum values, arithmetic means, median values, etc. The sampling programme should be designed to be capable of estimating the error in such values as affected by statistical sampling error and errors in chemical analysis.

Additionally, a list of parameters of interest should be compiled and the relevant analytical procedures consulted since these might give guidance on precautions to be observed during sampling and subsequent handling (general guidance on handling of samples is given in ISO 5667-3).

It can often be necessary to carry out a preliminary sampling and analysis programme before the final objectives can be defined. It is important to take into account all relevant data from previous programmes at the same or similar locations and other information on local conditions. Previous personal experience of similar programmes or situations can also be very valuable when setting up a new programme for the first time. Putting sufficient effort in time and money into the design of a proper sampling programme is a good investment that will ensure that the required information is obtained both efficiently and economically; failure to put proper effort into this aspect can result in either failure of the programme to achieve its objectives and/or over-expenditure of time and money.

Three broad objectives can be distinguished as follows (these are covered in more detail in 8.2, 8.3 and 8.4):

— quality control measurements within water or waste water treatment plants used to decide when short-term process corrections are required;

— quality characterization measurements used to estimate quality, perhaps as part of a research project, for setting and measuring performance targets against regulatory targets, for long-term control purposes or to indicate long-term trends;

— identification and control of sources of contamination.

The purpose of the programme can change from quality characterization to quality control and vice-versa. For example, a longer-term programme for nitrate characterization might become a short-term quality control programme requiring increased frequency of sampling as the nitrate concentration approaches a critical value.

No single sampling study can satisfy all possible purposes. It is therefore important that specific sampling programmes are optimized for specific study purposes, such as the following:

a) to determine the suitability of water for an intended use and, if necessary, to assess any treatment or control requirements, for example, to examine borehole water for cooling, boiler feed or process purposes or, if a natural spring, as a possible source of water intended for human consumption;

b) to study the effect of waste discharges, including accidental spillages, on a receiving water;

c) to assess the performance and control of water, sewage and industrial effluent plants, for example

   1) to assess the variations and long-term changes in load entering a treatment works,

   2) to determine the efficiency of each stage in a treatment process,

   3) to provide evidence of quality of treated water,

   4) to control the concentration of treated substances including those which can constitute a health hazard or which can inhibit a bacteriological process, and

   5) to control substances which can damage the fabric of plant or equipment;

d) to study the effects of fresh and saline water flows on estuarine conditions in order to provide information on mixing patterns and associated stratification with variations in tides and freshwater flow;

e) to identify and quantify products lost from industrial processes; this information is required when product balances across the plant are to be assessed and when effluent discharges are to be measured;

f) to establish the quality of boiler water, steam condensate and other reclaimed water, enabling its suitability for a particular intended purpose to be assessed;

g) to control the operation of industrial cooling water systems; this enables the use of water to be optimized and, at the same time, the problems associated with scale formation and corrosion to be minimized;

h) to study the effects of atmospheric contaminants on the quality of rainwater; this provides useful information on air quality and also indicates if problems are likely to arise, for example, on exposed electrical contacts;

i) to assess the effect of inputs from the land on water quality from naturally occurring materials, or contamination by fertilizers, pesticides and chemicals used in agriculture, or both;

j) to assess the effect of the accumulation and release of substances by bottom sediments on the aquatic biota in the water mass or bottom sediment;

k) to study the effect of abstraction, river regulation and river-to-river transfers on natural water-courses; for example, varying proportions of waters of different quality can be involved in river regulation and the quality of the resulting blend can fluctuate;

l) to assess changes in water quality which occur in distribution systems for water for human consumption; these changes can occur for a number of reasons, for example, contamination, introduction of water from a new source, biological growths, deposition of scale or dissolution of metal;

m) to gather information for compiling pollution load estimations of river catchment areas as well as information about the significance of different pollution sources:

n) to assess the effect of anthropogenic changes (global warming, ocean acidification, eutrophication, dust storms, etc.) on the water quality in marine environments and long term variations in biogeochemical cycling and spatio-temporal distribution of environmentally important components (nutrients, dissolved gases, contaminants, suspended solids, etc).

On some occasions, the conditions can be sufficiently stable and the forms of variability understood for the required information and the accompanying estimates of errors to be obtained from a simple sampling programme. But, in most locations, quality characteristics are subject to continuous variations in time and space and, ideally, assessment should also be continuous. However, this is often very costly and in many situations impossible to achieve. In the absence of continuous low-error monitoring, and in the use of data collected by sampling, it is vital to take account of sampling error. When considering sampling programmes, the special considerations given in 5.4 should be borne in mind.

5.4 Specific considerations in relation to variability

Sampling programmes can be complex in situations and locations where wide, rapid and continuous variations occur in characteristics such as the concentrations of parameters of interest. These variations can be caused by such factors as extreme changes in temperature, flow patterns or plant operating conditions (as well as in things like chemical analysis). The design of any sampling programme should take this variability into account, either by means of continuous assessment (see Figure A.1) (although this is often very costly and in many situations impossible to achieve), or by taking into account the following recommendations.

a) The programme should be set in terms of the requirements of techniques that allow the estimation of statistical sampling error.

b) Sampling should be avoided at or near boundaries of systems unless those conditions are of special interest.

c) Care should be taken to eliminate or minimize any changes in the concentration of parameters of interest that might be produced by the sampling process itself, and to ensure that changes during the period between sampling and analysis are avoided or minimized. For detailed guidance on these issues, reference should be made to ISO 5667-14.

d) Composite sampling may be used to give the best indication of the average composition over a period of time, provided that the parameter being measured is stable during the period of sampling and examination. Data derived from composite sampling should be considered a specific data type in databases so that this type of data is not confused with discrete samples. It should be borne in mind that composite samples are of little value in determining transient peak conditions.

In situations of extreme variability of flow, or concentration, or both (for example, intermittent plant effluents), there may be a benefit in studying the discharge or flow parameters to ascertain whether a pattern is evident, before committing to a particular sampling programme.

5.5 Identifying the sampling location

Depending on the objectives to be achieved (see 5.3), the sampling network can be anything from a single site to, for example, an entire river catchment. A basic river network can comprise sampling sites at the tidal limit, major tributaries at its confluence and major discharges of sewage or industrial effluent.

In designing water quality sampling networks, it is usual to make provision for the measurement of flow at key stations (see Clause 9).

Identifying the sampling location enables comparative samples to be taken. In most river sampling situations, sampling locations can readily be fixed by reference to physical features on the river bank.

On uncovered estuarine and coastal shores, sampling locations can similarly be related to an easily recognizable static object. For sampling from a boat or ship in these situations, instrumental methods (e.g. global positioning system) for location identification should be used. Map references or other standard forms of reference can be valuable in achieving this.

6 Characteristics and conditions affecting sampling

6.1 General

Flow can change from streamlined to turbulent and vice-versa. Ideally, samples should be taken from turbulent, well-mixed liquids and whenever possible, turbulence should be induced in flows that are streamlined, except where samples for the determination of dissolved gases and volatile materials and volatile materials are to be collected, the concentration of which can be altered by induced turbulence.

Sampling staff should ensure that "reverse flow", which can occur from other parts of the system, does not produce contamination at the sampling point.

Discrete "slugs" of material can occur at any time, for example, dissolved contaminants, solids, volatile materials or oily surface layers. These should be captured within any sampling programme designed to produce valid and representative samples.

Where sampling from pipes is carried out, the liquids to be sampled should be pumped through pipes of adequate size and at linear velocities high enough to maintain turbulent flow characteristics. Horizontal pipe runs should be avoided. When sampling heterogeneous liquids, pipes with a minimum nominal bore of 25 mm should be used.

When liquids which are corrosive or abrasive are being sampled, resistance to these conditions should be taken into account. It should be borne in mind that the cheapest course is not necessarily to use expensive chemically-resistant equipment for short-term sampling if the equipment can readily be replaced and contamination of the sample by corrosive products is not likely to be significant.

Sampling programmes should be designed to take into account temperature variation over long or short periods, which can cause changes in the nature of the sample that can affect the effectiveness of equipment used for sampling.

The sampling of waters for suspended solids needs care with regard to monitoring and investigating freshwater quality and, more particularly, flowing freshwater systems such as rivers and streams.

Sampling for volatile constituents should be carried out with care. Material being sampled should be pumped with the minimum of suction lift. All pipework should be kept full of the water being sampled and the sample bled from a pressurized pipe after running some of the material to waste to ensure that the sample collected is representative.

The sampling of mixtures of waters of different densities should be carried out with care, for example, layering in a streamlined flow can take place with fresh water over saline water.

The possible presence of toxic liquids or fumes and the possible build-up of explosive vapours should always be taken into account in a sampling situation.

Changes in meteorological conditions can induce marked variations in water quality; such changes should be noted and allowance made for them when interpreting results.