भारतीय मानक

Indian Standard

IS 17614 (Part 1) : 2024
ISO 5667-1 : 2023

जल की गुणवत्ता — नमूने लेना

भाग 1 नमूने लेने की तकनीकों और नमूने लेने के कार्यक्रमों के डिज़ाइन पर मार्गदर्शन

(पहला पुनरीक्षण)

Water Quality — Sampling

Part 1 Guidance on the Design of Sampling Programmes and Sampling Techniques

(First Revision)

ICS 13.060.45

भारतीय मानक ब्यूरो
BUREAU OF INDIAN STANDARDS
मानक भवन, 9 बहादुर शाह ज़फर मार्ग, नई दिल्ली - 110002
MANAK BHAVAN, 9 BAHADUR SHAH ZAFAR MARG
NEW DELHI - 110002
www.bis.gov.in www.standardsbis.in

November 2024 **Price Group 14**

Water Quality Sectional Committee, CHD 36

NATIONAL FOREWORD

This Indian Standard which is identical to ISO 5667-1 : 2023 'Water quality — Sampling — Part 1: Guidance on the design of sampling programmes and sampling techniques' issued by the International Organization for Standardization (ISO) was adopted by the Bureau of Indian Standards on the recommendation of Water Quality Sectional Committee and approval of the Chemical Division Council.

The Indian Standard IS 17614 has been published in several parts under the general title 'Water quality — Sampling'. This part of IS 17614 specifies the general principles for, and provides guidance on, the design of sampling programmers and sampling techniques for all aspects of sampling of water (including waste waters, sludges, effluents, suspended solids and sediments). The other parts of this series are:

IS No.	*Title*
IS 17614	Water quality — Sampling
Part 3 : 2021	Preservation and handling of water samples
Part 4 : 2021	Guidance on sampling from lakes, natural and man-made
Part 5 : 2021	Guidance on sampling of drinking water from treatment works and piped distribution systems
Part 6 : 2021	Guidance on sampling of rivers and steams
Part 7 : 2021	Guidance on sampling of water and steam in boiler plants
Part 8 : 2021	Guidance on the sampling of wet deposition
Part 9 : 2021	Guidance on sampling from marine waters
Part 10 : 2021	Guidance on sampling of waste water
Part 12 : 2022	Guidance on sampling of bottom sediments from rivers, lakes and estuarine areas
Part 13 : 2021	Guidance on sampling of sludges
Part 14 : 2021	Guidance on quality assurance and quality control of environmental water sampling and handling
Part 15 : 2021	Guidance on the preservation and handling of sludges and sediment samples
Part 16 : 2021	Guidance on biotesting of samples
Part 17 : 2022	Guidance on sampling of bulk suspended solids
Part 19 : 2021	Guidance on sampling of marine sediments
Part 20 : 2021	Guidance on the use of sampling data for decision making compliance with thresholds and classification systems
Part 21 : 2021	Guidance on sampling of drinking water distributed by tankers or means other than distribution pipes
Part 22 : 2021	Guidance on the design and installation of groundwater monitoring points
Part 23 : 2021	Guidance on passive sampling in surface waters

(*Continued on third cover*)

Contents

Page

1 **Scope** 1
2 **Normative references** 1
3 **Terms and definitions** 1
4 **General safety precautions** 1
4.1 General 1
4.2 Safety of personnel 1
4.3 General environmental considerations 2
5 **Design of sampling programmes** 2
5.1 General 2
5.2 Sampling personnel 3
5.3 Broad objectives for the design of sampling programmes 3
5.4 Specific considerations in relation to variability 5
5.5 Identifying the sampling location 5
6 **Characteristics and conditions affecting sampling** 6
6.1 General 6
6.2 Variations from normal sampling conditions 7
7 **Standards for sampling from water** 7
7.1 Introduction 7
7.2 General standards in the 5667 series 7
7.2.1 General 7
7.2.2 ISO 5667-3, Water quality — Sampling — Part 3: Preservation and handling of water samples 7
7.2.3 ISO 5667-14, Water quality — Sampling — Part 14: Guidance on quality assurance and quality control of environmental water sampling and handling 7
7.2.4 ISO 5667-15, Water quality — Sampling — Part 15: Guidance on the preservation and handling of sludge and sediment samples 7
7.2.5 ISO 5667-16, Water quality — Sampling — Part 16: Guidance on biotesting of samples 8
7.2.6 ISO 5667-20, Water quality — Sampling — Part 20: Guidance on the use of sampling data for decision making — Compliance with thresholds and classification systems 8
7.2.7 ISO 5667-24, Water quality — Sampling — Part 24: Guidance on the auditing of water quality sampling 8
7.2.8 ISO/TS 5667-25, Water quality — Sampling — Part 25: Guideline on the validation of the storage time of water samples 8
7.3 Standards outside the 5667 series that provide guidance on sampling programmes in specific areas 9
7.3.1 General 9
7.3.2 ISO 19458, Water quality — Sampling for microbiological analysis 9
7.4 Standards within the ISO 5667 series providing specific guidance on the sampling of a range waters 9
7.4.1 General 9
7.4.2 ISO 5667-4, Water quality — Sampling — Part 4: Guidance on sampling from lakes, natural and man-made 9
7.4.3 ISO 5667-5, Water quality — Sampling — Part 5: Guidance on sampling of drinking water from treatment works and piped distribution systems 9
7.4.4 ISO 5667-6, Water quality — Sampling — Part 6: Guidance on sampling of rivers and streams 10
7.4.5 ISO 5667-7, Water quality — Sampling — Part 7: Guidance on sampling of water and steam in boiler plants 10

7.4.6 ISO 5667-8, Water quality — Sampling — Part 8: Guidance on the sampling of wet deposition 10
7.4.7 ISO 5667-9, Water quality — Sampling — Part 9: Guidance on sampling from marine waters 10
7.4.8 ISO 5667-10, Water quality — Sampling — Part 10: Guidance on sampling of waste water 11
7.4.9 ISO 5667-11, Water quality — Sampling — Part 11: Guidance on sampling of groundwaters 11
7.4.10 ISO 5667-12, Water quality — Sampling — Part 12: Guidance on sampling of bottom sediments from rivers, lakes and estuarine areas 11
7.4.11 ISO 5667-13, Water quality — Sampling — Part 13: Guidance on sampling of sludges 11
7.4.12 ISO 5667-17, Water quality — Sampling — Part 17: Guidance on sampling of bulk suspended solids 12
7.4.13 ISO 5667-19, Water quality — Sampling — Part 19: Guidance on sampling in marine sediments 12
7.4.14 ISO 5667-21, Water quality — Sampling— Part 21: Guidance on sampling of drinking water distributed by tankers or means other than distribution pipes 12
7.4.15 ISO 5667-22, Water quality — Sampling — Part 22: Guidance on the design and installation of groundwater monitoring points 13
7.4.16 ISO 5667-26, Water quality — Sampling — Part 26: Guidance on sampling for the parameters of the oceanic carbon dioxide system 13

8 Time and frequency of sampling 13
8.1 General 13
8.2 Water quality management programmes 14
8.3 Quality characterization programmes 14
8.4 Programmes for investigation of causes of contamination 14
8.5 Statistical considerations 14
8.5.1 Establishment of sampling programmes 14
8.5.2 Random and systematic variations of water quality 15
8.6 Duration of sampling occasion and composite samples 16

9 Flow measurements and situations justifying flow measurements for water quality purposes 16
9.1 General 16
9.2 Direction of flow 16
9.3 Velocity of flow 17
9.4 Discharge rate 17
9.5 Flow profile 17
9.6 Cross-sectional area 17
9.7 Justification for flow measurements in water quality control management 17
9.7.1 Treatment plant loads 17
9.7.2 Dilution effects (flux calculations) 18
9.7.3 Mass flow calculations 18
9.7.4 Transport of contaminants and rates of recovery 18
9.7.5 Flow-related parameters 18
9.7.6 Groundwaters 18
9.8 Methods available for flow measurement 18

10 Current sampling techniques 19
10.1 General 19
10.2 Spot samples 20
10.3 Periodic samples (discontinuous) 20
10.3.1 Periodic samples taken at fixed time-intervals (time-dependent) or constant time constant volume (CTCV) sampling 20
10.3.2 Periodic samples taken at fixed flow-intervals (volume-dependent) or constant time variable volume (CTVV) sampling 20

10.3.3 Periodic samples taken at fixed flow-intervals (flow-dependent) or constant volume variable time (CVVT) sampling 21
10.4 Continuous samples 21
10.4.1 Continuous samples taken at fixed flow rates (time-continuous sampling) 21
10.4.2 Continuous samples taken at variable flow rates (flow-continuous sampling) 21
10.5 Series sampling 21
10.6 Composite samples 21
10.7 Large-volume samples 21

11 Passive sampling 22

12 Sampling equipment for physical or chemical characteristics 22
12.1 General 22
12.2 Sampling containers 23
12.2.1 General 23
12.2.2 Types of sample container 23
12.3 Equipment for spot sampling 24
12.4 Sampling equipment for sediments 24
12.4.1 Grab or dredge sampling 24
12.4.2 Core samplers 25
12.5 Sampling equipment for dissolved gases and volatile materials 25
12.6 Sampling equipment for radioactivity characteristics 25
12.7 Sampling equipment for biological and microbiological characteristics 26
12.8 Automatic sampling equipment 26
12.9 Sampling equipment for passive sampling 26
12.10 Sampling equipment for suspended sediments 27

13 Quality assurance and quality control of environmental water sampling and handling 27
13.1 General 27
13.2 Sources of contamination 27
13.3 Control or prevention of contamination 28

14 Transport to, and storage of samples at, the depot or laboratory 28

15 Sample identification and records 29
15.1 General 29
15.2 Data management 29
15.3 Samples that can be used for legal purposes 30

Annex A (informative) **Diagrams illustrating types of periodic and continuous sampling 31**

Annex B (informative) **Diagram illustrating types of field paperwork and labels 34**

Annex C (informative) **Alternative and emerging sampling techniques 36**

Annex D (informative) **Preparation of sampling equipment 38**

Bibliography 39

Indian Standard

WATER QUALITY — SAMPLING

PART 1 GUIDANCE ON THE DESIGN OF SAMPLING PROGRAMMES AND SAMPLING TECHNIQUES

(First Revision)

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).

This document does not include detailed instructions for specific sampling situations, which are covered in various other parts of the ISO 5667 series 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 terminology databases for use in standardization at the following addresses:

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

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

4 General safety precautions

4.1 General

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

The following are general examples of safety considerations.

4.2 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, for example, ‘atmosphere explosible’ equipment, should be used.

4.3 General environmental considerations

While 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 can be required or recommended at national level. Also refer to 7.2.6, 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 parameter 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 can 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 can 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 can 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 (e.g. 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.

6.2 Variations from normal sampling conditions

Where sampling conditions are found to be different from those expected or normally encountered, personnel carrying out the sampling should consult as necessary before proceeding further.

7 Standards for sampling from water

7.1 Introduction

Attention is drawn to ISO 5667-23, which is not included in this clause. See Clause 11.

7.2 General standards in the 5667 series

7.2.1 General

The following standards provide general guidance on the design of sampling programmes that are used in conjunction with the specific sampling standards detailed in 7.4. These are regularly reviewed and updated so the user should always ensure that the latest versions are being referred to.

7.2.2 ISO 5667-3, Water quality — Sampling — Part 3: Preservation and handling of water samples

ISO 5667-3 is intended to be used in conjunction with ISO 5667-1, and specifies general requirements for sampling, preservation, handling, transport and storage of all water samples including those for biological analyses. It is not applicable to water samples intended for microbiological analyses as specified in ISO 19458, ecotoxicological assays, biological assays and passive sampling as specified in the scope of ISO 5667-23.

ISO 5667-3 is particularly appropriate when spot or composite samples cannot be analysed on site and have to be transported to a laboratory for analysis.

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

ISO 5667-14 is one of a group of International Standards dealing with the sampling of waters and should be read in conjunction with the other parts of the ISO 5667 series and in particular with ISO 5667-1 and ISO 5667-3. This part specifies quality assurance and quality control procedures and provides additional guidance on sampling of the various types of water covered in the specific parts of the ISO 5667 series.

It also provides guidance on the selection and use of various quality assurance and quality control techniques relating to the manual sampling of surface, potable, waste, marine and ground waters. The general principles outlined in ISO 5667-14 can, in some circumstances, be applicable to sludge and sediment sampling.

7.2.4 ISO 5667-15, Water quality — Sampling — Part 15: Guidance on the preservation and handling of sludge and sediment samples

ISO 5667-15 provides guidance on procedures for the preservation, handling and storage of samples of sewage and waterworks sludge, suspended matter, saltwater sediments and freshwater sediments, until chemical, physical, radiochemical and/or biological examination can be undertaken in the laboratory.

The procedures are only applicable to wet samples of sludge, sediment and suspended matter. Samples of sludge, sediment and suspended matter that are dried or freeze-dried behave similarly to dried soils.

For guidance on long- and short-term storage of (freeze) dried samples, see ISO 18512.

For guidance on freeze-drying, see ISO 16720.

7.2.5 ISO 5667-16, Water quality — Sampling — Part 16: Guidance on biotesting of samples

ISO 5667-16 gives practical guidance on sampling, pre-treatment, performance and evaluation of environmental samples in the context of performing biological tests. Information is given on how to cope with the problems of biotesting arising from the sample and the suitability of the test design.

ISO 5667-16 is applicable to biological tests for determining the effect of environmental samples like treated communal and industrial waste water, groundwater, fresh water, aqueous extracts (e.g. leachates, eluates), pore water of sediments and whole sediments. ISO 5667-16 is also applicable to chemical substances.

Primarily dealt with are substance-related problems concerning sampling and pre-treatment of environmental samples (e.g. waste water samples) for the performance of biotests.

It is not applicable to water samples intended for microbiological analyses as specified in ISO 19458.

7.2.6 ISO 5667-20, Water quality — Sampling — Part 20: Guidance on the use of sampling data for decision making — Compliance with thresholds and classification systems

ISO 5667-20 establishes principles, basic requirements, and illustrative methods to use of sample data for decision making. It specifies methods for preliminary examination of the sensitivity of decisions to error and uncertainty. It does not cover the full range of statistical techniques.

ISO 5667-20 provides general advice on decision making related to constraint formulation for expression of thresholds and targets and the form and scale of sampling programmes. It gives advice on what is required for sampling programmes in order that they are compatible with the way thresholds are defined.

Its main purpose is to establish the principle that uncertainty from sampling and analysis (and errors generally) should always be assessed and taken into account as part of the process of taking decisions.

7.2.7 ISO 5667-24, Water quality — Sampling — Part 24: Guidance on the auditing of water quality sampling

ISO 5667-24 provides an audit protocol to monitor conformity with declared, or assumed, practices in all areas of water quality sampling and specifically provides guidance on the systematic assessment of sampling practices and procedures in the field, and assessing conformity with any sampling manual. The key point in designing an audit programme is to ensure that the effort spent on auditing is proportional to the risk and the size of the organization.

ISO 5667-24 is applicable to auditing of sampling practices associated with potable water supplies, wastewaters including discharges to water bodies, environmental monitoring, commercial and industrial uses of water.

ISO 5667-24 is not applicable for the auditing (or calibration and maintenance) of on-site test equipment or kits.

Informative annexes contain a series of forms to assist with auditing for guidance only.

Auditing of water quality sampling identifies both positive and negative attributes with the aim to emphasize the effectiveness of "best practice" and to build up a knowledge base.

7.2.8 ISO/TS 5667-25, Water quality — Sampling — Part 25: Guideline on the validation of the storage time of water samples

ISO/TS 5667-25 addresses the need for harmonized and reliable data on stability, which is essential for the expression of recommendations for both normative and regulatory purposes.

The document describes test plans and different operating methodologies of these plans to define and verify the acceptable length of stability of substances prior to analysis in a sample under specified preservation conditions, such as temperature, matrix, light, addition of a stabilizer, etc.

It is not applicable to biological and microbiological methods.

It it is intended to be read in conjunction with ISO 5667-3.

7.3 Standards outside the 5667 series that provide guidance on sampling programmes in specific areas

7.3.1 General

The following standard provides specific guidance on the design, sampling and storage and is used in conjunction with the specific sampling standards detailed in 7.4 and the general standards detailed in 7.2. The user should always ensure that the latest versions are being referred to.

7.3.2 ISO 19458, Water quality — Sampling for microbiological analysis

ISO 19458 provides guidance on planning water sampling regimes, on sampling procedures for microbiological analysis and on transport, handling and storage of samples until analysis begins. It focuses on sampling for microbiological investigations.

General information in respect to the sampling from distinct water bodies is given in the respective parts of the ISO 5667 series shown in 7.4 below. Sampling objectives may serve different purposes, which are described in the ISO 5667 series, particularly ISO 5667-1 and ISO 5667-3.

7.4 Standards within the ISO 5667 series providing specific guidance on the sampling of a range waters

7.4.1 General

The following standards provide more specific information on sampling and may refer to more detailed requirements when designing programmes so should be referred to for specific guidance and advice.

These standards are used in conjunction with the general sampling standards detailed in 7.2 and can also refer to standards in 7.3. They are regularly reviewed and updated so the user should always ensure that the latest versions is being referred to.

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

ISO 5667-4 gives guidance on 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 and is applicable to lakes with and without aquatic vegetation. It should be read in conjunction with ISO 5667-1 and ISO 5667-3.

7.4.3 ISO 5667-5, Water quality — Sampling — Part 5: Guidance on sampling of drinking water from treatment works and piped distribution systems

ISO 5667-5 establishes principles to be applied to the techniques of sampling water in continuous supply drawn from municipal or similar distribution systems (including individual systems) where prior treatment and/or quality assessment has resulted in the water being classified as suitable for drinking or potable process purposes and intended for human consumption. It should be read in conjunction with ISO 5667-1 and ISO 5667-3.

ISO 5667-5 covers all water intended for drinking, cooking, food preparation or other domestic purposes, regardless of its origin, and water used in manufacture, processing, preservation or marketing of products or substancees intended for human consumption.

7.4.4 ISO 5667-6, Water quality — Sampling — Part 6: Guidance on sampling of rivers and streams

ISO 5667-6 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 and chemical assessment.

ISO 5667-6 is not applicable to the sampling of estuarine or coastal waters, sediment, suspended solids or biota. Passive sampling of surface waters is covered in ISO 5667-23 and in cases where naturally occurring or artificially constructed dams result in the retention or storage of water for several days or more, the stretch of the river or stream should be considered as a standing water body which is covered in ISO 5667-4. It should be read in conjunction with ISO 5667-1 and ISO 5667-3.

7.4.5 ISO 5667-7, Water quality — Sampling — Part 7: Guidance on sampling of water and steam in boiler plants

ISO 5667-7 recommends procedures and equipment for sampling water and steam in boiler plants including examples of sampling apparatus, to provide samples for physical and chemical analysis that are representative of the main body of water or steam from which they are taken. It should be read in conjunction with ISO 5667-1 and ISO 5667-3.

The procedures for sampling water apply to raw water, make-up water, boiler feed water, condensate, boiler water, and cooling water and for sampling steam covering both saturated and superheated steam.

ISO 5667-7 does not apply to the sampling of water and steam in nuclear power plants.

7.4.6 ISO 5667-8, Water quality — Sampling — Part 8: Guidance on the sampling of wet deposition

ISO 5667-8 provides guidance on the design of sampling programmes and the choice of instrumentation and techniques for the sampling of the quality of wet deposition. It should be read in conjunction with ISO 5667-1 and ISO 5667-3.

The main objectives of ISO 5667-8 are control of local emissions to determine loadings (i.e. mass; area; time) by wet deposition to a particular ecosystem of pollutants from point or area sources, and long-range transport of airborne pollutants to determine temporal and spatial variations in the constituents of precipitation on a regional scale.

It does not cover measurement of the quantity of rain, dry deposition or other types of wet deposition such as mist, fog and cloudwaters, since their measurements are still at research stages.

7.4.7 ISO 5667-9, Water quality — Sampling — Part 9: Guidance on sampling from marine waters

ISO 5667-9 provides guidance on the principles to be applied to the design of sampling programmes, sampling techniques and the handling and preservation of samples of sea water from tidal waters (e.g. estuaries and tidal inlets, coastal regions and the open sea).

The main objectives of ISO 5667-9 are the quality characterization measurement of variations in spatial distribution and temporal trends in water quality to establish the effects of climate, biological activity, water movements and the influences of man.

a) Quality control measurement of water quality over a long period of time at one or more defined places to establish whether water quality, remains suitable for defined uses, for example, bathing, protection of aquatic life, demineralization or cooling purposes.

b) Assessment of the cause, magnitude and effect of significant variations in water quality and investigation and identification of the sources and subsequent fate of pollutants discharged into marine waters.

c) Examination of the effects of man-made structures assessment of water quality variations caused by engineering developments, for example, barrages, jetties, bridges, ports.

It should be read in conjunction with ISO 5667-1 and ISO 5667-3. It does not apply to the collection of samples for microbiological or biological examination with general guidance on sampling for microbiological purposes is given in ISO 8199.

7.4.8 ISO 5667-10, Water quality — Sampling — Part 10: Guidance on sampling of waste water

ISO 5667-10 contains details on the sampling of domestic and industrial waste water, i.e. the design of sampling programmes and techniques for the collection of samples and covers waste water in all its forms, i.e. industrial, radioactive, raw and treated domestic waste waters and cooling water.

It deals with various sampling techniques used and the rules to be applied so as to ensure the samples are representative.

It should be read in conjunction with ISO 5667-1 and ISO 5667-3.

7.4.9 ISO 5667-11, Water quality — Sampling — Part 11: Guidance on sampling of groundwaters

ISO 5667-11 provides guidance on the sampling of groundwaters. It informs the user of the necessary considerations when planning and undertaking groundwater sampling to survey the quality of groundwater supply, to detect and assess groundwater contamination and to assist in groundwater resource management, protection and remediation.

It does not apply to sampling related to the day-to-day operational control of groundwater abstractions for potable purposes. The guidance includes sampling of groundwater from both the saturated (below water table) zone and the unsaturated (above the water table) zone.

It should be read in conjunction with ISO 5667-1 and ISO 5667-3 and ISO 5667-20.

7.4.10 ISO 5667-12, Water quality — Sampling — Part 12: Guidance on sampling of bottom sediments from rivers, lakes and estuarine areas

ISO 5667-12 provides guidance on the sampling of unconsolidated sediments for the determination of their geological, physical and chemical properties, as well as the determination of biological, microbiological and chemical properties at the water and sediment interface. Guidance on achieving sediment cores is given specifically for the measurement of rates of deposition and detailed strata delineation. The main emphasis of ISO 5667-12 is to provide methods that achieve sediment samples. It should be read in conjunction with ISO 5667-1 and ISO 5667-15.

The environments considered are limnic (rivers, streams and lakes, natural and man-made), and estuarine, including harbours.

It does not apply to sampling related to industrial and sewage works for sludges, suspended solids, paleolimnological sampling and sampling of open ocean sediments and are addressed in ISO 5667-13, ISO 5667-17 and ISO 5667-19 for such guidance.

7.4.11 ISO 5667-13, Water quality — Sampling — Part 13: Guidance on sampling of sludges

ISO 5667-13 gives guidance on the sampling of sludges from wastewater treatment works, water treatment works and industrial processes to provide data for the operation sludge plants and treatment facilities, determine the concentration of pollutants and determinewhether prescribed substance limits are contravened based on the use of the sludge and to aid in optimizing costs.

It is applicable to all types of sludge arising from these works and also to sludges of similar characteristics, for example, septic tank sludges.

More specific guidance is also given on the design of sampling programmes and techniques for the collection of samples.

ISO 5667-13 should be read in conjunction with ISO 5667-1 and ISO 5667-15.

7.4.12 ISO 5667-17, Water quality — Sampling — Part 17: Guidance on sampling of bulk suspended solids

ISO 5667-17 provides guidance on the sampling of suspended solids for the purpose of monitoring and investigating freshwater quality, and more particularly to flowing freshwater systems such as rivers and streams and provides guidance to the various sampling procedures, their biases, and alternatives. Certain elements of ISO 5667-17 may be applied to freshwater lakes, reservoirs and impoundments; however, field sampling programmes can differ and are not necessarily covered within ISO 5667-17.

It excludes sampling protocols that apply to conventional water sampling, field and laboratory filtration procedures used to measure the quantity of suspended solids.

It should be read in conjunction with ISO 5667-1 and ISO 5667-15.

7.4.13 ISO 5667-19, Water quality — Sampling — Part 19: Guidance on sampling in marine sediments

ISO 5667-19 provides guidance for the sampling of sediments in marine areas for analyses of their physical and chemical properties for monitoring purposes and environmental assessments and includes information on specific sampling strategies, sampling devices, handling and packaging of samples and guidance on observations made and information obtained during sampling.

The main objective of ISO 5667-13 is to provide information around a common set of procedures for monitoring of marine bottom sediments, involving both qualitative and quantitative analyses of contaminants.

It excludes guidance for sampling of freshwater sediments.

It should be read in conjunction with ISO 5667-1 and ISO 5667-15.

7.4.14 ISO 5667-21, Water quality — Sampling— Part 21: Guidance on sampling of drinking water distributed by tankers or means other than distribution pipes

ISO 5667-21 is one of the specific water-type sampling parts, and provides guidance on the sampling of drinking water, with or without prior treatment, when the water is supplied by means other than a piped distribution system contiguous to a water source. ISO 5667-21 should be read in conjunction with ISO 5667-1, ISO 5667-3 and ISO 5667-5.

It establishes principles to be applied to the techniques of sampling water provided for drinking and for use in the manufacture of food and beverage products and is generally confined to those circumstances where water is drawn from municipal or similar public or private abstraction, treatment or distribution systems for which prior treatment or quality assessment has resulted in the water being classified as suitable for drinking or potable process purposes.

Specifically, ISO 5667-21 is applicable to water that is supplied by tanker or other non-contiguous bulk means, but not continuously as part of a piped distribution system, during any stage of use up to and including the point of consumption or transfer to a piped distribution system. ISO 5667-21 is also applicable to the distribution and bulk storage of water on aircraft, trucks, trains, ships, and other vessels and vehicles, as well as to sampling situations that can arise during the investigation of system defects, initiation of new systems and re-initiation of systems that have been unused for long periods or emergency situations where the safety of sampling operatives is not compromised.

ISO 5667-21 does not provide guidance on:

a) the sampling of source water, for example, groundwater and impoundments;

b) the sampling of potable water supplies derived from contiguous piped supplies covered by ISO 5667-5;

c) the sampling of beverage products (including bottled waters) or food containing potable water used in its preparation;

d) the sampling of drink vending machines.

7.4.15 ISO 5667-22, Water quality — Sampling — Part 22: Guidance on the design and installation of groundwater monitoring points

ISO 5667-22 gives guidance on the design, construction and installation of groundwater quality monitoring points to help ensure that representative samples of groundwater can be obtained.

ISO 5667-22 provides information on the most commonly applied and available techniques, and lists their advantages, disadvantages and limitations of use where these are known and provides details around information on making an informed assessment of data and results obtained from existing installations, as construction can potentially have an impact on sample integrity.

They are intended for installations and monitoring in different environments including those where background or baseline groundwater conditions are being established or monitored and those in which impacts of contamination are being investigated.

ISO 5667-22 should be used in conjunction with other guidance on sampling groundwater and for investigating contaminated or potentially contaminated sites, as any groundwater sampling from such sites is likely to form part of a much wider investigation programme.

It should be read in conjunction with ISO 5667-1, ISO 5667-3 and ISO 5667-11.

7.4.16 ISO 5667-26, Water quality — Sampling — Part 26: Guidance on sampling for the parameters of the oceanic carbon dioxide system

ISO 5667-26 specifies how to collect discrete seawater samples from a Niskin or other water sampler, that are suitable for the analysis of pH and three inorganic carbon parameters: total dissolved inorganic carbon, total alkalinity and carbon dioxide (CO_2) fugacity.

It provides sampling information to support the measurement of CO_2 in seawaters which are currently absorbing about one quarter of the carbon dioxide being emitted. This causes a chemical reaction that reduces the pH, leading to ocean acidification, which affects many marine organisms, but especially those that build their shells and skeletons from calcium carbonate.

It is intended to be read in conjunction with ISO 5667-14.

8 Time and frequency of sampling

8.1 General

Information is normally required over a period of time during which the water quality can vary. Samples should therefore be taken at times which will adequately represent the quality and its variations with minimum effort. The sampling programme should be designed to account for seasonal and diurnal cycles and consider business week cycles, random or transient events, and long-term persistence or trends. This approach contrasts with the choice of sampling frequency based on either subjective considerations or the amount of effort available for sampling and analysis. Both of these methods can lead either to totally inadequate sampling or, in theory, to unnecessarily frequent sampling.

It can be necessary to increase sampling frequency while abnormal conditions persist, for example, during process plant start-up, during flood conditions in a river or at times of algal blooms. In calculating long-term trends, results obtained from these samples should be used only if allowance is made for the increased frequency, and these samples are weighted in time so that a period of intense sampling receives appropriate weight.

8.2 Water quality management programmes

Water quality management programmes usually involve the control of concentration of one or more parameters within defined limits. The results are required in order to decide whether immediate action is needed. The sampling frequency should therefore be chosen to ensure that important deviations outside the control limits are identified between successive measurements. There are two primary factors that fix this frequency:

a) the magnitude and duration of deviations from the desired conditions;

b) the probabilities of occurrence of deviations from the desired conditions.

Often, only approximate definitions of these factors will be possible, but reasonable estimates will enable a working value for the sampling frequency to be deduced.

8.3 Quality characterization programmes

Quality characterization programmes aim to estimate one or more statistical parameters that characterize the concentration of one or more parameters or its variability during a defined period, or both. For example, the mean or median indicates the central tendency of results and the standard deviation indicates the variability. The results can be required as part of a research investigation or for characterization of parameters which do not currently need to be controlled or for long-term control purposes.

8.4 Programmes for investigation of causes of contamination

Programmes for investigation of causes of contamination should be designed to determine the characterization of polluting discharges of unknown origin.

They are generally based on a knowledge of the nature or natures of the contaminants, and the coincidence of the periodicity of the appearance of contamination and of sampling.

These criteria necessitate that the sampling, in contrast with that carried out for water quality management and quality characterization, should be carried out with a fairly high frequency in relation to the frequency of appearance of contamination.

Inventory sampling from a large number of locations is often found to be useful in locating undocumented sources of contaminants.

8.5 Statistical considerations

8.5.1 Establishment of sampling programmes

The times and frequencies of sampling in any programme can be properly decided only after detailed preliminary work, in which a high sampling frequency is necessary to provide the information to which statistical techniques may be applied. Once the frequency of sampling has been decided, the data obtained should be reviewed regularly so that changes can be made as required.

If quality is subject to variations, either random or systematic, the values obtained for statistical parameters, such as the arithmetic mean, standard deviation, maximum and percentile values, are only estimates of the true parameters which will generally differ from them. In the case, of purely random variations, the differences between these estimates and the true values can be calculated statistically, and they decrease as the number of samples increases.

The determination of confidence intervals and number of samples using the formula outlined below is an example of the above approach, using one statistical method applied to the arithmetic mean, and assumes that the normal distribution applies to the source data. The terminology used is in accordance with the ISO 3534 series to which reference should be made for definitions of the terms used. For a full treatment of calculation of the mean in terms of confidence interval, reference should be made to ISO 2602:1980.

For more complex calculations involving the assessment of the sampling frequencies, it is necessary to determine other statistical parameters (e.g. percentile values).

8.5.2 Random and systematic variations of water quality

Random variations commonly have either a normal or a lognormal distribution. Systematic variations can be either trends or cyclic variations, and combinations of the two can occur. The nature of the variability may be different for different determinands in the same water body. If random variations are dominant, times of sampling are generally not statistically important, although they may be important for quality control purposes.

If cyclic variations occur, times of sampling are important if it is necessary to characterize the changes occurring over the whole cycle or to detect maximum or minimum concentrations of interest. Times of sampling should be spaced approximately equally over such periods. In each of the above situations, the number of samples should be governed largely by the statistical considerations outlined above.

In cases where there are cyclic variations (e.g. diurnal or month to month variations) and the objective of a sampling programme is solely to detect whether any systematic changes in quality have occurred between one defined period and another (e.g. over two successive yearly periods), the most efficient sampling programme is to sample at precisely the same day of the week and time of the day, as this reduces the need to assess quality variations that are not of interest.

In each of the above situations, the number of samples should be governed largely by statistical considerations outlined above. If cyclic variations or systematic variations are either absent or small compared with random fluctuations, the number of samples to be taken need only be large enough to meet the acceptable uncertainty of the statistical parameter being sought at a given confidence level. For example, if normal distribution applies, according to the above, the confidence interval L of the mean of n results, at a chosen confidence level, is given by the formula:

$$L = \frac{2K\sigma}{\sqrt{n}}$$

where

σ is the standard deviation of the distribution;

K is the confidence level.

If the required confidence interval were to be 10 % of the mean, the required confidence level 95 % and the standard deviation 20 % of the mean, then

$$10 = \frac{2 \times 1{,}96 \times 20}{\sqrt{n}}$$

and hence

$$n = 7{,}84^2$$

and

$$n = 61$$

and hence, n is 61 samples.

This indicates a sampling frequency of 2 samples per day if the period of interest were to be 1 month, or of between 1 and 2 samples per week if the period of interest were to be 1 year.

Guidance is provided in ISO 5667-20 on the use of sampling data for decision making and compliance with thresholds and classification systems.

Also, ISO 5667-14 provides guidance on the selection and use of various quality assurance techniques relating to the manual sampling of surface waters, potable waters, waste waters, marine waters and groundwaters.

The general principles outlined in ISO 5667-14 can, in some circumstances, be applicable to sludge and sediment sampling.

8.6 Duration of sampling occasion and composite samples

If only the average quality during a period is of interest, and provided the determination is stable, it can be useful for the duration of collection of samples to be long and preferably done during this period of interest.

This principle is similar to the preparation of composite samples. Both approaches reduce analytical work at the expense of knowledge of quality variations.

9 Flow measurements and situations justifying flow measurements for water quality purposes

9.1 General

The control of sewage and effluent treatment and the quality management of natural waters using mathematical modelling techniques have increased the importance of flow data. For example, contamination loads cannot be assessed without flow measurements. This subclause indicates the flow principles that should be taken into account when setting up a sampling programme. However, as the measurement of flow is not normally made by the water examination scientist, practical details are not included. For these, reference should be made to appropriate International Standards prepared by ISO/TC 30, *Measurement of fluid flow in closed conduits*, and by ISO/TC 113, *Hydrometry*.

There are five aspects of flow that need to be measured, namely,

a) direction of flow,

b) velocity of flow,

c) discharge rate,

d) flowprofile, and

e) cross-sectional area.

9.2 Direction of flow

In most inland watercourses, the direction of flow is self-evident, but in navigational canals and drainage channels this is not always so as the direction of flow can vary with time and there is a possibility of reversal of direction and even counter flow situations. Rivers can also show reverse flow in eddies or in other circumstances.

Knowledge of the pattern of groundwater flow within an aquifer is of primary importance in assessing the consequences of aquifer contamination and in selecting sites for sampling boreholes.

In treatment processes, the pattern of water movement in tanks affects the mixing of the contents, and the settling of suspended matter should be taken into account to ensure that representative samples are collected.

In estuaries and coastal water, it is frequently necessary to measure the direction of water movement as an essential part of the sampling programme. Both direction and velocity can be highly variable, being dependent on tidal currents modified by meteorological conditions and other factors and conditions.

9.3 Velocity of flow

Current velocity is of importance

a) in calculating the discharge rate,

b) in calculating the mean velocity or time of travel which, for water quality purposes, is the time required for a given body of water to move through a given distance, and

c) in assessing the effect of turbulence and the mixing of a water body produced by velocity.

9.4 Discharge rate

The discharge rate is the volume of liquid that passes a given point per unit time (see Figure A.2). Information on the mean and on extreme rates of discharge is essential for the design and operation of effluent, sewage and water treatment plants, and for setting rational quality limits to safeguard natural watercourses.

9.5 Flow profile

The profile of the flow can strongly influence the rate of mixing vertically and laterally. Care should be taken to assess whether flow is in one confined channel, in several channels (i.e. braided) and whether or not eddies are present. Ideally, samples should be collected from a single, well-mixed channel; observations of flow profile in multiple channels and eddies, for example, suggest that samples can be unrepresentative.

9.6 Cross-sectional area

Sampling cross-sections can range from being approximately rectangular to having a deep channel at one edge, from shallow and wide to narrow and deep. These features affect both mixing and erosion, and they can change over time in natural streams and man-made channels.

9.7 Justification for flow measurements in water quality control management

9.7.1 Treatment plant loads

Flow data are necessary in order to assess the polluting load imposed on a treatment plant. This can require making measurements at points of discharge to a sewerage system as well as at the works itself. If the waste water to be treated varies in quantity or quality with time, a continuous-flow discharge record is necessary to obtain a reliable estimate of load. Frequently, composite samples are made up by mixing samples in relation to the recorded flow at the time of sampling. The cost of treatment of trade effluents discharged to public sewers is directly proportional to both the quality and the volume of effluent discharged.

Refer to Clause 10 below for sampling techniques, specifically continuous sampling or composite sampling (time or flow).

9.7.2 Dilution effects (flux calculations)

Full use of the dilution effects afforded by the receiving sewerage system should be made when evaluating the probable effects of a discharge upon a natural watercourse and the quality limits that need to be imposed on it. The dilution factor should be calculated. While sampling is carried out, the discharge of hazardous substances to public sewers should be controlled so that sampling personnel, sewers and treatment processes are not adversely affected.

9.7.3 Mass flow calculations

Mass flow calculations are widely used in the setting of compliance limits for discharges and for evaluating the quality effects of river abstractions and augmentations. Such calculations are fundamental for modelling quality in whole-river and estuary systems and are frequently based upon typical or mean-flow discharge data. Dynamic modelling techniques require both continuous flow data and computation of flow-frequency values.

9.7.4 Transport of contaminants and rates of recovery

If the concentration of a contaminant in a discharge varies with time, a reliable estimate of the dispersion or degradation of the contaminant can only be obtained if the rate of transport of the contaminant from the point of discharge is known. Hence, a sampling programme for a river or estuary should attempt to sample the same body of water as it moves along the water-course.

When an accidental spillage of a contaminant enters a water-course, a knowledge of the time required for the contaminant to reach downstream abstractors is invaluable in assessing the effects of such contamination.

9.7.5 Flow-related parameters

The concentrations of certain water quality parameters, such as temporary hardness or chloride, have been found, in certain circumstances, to be related to the flow rate in rivers and streams, usually over a limited range. If suitable records are available, linking flow rates with the concentrations, an estimate of water quality in relation to these parameters can be made from flow rate measurements alone. Checks should be made at intervals to ascertain whether the relationships remain valid.

9.7.6 Groundwaters

A reliable assessment of contamination risks to groundwater sources and the expected rates of recovery from them requires a knowledge of the direction and velocity of groundwater movement. This information can then be used to avoid the difficulty and cost of sampling groundwaters for the assessment of contamination.

9.8 Methods available for flow measurement

9.8.1 Measurements can be either discrete, such as those made by use of floats in an estuary or a direct-reading current-meter in a river, or they can be continuous, such as those made by most discharge flow meters.

9.8.2 Direction and velocity can be measured by using

a) drogues,

b) floats and drifters,

c) chemical tracers (including dyes),

d) microbiological tracers, and

e) radioactive tracers.

9.8.3 Velocity can also be measured by using

a) current meters, direct-reading and recording types,

b) acoustic techniques, for example, ultrasonic,

c) electromagnetic techniques, and

d) pneumatic techniques.

9.8.4 Discharge can be determined by using

a) velocity measurements made in a channel of known cross-sectional area,

b) direct mechanical means, such as a tipping bucket or a standard water-meter,

c) measurement of water level above a constriction in the flow, such as a weir or flume; the level can be measured

   1) visually by means of a gauging board, and

   2) automatically, by means of a float, changes in electrical resistance, pressure differential, photographically or acoustically;

d) the following means in a closed pipe:

   1) pressure differences across a venturi throat,

   2) pressure differences across an orifice plate,

   3) pressure differences across a tuyere,

   4) pumping rate, multiplied by the duration of pumping,

   5) electromagnetic, ultrasonic and other techniques, and

   6) dilution gauging, for carrying out spot measurement of discharges in natural watercourses.

10 Current sampling techniques

10.1 General

There are many sampling situations, some of which can be satisfied by taking simple spot samples, whereas others can require sophisticated instrumental sampling equipment. There is also a need to ensure any equipment required is prepared correctly before use and some information on this is found in Annex D.

The various types of sampling and sampling techniques are examined in some detail in subsequent parts of ISO 5667, and reference should be made to these whenever required (see Clause 7).

Analytical data can be required to indicate the quality of water by determination of parameters such as the concentrations of inorganic material, dissolved minerals or chemicals, dissolved gases and volatile materials, dissolved organic material and matter suspended in the water or bottom sediments at a specific time and location or over some specific time interval at a particular location.

Certain parameters, such as the concentration of dissolved gases and volatile materials, should be measured in situ if possible, to obtain accurate results. Sample preservation procedures should be carried out in appropriate cases – see ISO 5667-3 and ISO 5667-15 for guidance.

Separate samples should be used for chemical, microbiological and biological analyses because the procedures and equipment for collection and handling are different and are incompatible.

It is necessary to differentiate between sampling from standing and flowing waters. Spot samples (10.2) and composite samples (10.6) are applicable to both standing and flowing waters. Periodic sampling (10.3) and continuous sampling (10.4) are applicable to flowing waters, whereas series sampling (10.5) is more applicable to standing waters.

NOTE There are also some new and emerging sampling techniques which are in various stages of development – some examples of these are shown in Annex C.

10.2 Spot samples

Spot samples are discrete samples, usually collected manually but which can also be collected automatically, for waters at the surface, at specific depths and at the bottom.

Each sample will normally be representative of the water quality only at the time and place at which it is taken. Automatic sampling is equivalent to a series of such samples taken on a preselected time or flow-interval basis.

Spot samples are recommended if the flow of the water to be sampled is not uniform, if the values of the parameters of interest are not constant and if the use of a composite sample would obscure differences of interest between individual samples due to either masking short-term variations or even reaction between them.

Spot samples should also be carried out, where possible, in investigations of the possible existence of contamination, or in surveys to indicate its extent or, in the case of automatic discrete sample collection, to determine the time of day when contaminants are present. They can also be taken for guidance in the establishment of a more extensive sampling programme. Spot samples are essential when the objective of a sampling programme is to estimate whether a water quality complies with limits not related to average quality. Spot samples should be taken for the determination of unstable parameters, such as the concentration of dissolved gases and volatile materials, residual chlorine and soluble sulfides.

10.3 Periodic samples (discontinuous)

10.3.1 Periodic samples taken at fixed time-intervals (time-dependent) or constant time constant volume (CTCV) sampling

These samples are taken using a timing mechanism to initiate and terminate the collection of water during a specific time-related interval (see Figure A.3). Equal volume of samples or sub sample is collected at fixed time intervals.

A common procedure is to pump the sample into one or more containers for a fixed period, a set volume being delivered to each container.

NOTE The parameter of interest can affect the time interval.

10.3.2 Periodic samples taken at fixed flow-intervals (volume-dependent) or constant time variable volume (CTVV) sampling

Flow proportional sampling based on collecting samples at fixed time intervals, but where the volume of sample is varied in proportion to the flow. These samples are taken when variations in water quality and effluent flow rate are not interrelated.

At constant time intervals, samples of different volumes are taken, the volume depending upon the flow (see Figure A.4).

10.3.3 Periodic samples taken at fixed flow-intervals (flow-dependent) or constant volume variable time (CVVT) sampling

Flow proportional sampling based on collecting equal volumes of samples at a time frequency proportion to the flow. These samples can be taken when variations in water quality criteria and effluent flow rate are not interrelated.

For each unit volume of liquid flow, a controlled sample can be taken irrespective of time (see Figure A.5).

10.4 Continuous samples

10.4.1 Continuous samples taken at fixed flow rates (time-continuous sampling)

Samples can be taken by this technique at fixed sample flow rates (see Figure A.6) and contain all constituents present during a sampling period, but in many cases, do not provide information about the variation of concentrations of specific parameters during the sampling period.

10.4.2 Continuous samples taken at variable flow rates (flow-continuous sampling)

Samples can also be taken at variable sample flow rates in proportion to the flow of water being sampled (see Figure A.7). In this case, the flow-proportional samples collected are representative of the bulk water quality. If both the flow and composition vary, flow-proportional samples can reveal variations that might not be observed by the use of spot samples, provided that the samples remain discrete and a sufficient number of samples is taken to differentiate between the changes in composition. Consequently, this is the most precise method of sampling flowing water if both the flow rate and the concentration of contaminants of interest vary significantly.

10.5 Series sampling

Series sampling can involve a number of samples taken from various depths of a body of water at a specific location (depth profile samples), or a series of water samples taken from a particular depth of a body of water at various locations (area profile samples).

10.6 Composite samples

Composite samples can be obtained manually or automatically, irrespective of the type of sampling (flow-, time- or volume-dependent). Continuously taken samples can be put together to obtain composite samples. Composite samples provide average compositional data. Consequently, before combining samples it should be verified that such data are desired, or that the parameter(s) of interest do(es) not vary significantly during the sampling period. Composite samples are valuable in cases when compliance with a limit is based on the average water quality.

10.7 Large-volume samples

Some methods of analysis for certain parameters require the sampling of a large volume of water, for example, >20 l. Such large samples are necessary, for example, when analysing for pesticides, radiochemical parameters or microorganisms that cannot be cultured. The sample can either be collected in a conventional manner, with great care being taken to ensure cleanliness of the container or tanker holding the sample, or by passing a metered volume through an absorbent cartridge or filter, depending on the parameter. For example, an ion exchange cartridge or an activated carbon cartridge can be used to sample some pesticides.

The precise details of the latter procedure depend on the type of water sampled and the parameters. A regulator valve to control the flow through the cartridge or filter should be used for supplies under pressure. For most parameters, a pump should be placed after both the filter or cartridge and the meter. If the parameter is volatile, the pump should be placed as close as possible to the sample origin, with the meter being placed after the filter or cartridge.

When sampling a turbid water containing suspended solids that can blind the filter or cartridge, or if the amount of parameter required for analysis exceeds the capacity of the largest filter or cartridge available, a series of filters or cartridges arranged in parallel should be used, with the inlet and exit manifolds fitted with stopcocks. Initially, the sampling flow should be directed through one filter or cartridge, with the others not receiving the flow, and when the flow rate decreases significantly then the flow should be diverted to a fresh filter or cartridge. If there is a danger of the filter or cartridge being overloaded, then fresh filters or cartridges should be connected online sequentially before the original one is exhausted; the flow to the exhausted cartridge is then stopped.

When more than one filter or cartridge is used, they should be treated together and considered as a composite sample. If the waste water from such a sampling regime is returned to the body of water being sampled, then it is essential that it be returned sufficiently distant from the sampling point, so that it cannot influence the water being sampled.

11 Passive sampling

Passive sampling devices can be used for monitoring concentrations of a wide range of analytes, including metals, inorganic anions, polar organic compounds (e.g. polar pesticides and pharmaceutical compounds), non-polar organic compounds (e.g. non-polar pesticides, polyaromatic hydrocarbons and polychlorinated biphenyls) in aquatic environments.

Pollutant levels in surface waters have a tendency to fluctuate over time and so it can be more desirable to monitor pollutants over an extended period in order to obtain a more representative measure of the chemical quality. This can be achieved by passive sampling or other methods such as repeated spot sampling, continuous monitoring and biomonitoring.

Passive sampling involves the deployment of a passive sampling device that selectively accumulates pollutants on a sorbent over the deployment time (i.e. days to weeks).

This process is followed by extraction and analysis of pollutants in a laboratory.

See also ISO 5667-23.

12 Sampling equipment for physical or chemical characteristics

12.1 General

The volume of sample collected should be sufficient for the required analyses and for any repeat analyses. The use of very small sample volumes can cause the samples collected to be unrepresentative. In addition, small samples can also increase problems of adsorption because of the relatively high area to volume ratio. However, the analysing laboratory can provide guidance here.

Effective sampling equipment should

a) minimize the contact time between the sample and the sample container,

b) use materials such that no sample contamination occurs,

c) be simply designed to ensure ease of cleaning, with smooth surfaces and the absence of flow disturbances such as bends and with as few taps and valves as possible (all samplers should be checked to ensure that no bias is being introduced), and

d) be designed with the suitability of the system in relation to the required water sample (i.e. chemical, biological, microbiological or radiological) in mind.

For sampling of dissolved gases or volatile materials, reference should be made to 12.5.

12.2 Sampling containers

12.2.1 General

The sample container should be designed to preserve the composition of the sample from losses due to adsorption and volatilization, or from contamination by foreign substances.

The sample container used to collect and store the sample should be chosen after considering, for example, resistance to temperature extremes, resistance to breakage, ease of good sealing and reopening, bottle neck width, bottle volume, size, shape, mass, availability, cost, potential for cleaning and re-use, etc.

Reference should be made to ISO 5667-3, ISO 5667-15 and ISO 5667-16 for specific sampling situations and to determine the correct type of sampling container to be used.

It is recommended that detailed advice be sought from the analysing laboratory on the final choice of sample container and the materials constituting the sampling equipment.

Precautions should be taken to prevent unintentional sample freezing, particularly when glass sample containers are used.

NOTE Freezing can be required for some preservation purposes.

In addition to the desired physical characteristics, the sample containers used to collect and store the samples should be selected by taking into account the following predominant criteria (especially when the constituents to be analysed are present in trace quantities):

a) minimization of contamination of the water sample by the container or stopper material, for example, leaching of inorganic constituents from glass (especially soft glass) and organic compounds and metals from plastics and elastomers (plasticized vinyl cap liners, polychloroprene jackets);

b) ability to clean and treat the walls of the containers, to reduce surface contamination by trace constituents such as heavy metals or radionuclides;

c) chemical and biological inertness of the container material, in order to prevent or minimize reaction between constituents of the sample and the container;

d) sample containers which can also cause errors by adsorption of chemical parameters; trace metals are particularly liable to this effect, but other parameters (e.g. detergents, pesticides, phosphate) can also be subject to error.

Sampling pipes are generally used in automatic sampling to supply samples to continuous analysers or monitors. During the residence time within the pipe, the sample can be considered as being stored in a container having the composition of the sampling line. Guidelines for the selection of materials for sample containers also, therefore, apply to sampling pipes.

12.2.2 Types of sample container

12.2.2.1 General

Polyethylene and borosilicate glass bottles are suitable for conventional sampling for the determination of physical and chemical parameters of natural waters. Screw-cap, narrow-mouthed and wide-mouthed bottles should be fitted with inert plastics stoppers/caps or ground glass stoppers (although these are susceptible to seizing with alkaline solutions).

Chemically active filler material should not be used between the bottle cap and liner since such fillers can be a source of contamination.

ISO 5667-14 guidance is given on measuring the contamination impact of the container. The analyte level in the blank should be negligible compared to the analyte level to be measured in the sample. If the samples are transported in a case to a laboratory for analysis, containers should be stored to prevent loosening of the stopper, which can result in spilling and/or contamination of the sample.

To ensure appropriate sample containers are used, refer to ISO 5667-3, ISO 5667-15 and ISO 5667-16.

12.2.2.2 Sample containers for photosensitive materials

In addition to the considerations already mentioned, the storage of samples containing photosensitive materials, including algae, requires their protection from exposure to light. In such cases, containers constructed of opaque materials or non-actinic glass should be used and they should be placed in light-proof cases during extended periods of storage.

12.2.2.3 Sample containers for dissolved gases, volatile materials or constituents

For the collection and analysis of samples containing dissolved gases, volatile materials or constituents that would be altered by aeration, narrow-mouthed bottles or head space vials with PTFE cap liner should be used.

See ISO 5667-3 (volatile organic compounds).

12.2.2.4 Sample containers for trace organic contaminants

Sample bottles used for trace organic contaminants should be made of glass, as virtually all plastics containers interfere with the highly sensitive analysis. The closure should be of glass or PTFE.

12.2.2.5 Sample containers for microbiological examination

Guidance on sample containers for microbiological examination is detailed in ISO 19458. Where sampled containers are going to be autoclaved, they should be able to withstand the high temperatures of that process. During sterilization or sample storage, the materials should not produce or release chemicals that can inhibit microbiological viability, release toxic chemicals or encourage growth. The samples should remain sealed until opened in the laboratory and should be covered to prevent contamination.

12.2.2.6 Sample containers for biotesting of samples

Guidance on sample containers for biotesting examination is detailed in ISO 5667-16. The sample container should be resistant to heating and freezing and it should be autoclavable and easy to clean. Polypropylene (PP), polytetrafluoroethylene (PTFE) or polyethylene (PE) containers are appropriate, but polyethylene is not autoclavable. Glass bottles are generally (but not always) suitable for organic chemical compounds and biological species.

12.3 Equipment for spot sampling

Spot samples are usually taken manually according to the conditions described in 10.2. The simplest equipment for taking surface samples is a bucket or wide-mouthed bottle dropped into a body of water and hauled out after filling. The nature of the problem being studied should determine the type of sample that needs to be collected. In general, it is best to take the sample directly into the sample container.

Refer to ISO 5667-4, ISO 5667-6 and ISO 5667-10 for further information and guidance.

12.4 Sampling equipment for sediments

12.4.1 Grab or dredge sampling

Sediments can be sampled by grabs or dredges designed to penetrate the substrate as a result of their own mass or leverage. Design features vary and include spring-activated or gravity-activated modes of jaw closure. They also vary in the shape of the substrate bite, from square to sharp angle, and in the area and size of sample taken. The nature of the sample obtained is therefore affected by such factors as

a) the depth of penetration of the substrate,

b) the angle of jaw closure,

c) the efficiency of closure (ability to avoid obstruction by objects),

d) the creation of a “shock” wave and resultant loss or “wash-out” of constituents or organisms at the mud-water interface, and

e) the stability of samples in rapidly moving streams.

In selecting dredges, the habitat, water movement, area of sample and any boat equipment necessary should be taken into account.

Clam-shell buckets resemble similar equipment used in land excavation. Usually operated from a boom, they are lowered at a selected sampling site to obtain a relatively massive composite sample. The resulting sample is more precisely defined with respect to a sampling site than when a dredge is used.

Refer to ISO 5667-12 and ISO 5667-19 for further information and guidance.

12.4.2 Core samplers

Core samplers are used when information concerning the vertical profile of a sediment is of interest. Unless the sample obtained has mechanical strength, care should be exercised in its removal from the coring device to preserve its longitudinal integrity.

Refer to ISO 5667-12 and ISO 5667-19 for further information and guidance.

12.5 Sampling equipment for dissolved gases and volatile materials

Samples suitable for accurate determinations of dissolved gases and volatile materials should only be obtained with equipment that collects a sample by displacement of water, rather than air, from the sampler.

If pumping systems are used for the collection of dissolved gas samples, it is essential that the water be pumped in such a way that the pressure applied to it does not drop significantly below atmospheric pressure. The sample should be pumped directly into the storage or analysis bottle, which should be flushed by an amount equal to at least three times its volume before starting analysis or stoppering the bottle.

If approximate results are acceptable, samples for dissolved oxygen determinations can be collected using a bottle or a bucket. The error introduced into these determinations by contact between the sample and the air varies with the degree of saturation of the gas in the water.

Where samples are collected in a bottle from a tap or pump outlet, a flexible inert tube that delivers liquid to the bottom of the bottle should be used, to ensure that liquid is displaced from the bottom of the bottle in order to prevent aeration.

Collection of samples for dissolved oxygen from ice-covered water bodies should be conducted with great care to prevent contamination of the samples by air.

12.6 Sampling equipment for radioactivity characteristics

Depending on the objective and the national legal regulations, most of the sampling techniques and equipment available for sampling waters and waste waters for chemical constituents are generally applicable for obtaining samples for the measurement of radioactivity.

Detailed guidance on preservation and handling of radiochemical samples is contained in ISO 5667-3.

12.7 Sampling equipment for biological and microbiological characteristics

Detailed guidance on microbial sampling for water quality is contained in ISO 19458.

Detailed guidance on biotesting of samples is contained in ISO 5667-16.

Detailed guidance on handnet sampling of aquatic benthic macro-invertebrates, the design and use of quantitative samplers for benthic macro-invertebrates on stony substrata in shallow freshwaters and the use of colonization, qualitative and quantitative sampling in deep waters for macro-invertebrates is contained in ISO 10870.

Detailed guidance for quantitative sampling and sampling processing of marine soft-bottom macrofauna are contained in ISO 16665.

12.8 Automatic sampling equipment

Automatic sampling equipment can be used to advantage in many sampling situations, since it allows a continuous sample or series of samples to be collected without manual intervention. It is particularly useful in preparing composite samples and studying variations in quality with time.

The choice of the most suitable type of machine will depend on the particular sampling situation, for example, sampling in order to estimate the average load of dissolved trace metals in a river or stream can best be carried out using a continuous flow-proportional device, utilizing a peristaltic pumping system.

Automatic sampling devices may be of the discrete or continuous type and may be operated on a time, flow or volume proportional basis. Automatic samplers having the ability to take individual samples (a few ml to 1 l) by remote triggering. Remote triggering allows the sampler to be controlled via a smartphone or a dedicated web interface, allowing real-time data analysis, transmission and visualization.

Sampling lines are generally used in automatic sampling. Therefore, the guidance on selection of materials for sample containers also applies to sampling lines. The sample lines should be purged of any liquid prior to each sample to avoid sampling liquid that has sat in the pipe and to take a fresh sample each time.

More refined, flow-proportional machines continuously measure the flow in the river or stream and take samples after a fixed volume of water has passed the sampling point.

Care should be taken to ensure the sample is non-degradable or is suitably stabilized if the sample is to remain in the machine for any length of time.

If each sample is being analysed, care should be taken to ensure the volume in each container is sufficient for the analysis of interest.

In all cases, the automated sampling equipment should be tested to ensure satisfactory performance in the situation being investigated. See EN 16479:2014 [9].

12.9 Sampling equipment for passive sampling

Several kinds of passive sampling devices exist for monitoring pollutants present in water. They are exposed in the aquatic environment from several days or up to weeks to yield time-integrated average concentration for various contaminants (e.g. organic compounds of medium hydrophobicity, heavy metals). Some of the passive samplers have been validated and provide high sampling rates (l/d) for various contaminants and thus allow qualitative or semi-quantification of extremely low pollution levels in water.

Depending on the target substance to be sampled, different passive sampler devices can be selected, for example, chemcatcher, semi-permeable membrane devices (SPMDs), polar organic chemical integrative samplers (POCIS), diffusion gradient thin films (DGTs).

ISO 5667-23 provides guidance on passive sampling in surface waters.

12.10 Sampling equipment for suspended sediments

There are a number of different sampling techniques with differing apparatus for the bulk collection of suspended solids. Many of these samplers are specific to site conditions and can require deployment from boats, bridges or by wading.

As there are currently no standardised instructions for sampling suspended solids, it is important to observe a standard procedure so that long-term observations are comparable.

Suspended solids are sampled by a variety of sampling methods that use different equipment:

a) centrifuging methods (e.g. continuous-flow centrifuges);

b) sedimentation methods (e.g. sedimentation tanks and boxes, floating collectors);

c) filtration methods (normal, pressure and vacuum filtration).

Detailed guidance on in situ procedures for the sampling of suspended sediments is contained in ISO 5667-17.

13 Quality assurance and quality control of environmental water sampling and handling

13.1 General

Avoiding contamination during sampling is essential. All possible sources of contamination should be taken into account and the appropriate control applied if necessary.

13.2 Sources of contamination

Potential sources of contamination can include the following:

a) the residue of earlier samples remaining on sampling containers, funnels, scoops, spatulas and other equipment;

b) personnel, for example, cosmetic products;

c) contamination from personnel due to hygiene;

d) contamination from container labels, glue or markers;

e) contamination from the sampling site during sampling;

f) contamination from vehicle or other equipment carried;

g) residual water in or on ropes, chains or extension handles;

h) contamination of funnels from preserved samples;

i) contamination of bottle caps or tops by dust or water;

j) contamination of the barrel of syringes and from filter medium;

k) contamination from hands, fingers, gloves and general handling;

l) contamination from internal combustion exhaust;

m) inappropriate sampling devices, bottles and filtration devices;

n) degraded reagents;

o) exhaust fumes from sampling vehicles, for example, cars, boats, snowmobiles.

13.3 Control or prevention of contamination

Control and identification of contamination can be achieved by the following actions, where appropriate:

a) appropriate personnel training;

b) appropriate procedures, techniques and sampling manuals;

c) adopting a philosophy of maximizing the degree of isolation for the sample bottle from contamination, which produces better quality data;

d) taking care to avoid disturbance at the sampling site;

e) different equipment for different sampling activities;

f) different clothing or protective equipment;

g) thoroughly rinsing and cleaning of the equipment;

h) rinsing the funnel inside and out after sub-sampling preserved samples;

i) rinsing the barrel of the syringe and filter medium before use;

j) storing bottle caps and tops securely to avoid contamination;

k) wiping and drying ropes, chains or extension handles between sampling and prior to storage;

   1) avoiding touching the sample itself with fingers, hands or gloves; this is particularly important during microbiology sampling where no contact should be made with the interior or rim of the bottle or the cap;

   2) ensuring that all ice augers, vehicles and boats are well downwind (and downstream in the case of boats), allowing a few minutes for exhaust gases to dissipate; ice augers, slush scoops and spades should be kept clean like any other sampling equipment; spade should not be greased;

   3) examining each sample or sample bottle for large particles such as leaves or detritus; if these are observed, discard the sample and collect a new sample;

   4) using suitable quality assurance techniques and suitable quality control procedures, for example, replicate quality control samples, field blank samples, rinsing of equipment (sampling containers), filtration recovery, spiked samples, effectiveness of homogenization equipment as outlined in ISO 5667-14.

14 Transport to, and storage of samples at, the depot or laboratory

Samples should be stored and transported in accordance with ISO 5667-3, ISO 5667-16 or ISO 19458 until they reach the analysing laboratory. It is the laboratory’s responsibility to ensure storage is suitable after the samples have been delivered.

Samples should be delivered to the analysing laboratory within the stability window for the tests to be carried out otherwise the samples will not remain representative.

If the samples are to be exposed to excessive heat or excessive cold, i.e. contained in the sampling vehicle in hot conditions or in adverse weather, then the samples (or those sub-samples) should be cooled or heated as required. The vehicle should preferably be fitted with temperature control fridge units (cool boxes can be used but they are not efficient and effectively are only suitable for preventing temperature rise). It should be noted that the BOD of a sample can be reduced by 40 % if stored under high ambient temperatures or light conditions in a sampling vehicle for 8 h.

A system should be in operation that clearly identifies to the laboratory courier which samples and associated paperwork are for transmission to the laboratory.

All preservation steps should be recorded in the report and the temperature measured and recorded on site, if appropriate. Ideally other physical and chemical parameters (e.g. pH value) should be determined on site or as soon as possible afterwards.

15 Sample identification and records

15.1 General

The source of the sample and the conditions under which it was collected should be recorded and a suitable record attached to the bottle immediately after filling. A water analysis is of limited value if it is unaccompanied by detailed information about the sample.

The results of any on-site analyses carried out should also be included in a report with the sample. Labels and forms should always be completed at the time of sample collection. The sampler should never move on to another task before completing all documentation at a site.

The sampling report should include at the least the following information:

a) location and name of sampling site, with coordinates and any other relevant locational information;

b) details of sampling point, including kind of sample (e.g. water intended for human consumption, waste water),

c) date of collection;

d) time of collection;

e) name of sample collector;

f) sample type (e.g. single sample, composite sample);

g) weather conditions (if applicable);

h) field observations;

i) water temperature (if applicable);

j) nature of any pretreatment including preservation;

k) method of collection and any details of non-compliance with standard conditions or sampling practices (e.g. sample collected through ice, seasonal observations, land-based activities).

Examples of type of field paperwork are labels that can be used can be found in Annex B.

15.2 Data management

Data management is an increasingly important aspect of monitoring programmes, which should be planned before any sampling activity takes place. Additional value can be extracted from the collated information if sample results can be reviewed together with the associated metadata including details, for example, about the test methods used. Collection of comprehensive metadata is also an essential requirement for comparison and utilization of data from different sources and contexts. It is therefore essential that metadata related to the sample is collected in a consistent manner such that it can be stored in electronic systems. Such systems need to be provided with information consistent with established data retrieval protocols, for example, using the correct input notation for dates, location (latitude and longitude). It is also important to establish at the planning stage the necessary linkages to information on the calibration of field equipment, operator training, and local weather conditions which will be linked to the data collected during the sampling exercise. In addition, it will also be of historical relevance to document within the electronic system when changes to test methodology were made, for example, improvement in limits of detection or other performance-related features. If there is any doubt as to the precise specification for metadata collection, it is recommended that the data managers and users are consulted with respect to the needs of the electronic system and specific local requirements.

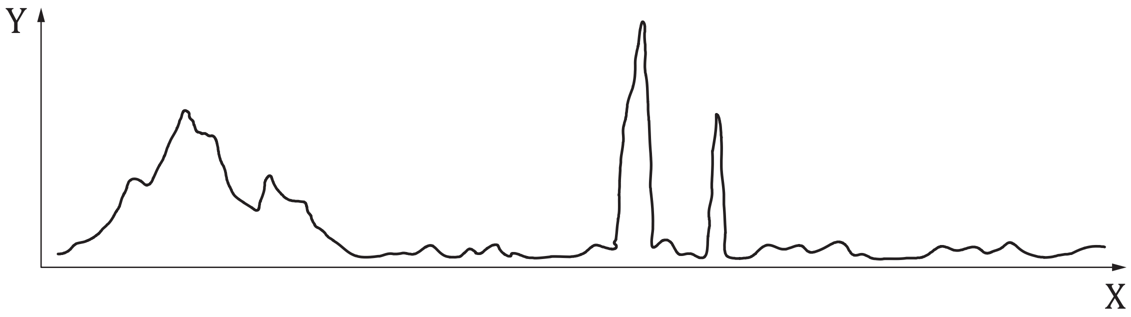
15.3 Samples that can be used for legal purposes

Often a legally defined chain of custody is required which proves who was responsible for the safe keeping of the sample at all times between the moment the sample was taken and the completion of the analysis. The legal system in a particular state will define the requirements that a chain of custody has to fulfil. This will normally include some documentation additional to that normally used for non-legal samples, showing by signature, dates and time who was responsible for the samples. The chain of custody should include the sampling operative, the person delivering the sample to the depot, if different, the laboratory courier and verification that all parts of the sample that were sent have been received.

The courier should deliver the sample to a nominated, responsible officer at the laboratory who should complete the record, and the original copy of the document should be returned to the sampling officer with a copy retained by the laboratory. Alternatively, if the samples are delivered outside normal office hours, some proof that the sample is deposited securely at the depot should be requested.

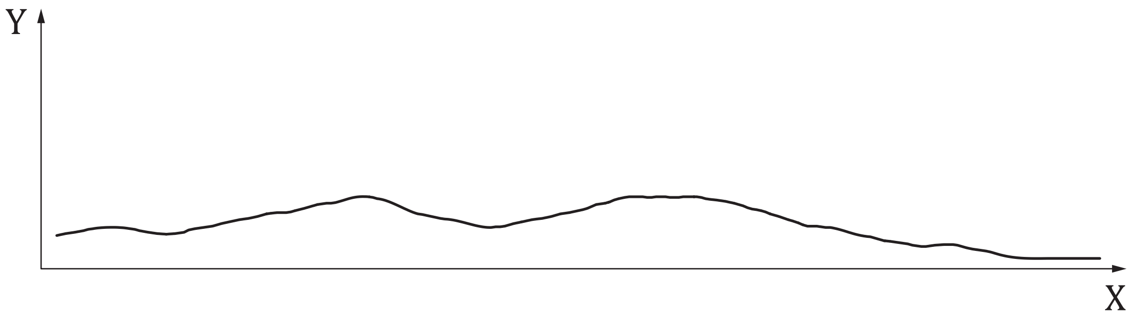
Annex A
(informative)

Diagrams illustrating types of periodic and continuous sampling



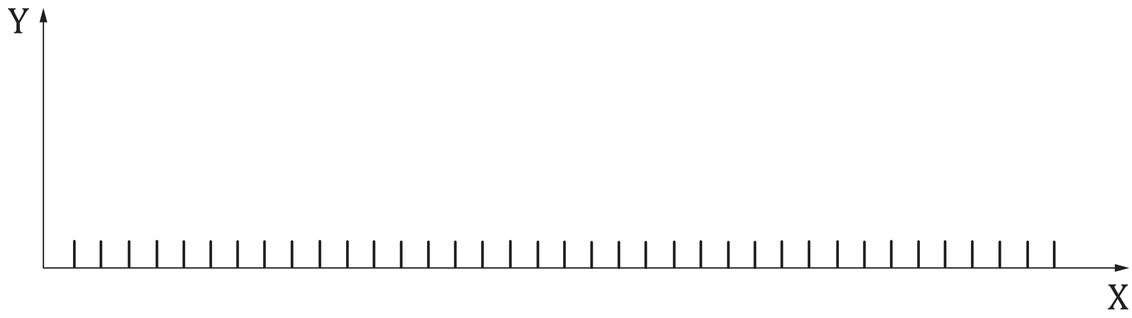
Key
X time
Y concentration

Figure A.1 — Continuous direct measurement — Continuous online measurement



Key
X time
Y flow

Figure A.2 — Periodic samples — Time scale of flow

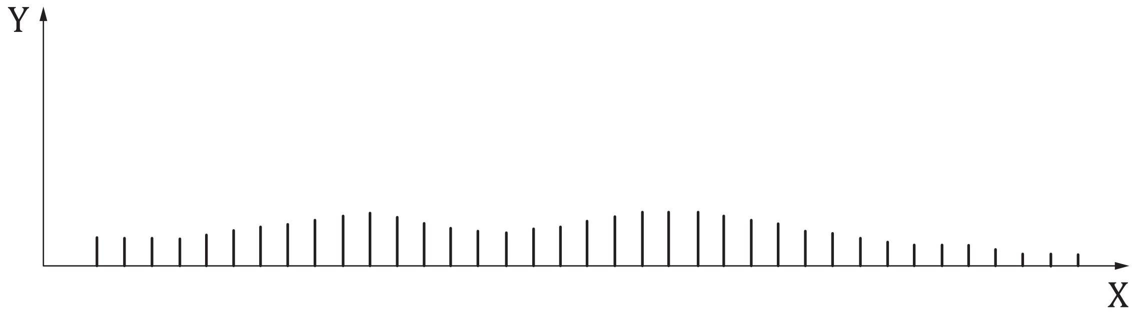


Key

X time

Y volume

Figure A.3 — Periodic samples — CTCV — Periodic samples taken at fixed time-intervals (time-dependent) or CTCV sampling



Key

X time

Y volume

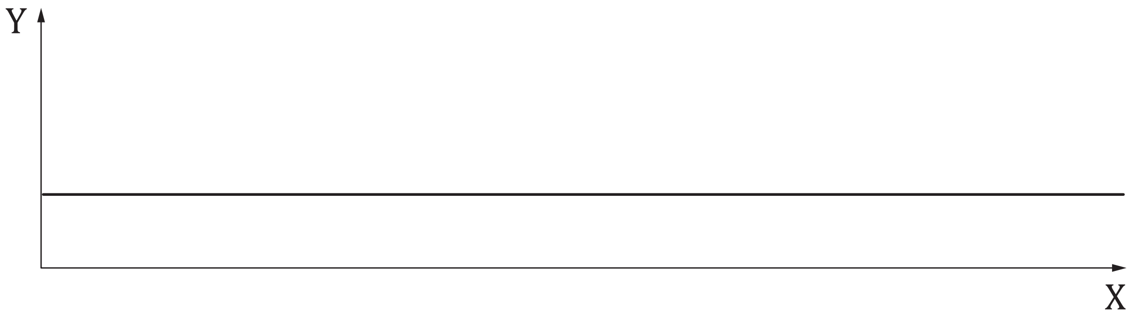
Figure A.4 — Periodic samples — CTVV — Periodic samples taken at fixed flow-intervals (volume-dependent) or CTVV sampling

Key

X time

Y volume

Figure A.5 — Periodic samples — CVVT — Periodic samples taken at fixed flow-intervals (flow-dependent) or CVVT sampling

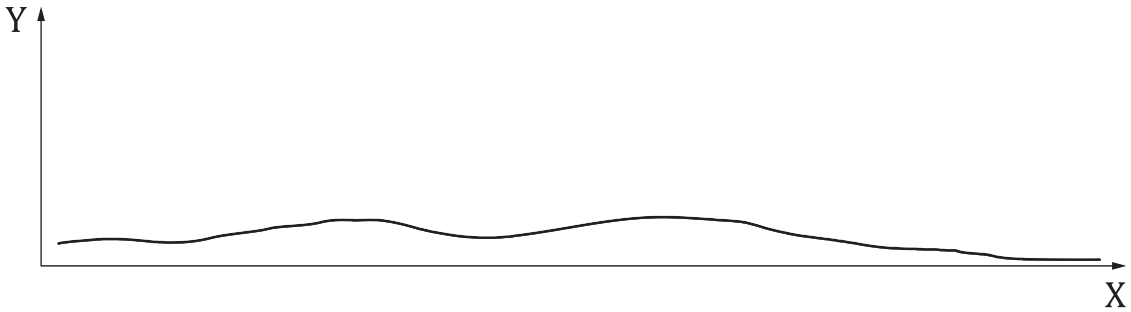


Key

X time

Y volume

Figure A.6 — Continuous samples — Continuous samples taken at fixed flow rates (time-continuous sampling)



Key

X time

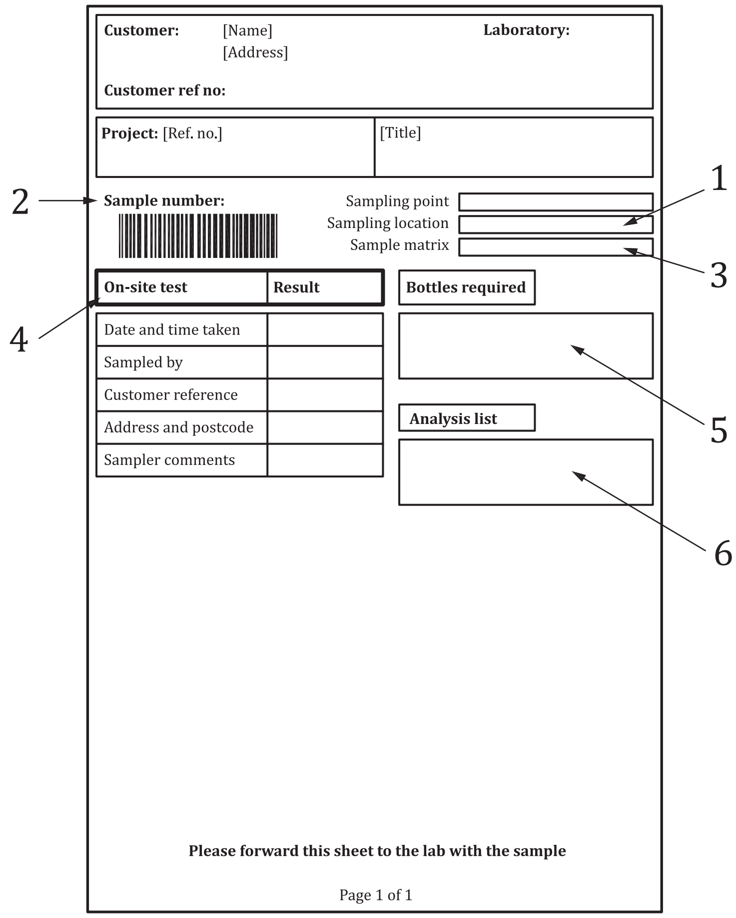
Y volume

Figure A.7 — Continuous samples — Continuous samples taken at variable flow rates (flow-continuous sampling)

Annex B
(informative)

Diagram illustrating types of field paperwork and labels

Figure B.1 shows an annotated example of logged field sampling information.



Key

1 location of where the sample was taken (matches the sample text ID of the labels)

2 sample number needs to match the numbers on the labels used for this sample, to link the information in this sheet with the sample results; there is only one sheet per sample

3 type of water being sampled and tested

4 on-site test and results to be completed with the following:

a) date and time sample was taken (failure to record this constitutes deviation);

b) name of sampling operative;

c) any unique reference to be linked to this sample (this will be included in the test certificate);

d) address (including postcode) of sampling location if sample taken from a property;

e) any additional information to be linked to this sample (this will not appear in the test certificate, but will be stored)

5 bottle codes required for the sample, e.g. METALS (1); failure to enter any of these can result in some tests not being carried out or results being compromised

6 list of the tests assigned to this sample (e.g. COLOUR, METAL)

Figure B.1 — Example format of logged field sampling information

Annex C
(informative)

Alternative and emerging sampling techniques

C.1 In situ testing

In situ testing is becoming more common in two areas. The increasing use of sampler deployed instrumentation such as pH, electrical conductivity and instruments for the detection of ammonia, chlorine, and chlorine dioxide. In addition, similar technologies are also being deployed for process control generating large amounts of data by being deployed as in line monitors. Both applications present different needs when planning sampling and data use strategies.

C.2 On-site analysis performed by samplers

Data collected in this manner needs to be supported by the application of commensurate quality control and assurance programmes to provide evidence of calibration and operator competence to support the data quality and traceability. The sample planning needs to ensure that sufficient metadata are collected to allow traceability of the relevant supporting information. For example, instrument serial numbers and user identity which can be linked to calibration records and quality control evaluations.

C.3 In line plunger

The use of in line plungers is developing and becoming more common and is used for sampling from pressurized pipes. Special attention must be paid to the purging of the in line plunger (see 12.8).

C.4 In line testing performed by automated equipment

The use of in line monitors can form an important part in the development of sampling strategy and multiple sets of data can complement each other. For example, by providing evidence of influences such as diurnal variability at points in a catchment, or process plant, which may otherwise not be detect during the deployment of spot sampling or with the deployment of automatic samplers. Similar considerations to sampler deployed instruments need to be applied to the data recording process by identify key metadata. It is recommended that information such as the identification of instrument calibration and service data to support the quality and traceability of the data set is made available to the information user. This is to eliminate the potential influence of phenomena such as calibration drift or the gradual fouling of probes when interpreting the wider data set in conjunction with that obtained from other sampling techniques.

NOTE It is important to test any field equipment regularly with analytical quality control samples to ensure continued accuracy while in use.

C.5 Use of drones

The benefits of using these technologies will need to be determined on a case specific basis but is recommended that they should not be dismissed without careful consideration. However, part of the overall consideration will be local regulations regarding the use of drones and any impact on air traffic movements.

C.6 Investigative drones

There is an increasing use of photographic drones across several investigative disciplines. In the field of water quality sampling they can be used to identify various physical characteristics which can inform the development of a sampling plan or enhance the interpretation of results obtained from such a plan.

Some examples are:

— The deployment of a photographic drone over a lake to determine the extent and relative movement of an algal bloom which has been identified from samples taken at fixed monitoring points.

— Identification of areas of differences in vegetative stress under draught conditions to assist in differentiating leaking pipes from boundaries of naturally occurring near surface groundwater. Such information can be used to aid the location of investigative trial pitting and water sampling to confirm water sources.

C.7 Sampling drones

Specially adapted drones have the potential to provide rapid coverage of near surface phenomena such as algal blooms by geo specific sampling without the use of surface craft. Surface craft may otherwise cause turbulence and reduce the value of the geospatial information. Such devices may also allow greater distances to be covered during sampling exercise and increase accessibility to remote areas of exposed water in wetland areas. It is also possible that such techniques can increase sampler safety in remote areas where potentially dangerous wildlife can impede accessibility.

C.8 Leak detection dogs

In some cases, dogs have been used with great success to enhance surveying of potentially leaking pipes to identify areas of seepage associated with chlorinated water. Techniques such as this may form part of an overall investigation strategy where the use of water quality sampling may prove inconclusive when trying to confirm the identity of seepage water in, for example, saturated soil environments.

Annex D
(informative)

Preparation of sampling equipment

Sampling equipment should be prepared as shown in Table D.1.

Table D.1 — Preparations for sampling

Equipment	Preparation
Personal safety equipment	Ensure that there are sufficient disposable gloves for the day, mobile phone, ice anchors, first-aid kit, hand wipes, goggles, etc.
Sampling vessels Funnels Ropes Chains Extension handles Filters and filter equipment	Check for scratches, signs of wear and tear and insecure fitting. Check and clean, if necessary, for obvious sources of contamination like remains of sediment, dust, oil, etc. Check the full functionality of the equipment prior to use.
Bottles	Check the condition of the bottles and caps and discard any damaged ones found so that other sampling operatives do not select them. Ensure bottles are capped to reduce contamination and that they are stored securely. Ensure bottles for microbiology work have either their original wrapping intact or sterility indicator stripes visible and that the bottles are within date.
Labels and sample documents	If labels are pre-printed, check against schedule to ensure that none are missing.
Crates and sample carriers	Check that sufficient numbers are available for daily use. Inspect for damage or signs of deterioration. If necessary, swab the crates with a disinfectant.
Field instruments	Check that calibration is within date. If not, do not use but replace. Follow the sampling procedure/manufacturer's instructions for storage.
Test kits	Check that test kits needed for daily schedule are available for use. Ensure the manufacturer's instructions or work instructions are available for use. Check that the “use by date” has not expired; replace if necessary. Store separately from sample bottles.
Preservatives	Check that the “use by date” is not exceeded. Check dropper pipette for deterioration and replace as necessary. Ensure segregation from empty sample bottles.
Ice auger	Check the motor starts and the bit is sharp.

Bibliography

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

[2] ISO 3534 (all parts), *Statistics — Vocabulary and symbols*

[3] ISO 8199:2018, *Water quality — General requirements and guidance for microbiological examinations by culture*

[4] ISO 10870:2012, *Water quality — Guidelines for the selection of sampling methods and devices for benthic macroinvertebrates in fresh waters*

[5] ISO 16665:2014, *Water quality — Guidelines for quantitative sampling and sample processing of marine soft-bottom macrofauna*

[6] ISO 16720:2005, *Soil quality — Pretreatment of samples by freeze-drying for subsequent analysis*

[7] ISO 19458:2006, *Water quality — Sampling for microbiological analysis*

[8] ISO 18512:2007, *Soil quality — Guidance on long and short term storage of soil samples*

[9] EN 16479:2014, *Water quality — Performance requirements and conformity test procedures for water monitoring equipment — Automated sampling devices (samplers) for water and waste water*

[10] BS 1427:2009, *Guide to on-site test methods for the analysis of waters*

(*Continued from second cover*)

Part 24 : 2021 Guidance on the auditing of water quality sampling

Part 25 : 2022 Microbiological analysis

This standard was published in 2021 as an identical adoption of ISO 5667-1 : 2020 under dual numbering. This first revision has been brought out to adopt the latest version of ISO 5667-1 published in 2023. In this revision, following modifications have been incorporated:

a) Corrections have been made to **10.3** and associated cross-references to Annex A; and

b) Subclauses have been included in **7** referring to the most recent additions to the ISO 5667 series.

The text of ISO standard has been approved as suitable for publication as an Indian Standard without deviations. Certain conventions are, however, not identical to those used in Indian Standards. Attention is particularly drawn to the following:

a) Whenever the words 'International Standard' appears referring to this standard, they should be read as 'Indian Standard'; and

b) Comma (,) has been used as a decimal marker, while in Indian Standards, the current practice is to use a point (.) as the decimal marker.

Bureau of Indian Standards

BIS is a statutory institution established under the *Bureau of Indian Standards Act*, 2016 to promote harmonious development of the activities of standardization, marking and quality certification of goods and attending to connected matters in the country.

Review of Indian Standards

Amendments are issued to standards as the need arises on the basis of comments. Standards are also reviewed periodically; a standard along with amendments is reaffirmed when such review indicates that no changes are needed; if the review indicates that changes are needed, it is taken up for revision. Users of Indian Standards should ascertain that they are in possession of the latest amendments or edition by referring to the website- www.bis.gov.in or www.standardsbis.in.

This Indian Standard has been developed from Doc No.: CHD 36 (26063).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

BUREAU OF INDIAN STANDARDS

Headquarters:

Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002
Telephones: 2323 0131, 2323 3375, 2323 9402 *Website*: www.bis.gov.in

Regional Offices: *Telephones*

Central : 601/A, Konnectus Tower -1, 6th Floor, DMRC Building, Bhavbhuti Marg, New Delhi 110002 — 2323 7617

Eastern : 8th Floor, Plot No 7/7 & 7/8, CP Block, Sector V, Salt Lake, Kolkata, West Bengal 700091 — 2367 0012, 2320 9474

Northern : Plot No. 4-A, Sector 27-B, Madhya Marg, Chandigarh 160019 — 265 9930

Southern : C.I.T. Campus, IV Cross Road, Taramani, Chennai 600113 — 2254 1442, 2254 1216

Western : 5th Floor/MTNL CETTM, Technology Street, Hiranandani Gardens, Powai Mumbai 400076 — 25700030, 25702715

Branches : AHMEDABAD, BENGALURU, BHOPAL, BHUBANESHWAR, CHANDIGARH, CHENNAI, COIMBATORE, DEHRADUN, DELHI, FARIDABAD, GHAZIABAD, GUWAHATI, HARYANA (CHANDIGARH), HUBLI, HYDERABAD, JAIPUR, JAMMU, JAMSHEDPUR, KOCHI, KOLKATA, LUCKNOW, MADURAI, MUMBAI, NAGPUR, NOIDA, PARWANOO, PATNA, PUNE, RAIPUR, RAJKOT, SURAT, VIJAYAWADA.

Published by BIS, New Delhi