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Water quality — Sampling —

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

Qualité de l'eau — Échantillonnage —

Partie 21: Lignes directrices pour l'échantillonnage de l'eau potable distribuée par camions-citernes ou d'autres moyens que les tuyaux de distribution

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 5667-21 was prepared by Technical Committee ISO/TC 147, *Water quality*, Subcommittee SC 6, *Sampling (general methods)*.

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

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

— *Part 3: Guidance on the preservation and handling of water samples*

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

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

— *Part 6: Guidance on sampling of rivers and streams*

— *Part 7: Guidance on sampling of water and steam in boiler plants*

— *Part 8: Guidance on the sampling of wet deposition*

— *Part 9: Guidance on sampling from marine waters*

— *Part 10: Guidance on sampling of waste waters*

— *Part 11: Guidance on sampling of groundwaters*

— *Part 12: Guidance on sampling of bottom sediments*

— *Part 13: Guidance on sampling of sludges*

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

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

— *Part 16: Guidance on biotesting of samples*

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

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

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

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

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

— *Part 23: Guidance on passive sampling*

Introduction

ISO 5667 deals with the general aspects of sampling (see ISO 5667-1 and ISO 5667-3) and with the sampling of specific types of water (ISO 5667-4 onwards). This part of ISO 5667 is one of the specific water-type sampling parts, and deals with 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. This part of ISO 5667 should be read in conjunction with ISO 5667-1, ISO 5667-3 and ISO 5667-5.

Effective monitoring of drinking water requires collaboration between sampling programme designers, water operators including transporters and water couriers, sample collectors, laboratory analysts, and data users. This part of ISO 5667 gives guidance on the selection of sampling locations and the collection of samples when monitoring drinking water.

Understanding the purposes for monitoring drinking water and the principles behind the methods of analysis is important, since specific sampling protocols can vary widely in accordance with different purposes and different analytical methods.

Examples of sampling purposes include:

a) searching for the cause of pollution within the distribution chain (e.g. in response to customer complaints);

b) monitoring the quality of drinking water in storage and at the point of use on ships, aircraft and other vessels and vehicles that provide water for drinking, washing, cooking or other purposes;

c) assessing the effects of materials in contact with the water on its quality;

d) assessing the integrity of a non-contiguous distribution chain.

An important factor to take into account is that the potential for microbial regrowth due to faecal contamination of drinking water is always present and constitutes a genuine risk to human health. Chemical contamination events also occur, but these are likely to pose chronic hazards rather than the acute effects generated by faecal contamination.

Water quality — Sampling —

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

1 Scope

This part of ISO 5667 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.

The guidance given in this part of ISO 5667 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, this part of ISO 5667 is applicable to water that is supplied by tanker or other non-contiguous bulk means, but not contiguously 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. This part of ISO 5667 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, re-initiation of systems that have been unused for long periods or emergency situations where the safety of sampling operatives is not compromised.

This part of ISO 5667 does not provide guidance on:

a) the sampling of source water, e.g. 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.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced documents (including any amendments) applies.

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

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

ISO 5667-5:2006, *Water quality — Sampling — Part 5: Guidance on sampling of drinking water from treatment works and piped distribution systems*

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

ISO/TS 13530, *Water quality — Guidance on analytical quality control for chemical and physicochemical water analysis*

ISO 15553, *Water quality — Isolation and identification of* Cryptosporidium *oocysts and* Giardia *cysts from water*

ISO 15839, *Water quality — On-line sensors/analysing equipment for water — Specifications and performance tests*

ISO 19458, *Water quality — Sampling for microbiological analysis*

3 Terms and definitions

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

3.1
conventional water distribution
water distribution via a contiguous system of pipes and works from source to use

3.2
drinking water
water intended for human consumption

[ISO 24510:2007[3], 2.11]

3.3
non-contiguous water distribution
water distribution where there is no continuous system of pipes and works from source to use

EXAMPLE Distribution by tanker truck.

3.4
potable process water
water abstracted without treatment, or applied after treatment, in the food or beverage manufacturing industries, but excluding that contained within the end-product food and beverage, or the products themselves

NOTE Adapted from ISO 5667-5:2006, 2.3.

4 Monitoring programme design

Refer to ISO 5667-1 regarding the design of monitoring programmes, including statistical considerations.

5 Sampling equipment

Refer to ISO 5667-1 and ISO 5667-3 regarding sampling equipment, requirements for containers and materials in contact with the sample, and cleaning of sample containers.

Refer to ISO 15839 regarding performance characteristics for analysing equipment, and to ISO 19458 regarding equipment, bottles, and sterilization requirements specific to sampling for microbiological analysis.

6 Sampling programme design

6.1 General

Be aware that sampling locations, national regulations, and local safety regulations influence the methods of sample collection employed.

Before collection of samples, decide whether some of the analyses are to be performed on site. Be aware of any national regulations requiring on-site analysis.

When collecting samples for microbiological analysis, also be aware of ISO 19458.

6.2 Frequency and timing of sampling

The sampling frequency depends, among other factors, on:

a) the purpose for which sampling is being performed;

b) the number of consumers served;

c) the volume of water distributed;

d) the quality of the source water;

e) the variability of the raw-water quality;

f) the water treatment required;

g) the health hazard involved;

h) the complexity and characteristics of the specific distribution system being sampled;

i) specific parameters.

Detailed guidance, including statistical considerations, is given in ISO 5667-1. National or regional legislation, whichever has precedence, should be followed. Note that the minimum frequencies for different parameters need not be the same. For detailed guidance on assessment of hazards, see 6.5.

6.3 Location of sampling points

6.3.1 General

Choose sample collection locations to yield samples that are representative of the quality of the water contained in the bulk storage container and of the water quality at the point(s) where water is delivered to consumers, used as potable process water (e.g. in food and beverage processing) or transferred to a piped distribution system.

While the selection of each sampling point requires individual consideration, the following general criteria are usually applicable.

a) There should be at least one sampling point on the inlet to the bulk storage container and one sampling point on the outlet from the bulk storage container. Water extracted from these sampling points should represent water within the storage container and should not be extracted from the source or from a secondary distribution system.

b) In systems with more than one inlet or outlet, sample locations should reflect the potential differences in water quality, in accordance with the determination to be made.

c) Sampling points should include locations representative of the most unfavourable sources and locations considered vulnerable to contamination.

d) Where waters from different sources mix within the bulk storage container, sample locations should be chosen to be representative of the quality of the water from each source.

e) Where a container discharges to a piped distribution system on a ship, aircraft or other means of transport, or to a distribution system in a large building or group of buildings such as a hotel or an office block, sampling locations are required within each building, ship, aircraft or other vehicle.

f) If a distribution system includes many similar inlets or outlets, sample at least the most remote and the closest points to the reservoir.

g) Caution is required that the sampling process does not itself convey water into the system to avoid risk of injecting contaminants.

The presence of biofilms suggests problems with the materials used in the distribution system or the management of the delivery systems. If biofilms are suspected, use the methods of sampling and analysis specified in ISO 19458 to investigate the source of the problem. The sampling of biofilms is difficult, and the method employed is influenced by the specific sampling situation. Further guidance is given in Annex C.

6.3.2 Mobile tankers

Mobile tankers can be used either as temporary alternatives to piped or other supplies, or to fill other temporary or permanent non-contiguous supplies. They include tanks of drinking water transported by road, waterway, rail, and air. These transfer containers should be regarded as non-contiguous, non-piped sources of drinking or process water in their own right and be sampled accordingly (see 6.3.5). They should ideally be emptied, cleaned, and disinfected before refilling. If this is not done, enhanced sampling and analysis is recommended, commensurate with the increased risk of contamination (see Annex A).

6.3.3 Static tanks

Static tanks can be used as permanent sources of drinking water, process water supplying a piped distribution system or temporary alternatives to piped or other sources. When static tanks are used as integral parts of conventional water distribution systems, sample them according to ISO 5667-5. However, when static tanks are used as non-contiguous sources of drinking or process water in their own right, sample them accordingly (see 6.3.5).

Tanks which are emptied, cleaned and disinfected before refilling should be regarded as non-contiguous sources (see 6.3.5). If the cleaning is not done before refilling temporary tanks, enhanced sampling and analysis are recommended, commensurate with the increased risk of contamination or proliferation of micro-organisms, which could, for example, adversely affect taste and odour or give rise to more serious problems (see Annex A).

6.3.4 Bulk storage tanks on aircraft, trains and ships

Tanks on aircraft and trains should ideally be emptied, cleaned, and disinfected before refilling. If this is not done, enhanced sampling and analysis are recommended, commensurate with the increased risk of contamination. Where these tanks supply their own permanent distribution systems, sample both the tanks and their distribution systems in accordance with ISO 5667-5.

Tanks on ships, which are refilled from external sources of drinking water, should be sampled in a similar way to tanks on aircraft and trains. An exception is ships having their own treatment plants permanently connected to the storage tanks, in which case sample the treatment plant, storage tank(s), and distribution system(s) as a piped distribution system in accordance with ISO 5667-5.

6.3.5 Non-contiguous water distribution

On occasion, non-contiguous sources, such as road tankers, are used as a temporary alternative to piped supplies. Ideally, samples should be collected from outlet taps rather than by dip sampling. If dip sampling is necessary, then it is important to maintain the integrity of the water supply by thorough cleaning and disinfection of the sampling equipment.

NOTE Water is particularly vulnerable to contamination during filling and emptying operations.

Check that standpipes and hoses are protected from contamination and flushed before use. Also check that hose nozzles are kept immersed in suitable disinfectant solution prior to use, and that there is no cross-connection with non-potable water supplies. Back-flow from tank to storage tank, hoses or source water supply should be avoided.

6.3.6 Bottled water supplied in an emergency

On occasion, water is supplied on an emergency basis in bottles (or other small containers) directly to the consumer by the operator as a temporary alternative to piped supplies. A sample of filled bottles should be taken at random, at the point of filling and at the point of distribution, and taken to the laboratory for analysis. In such cases, sample the source water prior to bottling in accordance with ISO 5667-5.

6.4 Pre-collection cleaning, disinfection, and flushing

6.4.1 General

Cleaning, disinfection, and flushing prior to sample collection depend on the specific objectives of the monitoring programme. In general, sampling to ascertain the quality of the water delivered from the container, or to ascertain whether the quality of the water delivered within a building or transport vehicle is possibly altered by the service network within the building or vehicle, requires thorough cleaning and flushing of the sampling points. Investigation of water quality as delivered from a tap can require that samples be collected before cleaning and flushing, or samples can be required both before and after cleaning and flushing.

Be aware of local and national regulations. When samples are to be collected for microbiological analysis, also be aware of ISO 19458.

6.4.2 Tanks

Generally, not less than 2 min of free flow should be allowed to flush out any stagnant water within the sampling line before taking a sample. If this is insufficient or the volume of water stored in the tank is small, calculate the volume of water that needs to be displaced from the pipe, estimate the flushing time required at an appropriate flushing rate and then apply a flushing time of five times that value. Not more than 1 % of the volume of water in the tank should be discharged prior to sample collection. Take the precautions specified in ISO 5667-5:2006, 6.1 into consideration.

6.4.3 Taps

The procedure for sampling from taps[1)] is given in ISO 5667-5.

6.4.4 Dip sampling

Dip samples should only be collected where there is no appropriate alternative. A sampling tap should always be installed whenever regular sampling is planned.

1) ISO 5667-5:2005 uses the US term “faucet”.

Commercially available sterilized single-use dip samplers that are mounted on short rod handles can be used to sample small tanks. For larger reservoirs, sterile dip apparatus and sample bottles can be attached to a chain or rope of sufficient length. The chain or rope can be attached directly or via a bottle cage. Use extreme care to avoid contamination of both the supply and the sample during dip sampling. Preferably, autoclave bottle, apparatus, bottle cage, bottle lid, and chain, package them in suitable material, and remove the wrapping immediately prior to use.

6.4.5 Non-contiguous sources

All taps and hatches of a water tanker should be checked to ensure that they are secure and not damaged. Also check that the tanker does in fact contain water.

Note that water is particularly vulnerable during the filling operation. Check that standpipes and hoses are protected from contamination and flushed before use. Also check that hose nozzles are kept immersed in suitable disinfectant solution prior to use, and that there is no cross-connection with non-potable water supplies. Avoid back-flow from the tank into the fill hoses or into the source water supply.

Sample taps (including nozzles) as specified in ISO 5667-5. Dip sampling is not recommended. However, if dip sampling is necessary, the equipment should be thoroughly cleaned and disinfected prior to use. The procedure for dip sampling is specified in 6.4.4.

6.5 Assessment of hazards

Tanks, whether static or mobile, are particularly vulnerable to various hazards, listed in Table A.1. Regular sampling programmes to assess such hazards should include collection of all relevant parameters on the following schedule:

a) at the time of filling;

b) after cleaning to prove the quality of the rinse water;

c) from residual water, when a partially full tank is topped up;

d) before emptying;

e) not less than once per month during periods of active use.

It is recommended that tanks be emptied before refilling.

Table A.1 also lists various control activities which may be used to mitigate real or potential hazards.

Tanks which are kept in non-secure locations, have unlocked sample taps or other access or are refilled without being emptied are particularly vulnerable to hazards and should be sampled on a daily basis.

7 Sample collection and handling

7.1 General

Refer to ISO 5667-1 for guidance regarding sampling techniques and to ISO 5667-3 for guidance regarding the preservation and handling of samples. When sampling for emergency purposes, specific guidance should be sought from the analysing laboratory or other scientific expert to ensure meaningful samples are obtained. Also be aware of any national regulations requiring on-site analysis.

Because different analytical methods can require different methods of preservation, distribution of the sample into several containers can be required. To minimize changes in the samples during collection, storage, and transport, these operations should be carried out in as short a time period and as soon after sampling as possible.

If contact of the sample with air is to be avoided, the sample container should be filled completely and immediately stoppered.

If filtration is necessary on site, e.g. to separate two forms of a determinand, the sample should be filtered during or immediately after collection so as to minimize any changes that can occur in the sample. Simple techniques for filtering samples, such as through membrane or glass fibre filters, can be adequate, but for detailed guidance, refer to the relevant analytical International Standard.

Additionally, each sample bottle should be labelled, registered on an appropriate form, carefully packed to avoid breakage during shipping and delivered to the analysing laboratory within the prescribed timeframe. Before transporting the sample to the laboratory, the appropriate preservation technique should be applied during transport; refer to the guidance given in ISO 5667-3 and the relevant analytical International Standards.

Once delivered to the analysing laboratory, samples should be stored in a clean room separate from the laboratory. The storage area should be kept dark and cool, and should not be used for storage or use of reagent chemicals. General recommendations, precautions, and guidance regarding preservation and holding time are provided in ISO 5667-3.

Some parameters including residual chlorine, pH, and turbidity should be tested immediately after sampling as they are likely to change during transport and storage. It is essential that all field measurements be made on samples taken from the body of water. To avoid contamination, it is essential that probes used for field measurements not be inserted into the tank or into sample bottles intended for shipping to laboratories.

7.2 Volume of samples

7.2.1 General

The volume of the samples to be collected depends on the number and types of analyses to be performed. Refer to the relevant International Standards for the analytical methods for the volumes required for each determination.

If very small concentrations are to be determined, the volume of the samples might have to be large. Taking large-volume samples can mask changes in the water quality during the sampling period, but the sample volume can be an overriding factor in the requirements of the analysis.

Collecting composite samples is not recommended for the analysis of drinking water, except for special studies.

7.2.2 Precautions to minimize contamination

Be aware of ISO 5667-3 regarding preservation and handling of water samples. The following precautions should be taken during sample collection and handling to minimize contamination of samples:

a) thoroughly wash hands and wear disposable gloves;

b) never smoke while collecting or transporting samples;

c) do not eat or drink while taking samples;

d) avoid the presence of volatile substances during transportation (e.g. from a spare fuel container or at a fuel station);

e) only use laboratory-provided sample bottles and containers;

f) only use laboratory-supplied reagents;

g) where reagents are used for preservation, sequence the order of sample collection to minimize the chance of cross-contamination of samples by reagents;

h) do not use reagents that have passed their expiry date or that have an unusual appearance;

i) do not rinse sample bottles unless such rinsing is required in the study design;

j) minimize contamination of the outside of sample containers;

k) remove cap from a sample bottle immediately before sample collection and place the top in a clean and sterile bag or container while the sample is being collected — never place the cap on the ground, in a pocket or on a nearby object;

l) before taking a sample, care should be taken to ensure that the sampling tap, or area surrounding a dip sampling location, is free from dust and other debris, which may enter the sampling or storage container during collection — where possible, sample taps and dip access locations should be covered with a secondary protection device to exclude dust contamination (e.g. by securing a plastic bag over a sampling tap if it is not regularly used for abstraction);

m) never insert any foreign object (such as a thermometer or pH probe) into a bottle intended for other analyses;

n) avoid use of sample splitters unless specifically required;

o) never use metal sampling devices if the analysis is to detect trace metals;

p) prior to use, ensure that sample bottles are stored in clean areas and are capped or wrapped;

q) ensure that all sample bottles or containers are closed in an airtight fashion after sampling;

r) samples should be cooled, where appropriate, by refrigeration or cooling (i.e. placing on ice), especially in summer months, and kept in the dark before and during shipping (see ISO 5667-3);

s) if samples are to be frozen, there should be sufficient space in the sample container for expansion of the sample.

7.2.3 Sampling for physical, chemical and radiological analysis

Refer to ISO 5667-1 for guidance regarding sampling techniques, to ISO 5667-3 for guidance regarding the preservation and handling of samples or to the clause specifying methods of sampling and preservation of samples in the relevant analytical International Standard.

If contact with air is to be avoided, the sample container should be slowly filled to overflowing. The completely filled container should then be capped tightly and checked to ensure the absence of air bubbles.

Samples that are to be preserved or used as microbiological samples should not be filled to overflowing.

To determine dissolved oxygen or other gases, use a hose attached to the tap or pump outlet that reaches the bottom of the sample container. The water should be allowed to flow slowly into the sampling container through the hose.

7.2.4 Sampling for microbiological examination

Refer to ISO 19458 regarding equipment, bottles, and sterilization requirements specific to sampling for microbiological analysis.

When collecting the sample from a sampling line or tap, it can be necessary to flush any involved portion of the distribution system that has been stagnant for 2 h or more in order to remove stagnant water, except when investigating the microbiological quality of the water within the local pipework. For advice on flushing times, see 6.4.2. The water should be allowed to flow freely from the tap or outlet. The sampling container should be filled directly, but should not be filled to overflowing.

To avoid secondary contamination of the sample, the sampling outlet should be sterilized to inactivate any micro-organisms present. Metal outlets should be sterilized by flame, and plastic outlets by isopropyl alcohol (see ISO 19458). After sampling, the sampling container should be capped tightly. Contamination of the stopper should be avoided. Further information is given in ISO 5667-1 and ISO 19458.

Wide-mouth sample containers of at least 300 ml capacity with ground-glass stoppers or screw caps are recommended. The sample containers should be sterilized as recommended in ISO 19458. Disposable material that is supplied sterile can also be used (see also ISO 8199[1]).

During sterilization and sample storage, the materials should not produce or release chemicals which inhibit or promote microbiological viability (see also ISO 5667-1).

7.2.5 Sampling for pathogens and viruses

The collection of water samples for the detection of pathogens and viruses is similar in many respects to that for more routine microbiological analysis. The main difference is the large volume of sample required (see ISO 5667-1; for large volume sampling, see ISO 19458 and ISO 15553).

Generally, large volumes of water are required for these analyses and sampling techniques often involve pre-concentration by flocculation, centrifugation or filtration. This can present problems when sampling from low pressure systems, such as from small tankers, when a pumped sampling system may be required. Peristaltic pumps are suitable for this purpose. Precautions should be taken to ensure that the sample is not contaminated during sampling (ISO 19458).

8 Field measurements

On-site analysis is particularly recommended for such determinands as odour, taste, pH, chlorine, ozone, dissolved oxygen, acid or base capacity, carbon dioxide, specific (electrical) conductivity, water temperature and ambient air temperature as well as for the visual inspection of the sample.

Measurements or analyses taken at the time and place of sample collection should meet national requirements and comply with relevant analytical International Standards as to methods, quality assurance, and equipment maintenance.

Such measurements yield results rapidly and also tend to be somewhat less expensive than laboratory analyses. The primary drawback is that operating personnel require training in the relevant laboratory techniques if the results are to be reliable.

Refer to ISO/TS 13530 regarding analytical quality control for water analysis.

The calibration of thermometers and thermistors should be verified against a certified reference thermometer at least once per year. Many chemical instruments and sensors require very intensive and frequent calibration, as specified in the manufacturer's recommendations or in national regulations. Some instruments require daily calibration.

9 Safety precautions

Personnel responsible for the design of sampling programmes or for carrying out sampling operations shall ensure that the requirements of relevant national safety regulations are taken into account and complied with in full. For further information, see ISO 5667-1.

10 Sample identification and records

Immediately after the collection of each sample, the sample container should be labelled so that the sample is easily identifiable. Pre-labelling a series of containers is discouraged, due to the risk of sample misidentification when two containers are mistakenly interchanged in the field. It is suggested that samplers avoid label comments that are likely to alarm the public, e.g. “cyanide”.

A sample report should be prepared for each sampling location (see Annex B). The container and its location should be described in detail, with a statement as to field measurement results, weather conditions, unusual events or unusual appearance of the site, container or samples. When sampling for specific reasons (e.g. in response to a complaint), detailed information should be included. It is important that the time of collection for each sample be recorded. If the same container and sampling location are used repeatedly, it is not necessary to repeat all details every time. In this case, only a statement of the on-site measurements, time of sample collection, and information regarding weather conditions, unusual events, and similar observations, need be recorded.

The sampler should be identified on the report, preferably by signature, printed name and contact details. Additionally, photographs and detailed written records are invaluable when it comes to interpreting monitoring data.

11 Quality assurance and quality control for collection and handling of samples

11.1 General

Establish a quality assurance (QA) programme in accordance with ISO 5667-14 for every series of samples to ensure that data resulting from sampling programmes are both trustworthy and scientifically credible. Mistakes in any step of the sampling procedure can result in substantial errors within the resulting data.

Laboratories that analyse the collected samples should have rigorous programmes of QA and quality control (QC), as required by national regulations. This is not a substitute for the rigorous QA and QC programmes required for sample collection and handling.

QC entails the collection of data to assess the reliability of the sampling procedure. At a minimum, QC programmes should include the use of blank samples (samples of purified water handled as genuine samples) to assess contamination and use of replicate samples to assess precision and repeatability.

QA comprises all the steps taken to ensure that valid results are produced. QA programmes include the QC programmes. Additionally, they include documented evidence that the individuals who collect samples are competent and well trained, that appropriate sample collection and sample handling methods are employed, that equipment is maintained and calibrated, that correct practices are followed and that records are both complete and safely secured.

Particular importance should be given to the correct measurement of determinands carried out on site and their correct recording. Refer to ISO/TS 13530 regarding analytical QC for water analysis.

Analysing laboratories have particular expertise regarding QA and QC. It is therefore suggested they be involved in the design and evaluation of sampling QA and QC.

11.2 Sampling manual

Each person responsible for collecting drinking water samples should carry an up-to-date sampling manual. This manual should provide specific guidance regarding sampling methods to be employed, sample handling and preservation, and analytical methods for measurements to be performed at the sampling site. The manual should also detail all QA and QC procedures to be employed when collecting samples and when taking on-site measurements.

It is recommended that the manual additionally provide guidance as to appropriate sampling responses when unusual conditions are identified, plus a contingency plan for emergency conditions.

11.3 Training of samplers

All samplers should be fully trained before being allowed to work unsupervised. Guidance is given in ISO 5667-5.

11.4 Independent audits

It is important that users of data resulting from sampling have confidence in the operation of the quality system applied to sample collection and to sample handling. However, often it is not practical to subject sampling programmes to sufficient QC checks in order to demonstrate statistical control of the sample collection and sample handling programmes.

Great reliance is therefore placed on documented proof that methods of sample collection, sample handling and transport, and associated QA programmes have been correctly applied. The use of independent audits is recommended to provide this proof. Third party audits, such as those associated with ISO/IEC 17025[2], accreditation or customer audits by the data user, should be carried out on a regular basis, but by their nature they can only be carried out at a very low frequency and cannot, on any one occasion, be relied on to cover the entire sampling operation. They should therefore be augmented by a thorough and regular programme of internal audits carried out, as far as possible, by persons familiar with the process and objectives of sampling, but who are independent of the sampling process and its management.

These independent internal audits should cover the whole of the process from planning of the programme to delivery of samples to the laboratory, and should examine in detail the quality of execution of the programme and process, and their management.

Routine sampling programmes can be audited on a rolling programme, but one-off programmes should also have their own planned audit programme. It is especially important that an audit be carried out following emergency deployment of tankers and other temporary means of replacing or augmenting piped supplies to ensure that lessons are learned, and that optimal implementation and management of an effective monitoring programme can be achieved during any subsequent emergency deployment.

Annex A
(informative)

Examples of hazard factors associated with failure to clean and disinfect tanks between fillings, including refilling before emptying

Examples of hazard factors associated with failure to clean and disinfect tanks between fillings are given in Table A.1.

Table A.1 — Examples of hazard factors associated with failure to clean and disinfect tanks between fillings

Hazards factor	Hazard indicators	Control activities which may be used to mitigate real or potential hazards
Proliferation of micro-organisms eventually resulting in rejection of the water	Increased colony counts, taste and odour problems	Withdraw from use and empty, clean and disinfect before return to use. Maintain residual disinfectant concentrations at a level that inhibits growth of micro-organisms.
Proliferation of *Legionella* spp. with potential for illness with certain uses of the water	Increased *Legionella* spp. counts	Ensure water is not used for any process involving production of aerosols. Withdraw from use and empty, clean and disinfect before return to use. Maintain residual disinfectant at a level that inhibits growth of micro-organisms.
Accidental faecal contamination, particularly of sample taps, from human and animal activity, or from animals entering the tank, with potential for illness	Increased coliforms of faecal origin, E. coli or Enterococcus counts Increased turbidity of water Dead animals present in tank	Protect sample taps from contamination when not in use. Advise that water is boiled before use or withdraw from service. Keep hatches securely locked. Keep tank sample taps locked when not in use. Perform regular visual inspection of interior of tank.
Accidental chemical contamination, with potential for illness and aesthetic problems such as taste and odour resulting in rejection of the water	Abnormal changes in aesthetic and general physicochemical properties Elevated concentrations of the specific chemical(s)	Withdraw from use and empty, clean and disinfect before return to use. Keep hatches securely locked. Protect tank sample taps from contamination and keep locked when not in use.
Deliberate chemical or microbiological contamination (e.g. by a disgruntled former employee), with potential for illness and aesthetic problems resulting in rejection of the water	Increased microbiological counts Abnormal changes in aesthetic and general physicochemical properties Elevated concentrations of specific chemicals	Withdraw from use and empty, clean and disinfect before return to use. Keep hatches securely locked. Protect tank sample taps from contamination and keep locked when not in use. Keep tanks in protected area whenever possible.

NOTE 1 The lists are not exhaustive and are provided for illustration only. Each operator should carry out a full hazard assessment for their own circumstances. The hazard assessment and control measures or sampling should include any connected pipework and all other means of distribution.

NOTE 2 The parameters and frequencies of sampling chosen depend on the hazard assessment and the control measures adopted routinely or to be implemented, if necessary. It is good practice to sample tanks that are not in a secure location and are refilled without emptying, cleaning and disinfecting at least once a day for all relevant parameters.

NOTE 3 The enhanced frequency and parameters monitored depend on the nature and degree of the hazards and the control measures applied. However, where a specific significant hazard is identified without adequate control measures, sampling should be performed at least daily for all relevant parameters.

Annex B
(informative)

Example of a sampling report

An example of a sampling report form is given below.

<table>
<tr><td colspan="3">Sample reference number:.....</td><td colspan="4">Laboratory number: .....</td></tr>
<tr><td colspan="3">Sample point reference: .....</td><td colspan="4">Sample purpose: .....</td></tr>
<tr><td colspan="7">Sample point name: .....</td></tr>
<tr><td colspan="7">Sample point location: .....</td></tr>
<tr><td colspan="7">Weather conditions:.....</td></tr>
<tr><td colspan="3">Time of sampling: .....</td><td colspan="4">Date of sampling:.....</td></tr>
<tr><td colspan="3">Bottle type: .....</td><td colspan="4">Preservation and storage: .....</td></tr>
<tr><td rowspan="2">Field tests</td><td>Test</td><td>Result</td><td>Test</td><td>Result</td><td>Test</td><td>Result</td></tr>
<tr><td>.....</td><td>.....</td><td>.....</td><td>.....</td><td>.....</td><td>.....</td></tr>
<tr><td colspan="7">Storage in transit: .....</td></tr>
<tr><td colspan="3">Sampler's name: .....</td><td colspan="4">Signature: .....</td></tr>
<tr><td colspan="7">Contact number:.....</td></tr>
<tr><td colspan="7">Analysis required:.....</td></tr>
<tr><td colspan="7">Hazards: .....</td></tr>
<tr><td colspan="7">Sampler's comments:.....</td></tr>
<tr><td colspan="3">Time received in laboratory:.....</td><td colspan="4">Date: .....</td></tr>
<tr><td colspan="3">Received by:.....</td><td colspan="4">Signature: .....</td></tr>
<tr><td colspan="7">Laboratory comments:.....</td></tr>
<tr><td colspan="7">Special instructions to the analyst:.....</td></tr>
</table>

Annex C
(informative)

Guidance on the sampling of biofilms

Biofilm samples can be collected with swabs of appropriate material such as absorbent cotton wool. If the surface being examined is not wet, the swab should be moistened with Page's saline or dilute (1→40) Ringer's solution. The swab may be held with tweezers if necessary. While wiping the surface to be sampled, rotate the swab so that the whole surface of the swab is used. The swab should then be transferred to a tube (which should then be sealed) for transport to the laboratory. Alternatively, the swab should be snapped off into a small, known volume of Page's saline or dilute (1→40) Ringer's solution, contained in a sterile plastic screw-capped container (usually supplied by the laboratory carrying out the analysis). Thicker layers of biofilm should be scraped off with a sterile scraper and placed in tubes (which should then be sealed) for transport.

When sampling water storage tanks or other containers in which there is little change in water level, the biofilm should be collected at the interface between the water and atmosphere. Alternatively, a small amount of water might be drained from the container, and the sample collected from just below the normal water-line mark. In these situations, maximum growth of biofilms usually occurs at the water/air interface around the normal fill line. To facilitate quantification of organisms, a sterile template should be used so that a known surface area is sampled.

In the case of showerheads and pipes, if these are accessible, biofilms can also be sampled from their inside surfaces by means of a swab. The entire surface should be swabbed to maximize repeatability. Samples should then be labelled “Entire shower head”, etc.

It is difficult to collect samples of biofilms from enclosed water systems without dismantling all or part of the system. Also, the design of many taps does not enable swab samples to be taken easily. Anti-splash or spray nozzle devices inserted into taps can be the source of biofilm formation. They also can interfere with sampling. However, it is often impractical to remove them. It is difficult therefore to establish protocols for biofilm collection from taps so that the results can be readily and reliably quantified. Samples of biofilm might, however, be relatively easy to collect from the inside surfaces of cisterns and shower heads, etc. If it is necessary to remove attachments from taps or dismantle items such as shower heads for sampling, the correct plumbing tools should be used to prevent damage to the item.

If biofilm growth is of critical importance in a particular system, specialized monitoring devices can sometimes be built into water systems to monitor biofilm development. These devices, usually comprising a section of piping or conduit material, may be plumbed into water systems, via side-stream connections, which can then be isolated by appropriately placed valves to facilitate sampling. The devices can incorporate studs of known surface area, which can be aseptically removed for subsequent analysis of the biofilm growing on them. The studs that are removed are then replaced with new sterile studs, and the water flow resumed by re-opening the valves. Care is needed with interpretation as their very presence alters flow patterns within the system where they are inserted. A number of devices, often known as “Robbins devices”, are commercially available.

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