International Standard ISO 5667/1

INTERNATIONAL ORGANIZATION FOR STANDARDIZATION•МЕЖДУНАРОДНАЯ ОРГАНИЗАЦИЯ ПО СТАНДАРТИЗАЦИИ•ORGANISATION INTERNATIONALE DE NORMALISATION

Water quality — Sampling — Part 1 : Guidance on the design of sampling programmes

Qualité de l'eau — Échantillonnage — Partie 1 : Guide général pour l'établissement des programmes d'échantillonnage

First edition — 1980-09-15

UDC 614.777 : 620.113

Ref. No. ISO 5667/1-1980 (E)

Descriptors : water, quality, sampling, sampling equipment, generalities.

Price based on 13 pages

ISO 5667/1-1980 (E)

Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 5667/1 was developed by Technical Committee ISO/TC 147, *Water quality*, and was circulated to the member bodies in June 1978.

It has been approved by the member bodies of the following countries :

Australia	India	South Africa, Rep. of
Austria	Ireland	Spain
Brazil	Italy	Sweden
Bulgaria	Japan	Switzerland
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The member body of the following country expressed disapproval of the document on technical grounds :

Belgium

Printed in Switzerland

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0 Introduction

This International Standard is the first of a group of three standards intended to be used in conjunction with each other. ISO 5667/2 and ISO 5667/3 deal respectively with sampling techniques and with the preservation and handling of samples. The general terminology used is in accordance with that established in ISO/TC 147, *Water quality*, and, more particularly, with the terminology on sampling given in ISO 6107/2.

1 Scope and field of application

This International Standard sets out the general principles to be applied in the design of sampling programmes for the purposes of quality control, quality characterization, and identification of sources of pollution of water, including bottom deposits and sludges. Detailed instructions for specific sampling situations will be given in subsequent International Standards.

2 References

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

ISO 3534, *Statistics — Vocabulary and symbols.*

ISO 5667/2, *Water quality — Sampling — Part 2 : General guidelines to sampling techniques.*[1)]

ISO 5667/3, *Water quality — Sampling — Part 3 : General recommendations for the preservation and handling of samples.*[1)]

ISO 6107/1, *Water quality — Vocabulary — Part 1.*

ISO 6107/2, *Water quality — Vocabulary — Part 2.*[1)]

1) At present at the stage of draft.

Section one : Definition of objectives

3 Introduction

The purpose of this section is to emphasise the more important factors which have to be considered when devising a sampling programme in relation to water, bottom deposits and sludges. More detailed information is given in subsequent sections. Samples are collected and examined primarily to determine associated physical, chemical, biological and radiological parameters.

Whenever a volume of water, bottom deposit or sludge is to be characterized, it is generally impossible to examine the whole and it is therefore necessary to take samples. The samples collected should be as fully 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. The sampling of multiphase systems, such as water containing suspended solids or immiscible organic liquids, can present special problems.

Before any sampling programme is devised, it is very important that the objectives be 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. Some consideration should also be given to the degree of detail and precision that will be adequate, and also the manner in which the results are to be expressed and presented, for example concentrations or loads, maximum and minimum values, arithmetic means, median values etc. Additionally, a list of parameters of interest should be compiled and the relevant analytical procedures consulted since these will usually give guidance on precautions to be observed during sampling and subsequent handling. (General guidance on the latter aspects is given in Parts 2 and 3 of this International Standard respectively.)

It may 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 can also be very valuable. Time and money allocated to the design of a proper sampling programme is usually well justified by ensuring that the required information is obtained efficiently and economically.

Three main objectives may be distinguished as follows (for details, see clause 15) :

a) quality control measurements used by local management to decide when short-term process corrections are required;

b) quality characterization measurements used to indicate quality, perhaps as part of a research project, for long-term control purposes, or to indicate long-term trends;

c) identification of sources of pollution.

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

4 Requirements

Without attempting to list all the specific reasons for requiring sampling and analysis programmes, they may be grouped as follows.

4.1 General requirements

To establish the order of concentration levels or loads of specific parameters at selected positions (for example at the surface of, or in, a body of water) or, with bottom deposits, to obtain a visual indication of their nature.

4.2 Specific requirements

To establish in detail the concentration levels or load distributions of physical or chemical parameters and biological species of interest throughout the whole or part of a body of water. This will normally be linked to a study of changes with time, flow rates, operating plant conditions, weather conditions etc.

These reasons for sampling may be further sub-divided into more specific objectives 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 drinking water.

b) To study the effect of waste discharges, including accidental spillages, on a receiving water. Apart from contributing to the pollution load, such discharges may produce other reactions such as chemical precipitation or evolution of gases.

c) To assess the performance and control of water, sewage and industrial effluent plants — for example : to assess the variations and long-term changes in load entering a treatment works; to determine the efficiency of each stage in a treatment process; to provide evidence of quality of treated water; to control the concentration of treated substances including those which may constitute a health hazard or which may inhibit a bacteriological process; to control substances which may 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. This enables the suitability of the water for an 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 pollutants 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.

j) To assess the effect of inputs from the land on water quality. There may be contributions from naturally occurring materials, or contamination by fertilizers, pesticides and chemicals used in agriculture, or both.

k) To assess the effect of the accumulation and release of substances by bottom deposits on the aquatic biota in the water mass or bottom deposit.

m) 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 may be involved in river regulation and the quality of the resulting blend may fluctuate.

n) To assess changes in water quality which occur in distribution systems. 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.

On some occasions the conditions may be sufficiently stable for the required information to be obtained from a simple sampling programme, but in most locations quality characteristics are subject to continuous variations and, ideally, assessment should also be continuous. However, this is often very costly and in many situations impossible to achieve. When considering sampling programmes, the special considerations given in clause 5 should be borne in mind.

5 Special considerations in relation to variability

5.1 Sampling programmes may be complex in situations where wide and rapid variations occur in the concentrations of determinands of interest. These variations may be caused by such factors as extreme changes in temperature, flow patterns or plant operating conditions. Sampling should be avoided at or near boundaries of systems unless conditions are of special interest.

5.2 Even when concentration changes are slow and not very marked, the assessment of a large catchment area, such as a river basin, is a complex exercise.

5.3 Care should be taken to eliminate or minimize any changes in the concentration of determinands of interest that may be produced by the sampling process itself, and to ensure that changes during the period between sampling and analysis are avoided or minimized.

5.4 Composite samples give the best indication of the average composition over a period of time provided that the determinand is stable during the period between sampling and examination, but they are of little value in determining transient peak conditions.

Section two : Identification of sampling situations

6 Introduction

This section deals with the various situations that may be encountered in sampling practice and the extent to which these situations affect the choice of a sampling site. Attention is drawn to the safety precautions necessary in various situations which, in view of their importance and general character, are set out in clause 7.

7 General safety precautions

7.1 The enormously wide range of conditions encountered in sampling waters and bottom deposits can subject personnel to a variety of safety and health risks. Apart from physical injury, precautions must be taken to avoid inhalation of toxic gases and ingestion of toxic materials through the mouth and skin.

Personnel responsible for the design of sampling programmes and for carrying out sampling operations must ensure that the requirements of relevant safety regulations are taken into account and that sampling personnel are informed of the necessary precautions to be taken in sampling operations.

NOTE — Insurance against accidents may need to be considered.

More specific situations are discussed below.

7.2 Weather conditions should be considered in order to ensure the safety of personnel and equipment. Life-jackets and life-lines 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 to ensure reliability.

7.3 Stability is an important property of any boat used for sampling purposes. 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.

7.4 Sampling from unsafe sites, such as unsafe banks, should be avoided if possible. If this is unavoidable, the operation should be conducted by a team using appropriate precautions rather than one operator. Sampling from bridges should be used when appropriate.

7.5 Reasonable access in all weather is important and it is essential for frequent routine sampling. In some situations, consideration should be given to additional natural hazards such as poisonous foliage, animals and reptiles.

7.6 If instruments or other items of equipment are installed on a river bank, situations susceptible to flooding or vandalism should be avoided, or appropriate precautions taken.

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

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

7.9 In the sampling of steam and hot discharges, special care is necessary and recognised techniques should be applied.

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

7.11 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.

8 Special considerations in sampling

8.1 Design of sampling programmes

Depending on the objectives to be achieved (see clause 6), the sampling network may be anything from a single site to an entire river catchment. A basic river network may comprise sampling sites at the tidal limit, major tributaries at their confluence, and major discharges of sewage or industrial effluent.

In designing quality sampling networks it is usual to make provision for the measurement of flow at key stations (see section 4).

8.2 Identifying the sampling location

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

On uncovered estuarine and coastal shores, sampling locations may similarly be related to an easily recognizable static object. For sampling from a boat in these situations, instrumental methods for location identification should be used. Map references or other standard forms of reference may be valuable.

8.3 Character of flow

Ideally, samples should be taken from turbulent, well-mixed liquids and, whenever possible, turbulence should be induced in flows that are streamlined. This does not apply to the collection of samples for the determination of dissolved gases and volatile materials, the concentration of which may be altered by induced turbulence.

8.4 Change in flow characteristics with time

Flow may change from streamlined to turbulent and vice-versa. "Reverse flow" from other parts of the system may occur which could produce contamination at the sampling point.

8.5 Change of liquid composition with time

Discrete "slugs" of material may occur at any time, for example, dissolved contaminants, solids, volatile materials or oily surface layers.

8.6 Sampling from pipes

Liquids should be pumped through pipes of adequate size (for example, when sampling heterogeneous liquids, of minimum nominal bore 25 mm) at linear velocities high enough to maintain turbulent flow characteristics. Horizontal pipe runs should be avoided.

8.7 Nature of the liquid

The liquid may be corrosive or abrasive. Resistance to these conditions should be considered. 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 corrosion products is not likely to be important.

8.8 Temperature changes occurring in sampling systems

Temperature variation over long or short periods may cause changes in the nature of the sample that may affect the equipment used for sampling.

8.9 Sampling for determination of suspended solids

Solids may be distributed anywhere throughout the depth of a liquid. Adequate mixing should be carried out, if possible, by maintaining turbulent conditions. Ideally, the linear velocity should be sufficient to induce turbulence and samples should be taken under isokinetic conditions (see ISO 6107/2). If this is not possible, a series of samples should be taken across a full cross-section of the flow. It should be remembered that the size distribution of suspended solids may change during the time necessary to complete the sampling.

8.10 Sampling for volatile compounds content

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

8.11 Mixtures of waters of different densities

These can cause layering in a streamlined flow, for example the production of a layer of warm water over cold water or of fresh water over saline water.

8.12 Hazardous liquids

It is necessary to consider the possibility of the presence of toxic liquids or fumes, or both, and the possible build-up of explosive vapours.

8.13 Effect of meteorological conditions

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

9 Individual sampling situations — Natural waters

9.1 Precipitation

When samples of precipitation are collected for chemical analysis, the sampling site should be selected to avoid contamination by extraneous matter, for example dust, fertilizers, pesticides, etc. The sampling apparatus should preferably be placed in a lawn.

If the sample is frozen or consists of snow or hail, the funnel should preferably be kept warm by, for example, an electric heating element. Where this is not possible, the entire apparatus should be removed and thawed at low temperatures.

9.2 Estuaries, coastal waters, seas and oceans

9.2.1 Extent and depth

The boundaries of the area under investigation should be clearly defined and consideration given to the relation of the area to adjacent areas of water. Selection of sampling sites and positions should take into account the fact that tidal currents and their modification by wind, density, bottom roughness, shore line proximity and shipping can all produce considerable disturbance within the water and variation in water quality at the designated sampling site. In addition, the effect upon sampling of any local discharges should be carefully considered.

9.2.2 Use of boats

Boats, when used, should be capable of reaching all sampling positions within the time-limits of the survey in suitable weather conditions.

9.2.3 Ice cover

In water under ice cover, a restricted inverse thermal stratification develops with a thin layer (about 5 mm) of cold water at 0 to 3 °C on top of the main mass of water at 4 °C. Steep