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Service activities relating to drinking water supply, wastewater and stormwater systems — Guidelines for the implementation of continuous monitoring systems for drinking water quality and operational parameters in drinking water distribution networks

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Foreword

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The procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

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For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 224, *Service activities relating to drinking water supply, wastewater and stormwater systems*.

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

Introduction

Cases of drinking water contamination around the world have raised awareness of water utilities' exposure to risk. Contamination can arise from many causes, including societal mishaps, errors in operation, maintenance or management by the water utility, natural disasters, vandalism, sabotage, criminality and terrorist activity. The distributed nature of drinking water systems makes them especially vulnerable to contamination and can permit the rapid dispersion of a contaminant. The velocities and volumes of water in a drinking water distribution network can result in contamination affecting significant numbers of users in a short time (e.g. tens of minutes). Recognition of these risks has raised awareness of the need to consider the use of continuous monitoring systems to rapidly detect potential contamination events.

The occurrence of an event can rarely be predicted. However, the more frequently relevant data can be collected and examined, the greater is the chance of quickly detecting an event's occurrence. This supports consideration of the adoption of continuous monitoring systems to provide the data streams that can be used in event detection.

A contamination event can make a waterworks or a drinking water distribution network unusable for a time and require implementation of contingency plans. Such plans could involve, for example, accessing an alternative source water or providing an alternative water service other than via the drinking water distribution network.

To date, very few water utilities have installed continuous monitoring systems either in part or throughout their drinking water distribution network(s). This situation can result from a rational decision based on risk assessment and, in some cases, a cost-benefit analysis. However, it should be acknowledged that circumstances can change – gradually over time or rapidly in the face of events. Water utilities wishing to explore such an option can face uncertainties and gaps in their knowledge on how to proceed. In such circumstances water utilities typically face three main challenges:

— which types of measuring devices (MDs) to install in each continuous monitoring station;

— how many continuous monitoring stations to install per drinking water system;

— where to locate the continuous monitoring stations in the drinking water distribution network in order to achieve the best results.

The installation of continuous monitoring systems could reduce the risk to public health and mitigate the impact on users and other stakeholders during a contamination event. The value of continuous monitoring systems can be determined using appropriate risk assessment and cost-benefit analysis. Such an evaluation should take into account existing controls and establish the additional risk mitigation that might be achieved and likely costs.

Advances in MD technology have recently made the adoption and deployment of continuous monitoring more practicable. MDs are not limited to the measurement of drinking water quality alone. Continuous measurement of operational parameters such as water flow and water pressure can improve the water utility's capability to interpret results from the measurement of drinking water quality.

This document provides water utilities, their contractors, consultants and regulators with guidelines for the installation of continuous monitoring systems in drinking water systems, including guidance on their appropriate selection, maintenance and optimal calibration.

These guidelines can aid a water utility's processes for risk assessment and cost-benefit analysis. Taken together these can help a water utility's top management take informed, risk-based decisions on the worthwhileness of investment in a continuous monitoring system.

The guidance provided in this document is intended to be universally applicable, regardless of the structure and size of a water utility's drinking water system. An event detection process (EDP) that relies upon grab samples and intermittent data inputs could be implemented at lower cost. However, where a water utility's assets, finances, management system and technical capability make it practicable, the ability to provide continuous data streams offers advantages for event detection.

To gain experience, initial deployment could be limited to higher-risk areas within a wider drinking water system.

Service activities relating to drinking water supply, wastewater and stormwater systems — Guidelines for the implementation of continuous monitoring systems for drinking water quality and operational parameters in drinking water distribution networks

1 Scope

This document specifies guidelines for the implementation of continuous monitoring systems for drinking water quality and operational parameters in drinking water distribution networks.

It provides guidance for determining the:

— effective number of continuous monitoring stations in the drinking water distribution network;

— location of monitoring stations in the drinking water distribution network;

— types of operational and drinking water quality parameter measuring devices (MDs) that can be installed in a continuous monitoring station;

— quality control, maintenance and calibration requirements of the continuous monitoring system.

This document excludes guidance on the design, structure, number and type of MDs to be installed in a continuous monitoring system.

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 24513, *Service activities relating to drinking water supply, wastewater and stormwater systems — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 24513 and the following apply.

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

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

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

3.1
accuracy
measurement accuracy
accuracy of measurement
closeness of agreement between a measured quantity value and a true quantity value of a measurand

[SOURCE: ISO/IEC Guide 99:2007, 2.13, modified]

3.2
capability
quality of being able to perform a given activity

[SOURCE: ISO 15531-1:2007, 3.63, modified]

3.3
continuous monitoring
continuous near-real-time measurements of one or more sampling characteristics

Note 1 to entry: To determine the status, it is possible that one or more relevant parameters need to be checked, supervised, critically observed or measured compared with one or more pre-defined indicators.

Note 2 to entry: *Measuring device* (3.14) which provides a non-continuous but regular output signal at a given frequency can be used for the purpose of continuous monitoring.

Note 3 to entry: The location where a measuring device is installed shall be defined as a continuous monitoring station.

[SOURCE: ISO 2889:2010, 3.22, modified]

3.4
drinking water
DEPRECATED: potable water
water intended for human consumption

Note 1 to entry: Requirements for drinking water quality specifications are generally laid down by the national relevant authorities. Guidelines are established by the World Health Organization (WHO).

3.5
drinking water distribution network
asset system for distributing *drinking water* (3.4)

Note 1 to entry: Drinking water distribution networks can include pipes, valves, hydrants, washouts, pumping stations, reservoirs, and other metering and ancillary infrastructure and components.

Note 2 to entry: Pumping stations and reservoirs can be sited either in the *waterworks* (3.23) or in the drinking water distribution network.

3.6
drinking water system
asset system providing the functions of abstracting, treating, storing, distributing or supplying of *drinking water* (3.4)

3.7
event
situation when a behaviour deviates from the normal

Note 1 to entry: An event can be one or more occurrences and can have several causes.

Note 2 to entry: An event can consist of something not happening.

Note 3 to entry: An event can sometimes be referred to as an "incident" or "accident".

Note 4 to entry: An event without consequences can also be referred to as a "near miss", "incident", "near hit" or "close call".

3.8
event detection
recognition of event indicator or information about a new situation, or both

Note 1 to entry: New situations can be sorted into one of the following:

— event indicator or situation, or both, are considered known and non-hazardous;

— event indicator or situation, or both, are considered hazardous, but a procedure to handle them already exists;

— event indicator or situation, or both, are considered unknown, and a procedure for them does not yet exist.

3.9
event detection process
EDP
set of interrelated or interacting activities which transforms inputs (data or information on an actual or suspected *event* (3.7)) into outputs (to support the *water utility's* (3.22) operational activities)

3.10
event indicator
signal to the *water utility* (3.22) or one or more *stakeholders* (3.20) of expectations of service performance

Note 1 to entry: The signal can exist yet remain unobserved for a period.

3.11
maintenance
combination of all technical, administrative and managerial actions during the life cycle of an asset intended to retain it in, or restore it to, a state in which it can perform the required function

3.12
management
coordinated activities to direct and control a *water utility* (3.22)

Note 1 to entry: Management can include establishing policies and objectives, and *processes* (3.17) to achieve these *objectives*.

Note 2 to entry: The word "management" sometimes refers to people, i.e. a person or group of people with authority and responsibility for the conduct and control of a service. When "management" is used in this sense, it should always be used with some form of qualifier to avoid confusion with the concept "management" as a set of activities defined above. For example, "management should ..." is deprecated whereas "crisis management team should ..." is acceptable. Otherwise different words should be adopted to convey the concept when related to people, e.g. managerial or managers.

Note 3 to entry: The term "management" can be qualified by a specific domain it addresses. Examples include public health management, environmental management and *risk* (3.18) management.

3.13
measurement
process (3.17) to determine a value

3.14
measuring device
MD
component, or a group of components, used in an in-line or online operating position, which continuously (or at a given frequency) gives an output signal proportional to the value of one or more measurands in waters which it measures

Note 1 to entry: The device can be portable or fixed in position.

Note 2 to entry: The term "in-line measuring device" is often used for a measuring device used in an in-line position. The term "online measuring device" is often used for a measuring device used in an online position.

[SOURCE: EN 17075:2018, 3.1]

3.15
monitoring
determining the status of a system, a *process* (3.17) or an activity

Note 1 to entry: To determine the status, there can be a need to check, supervise or critically observe.

3.16
operation
action(s) taken in the course of normal functioning of *drinking water* (3.4) or wastewater systems

EXAMPLE Monitoring and regulation or diversion of drinking water or wastewater.

3.17
process
set of interrelated or interacting activities that use inputs to deliver an intended result

Note 1 to entry: Whether the "intended result" of a process is called an output, product or service depends on the context of the reference.

Note 2 to entry: Inputs to a process are generally the outputs of other processes and outputs of a process are generally the inputs to other processes.

Note 3 to entry: Two or more interrelated and interacting processes in series can also be referred to as a process.

Note 4 to entry: Processes in an organization are generally planned and carried out under controlled conditions to add value.

Note 5 to entry: A process where the conformity of the resulting output cannot be readily or economically validated is frequently referred to as a "special process".

Note 6 to entry: In benchmarking, organizational and technical processes and combinations of both are considered. A process within the meaning of benchmarking comprises a combination of one task with one plant or object (e.g. operate sewer network, treat wastewater, treat *drinking water* (3.4), provide domestic connection, further train staff, purchase material).

Note 7 to entry: In service standards, the term "process" can have a broader meaning than its narrower interpretation in management system standards. For example, it can also include some elements.

3.18
risk
combination of the likelihood of a hazardous *event* (3.7) and the severity of consequences, if the hazard occurs in the *drinking water system* (3.6), wastewater system or stormwater system

Note 1 to entry: Risk is often characterized by reference to potential events and consequences or a combination of these.

Note 2 to entry: The English term "likelihood" does not have a direct equivalent in some languages; instead, the equivalent of the term "probability" is often used. However, in English, "probability" is often narrowly interpreted as a mathematical term. Therefore, in risk management terminology, "likelihood" is used with the intent that it should have the same broad interpretation as the term "probability" has in many languages other than English.

Note 3 to entry: Risk can also be defined as the effect of uncertainty on objectives, where uncertainty is the state, even partial, of deficiency of information related to understanding or knowledge of an event, its consequence or likelihood.

3.19
sensor
electronic device that senses a physical condition or chemical's presence and delivers an electronic signal proportional to the observed characteristic

[SOURCE: ISO/IEC TR 29181-9: 2017, 3.14, modified]

3.20
stakeholder
interested party
person or organization that can affect, be affected by or perceive itself to be affected by a decision or activity

EXAMPLE *Users* (3.21) and building owners, relevant authorities, responsible bodies, operators, employees of the operator, external product suppliers and providers of other services, contractors, communities, customers and environmental associations, financial institutions, scientific and technical organizations, laboratories.

Note 1 to entry: Stakeholders will typically have an interest in the performance or success of an organization.

Note 2 to entry: For the application of this document, environment is considered as a specific stakeholder.

3.21
user
DEPRECATED: consumer
person, group or organization that benefits from *drinking water* (3.4) delivery and related services, wastewater service activities, stormwater service activities or from reclaimed water delivery and related services

Note 1 to entry: Users are a category of stakeholder.

Note 2 to entry: Users can belong to various economic sectors: domestic users, commerce, industry, tertiary activities or agriculture.

Note 3 to entry: The term "consumer" can also be used, but in most countries the term "user" is more common when referring to public services.

3.22
water utility
whole set of organization, processes, activities, means and resources necessary for abstracting, treating, distributing or supplying *drinking water* (3.4) or for collecting, conveying, treating, disposing or reusing of wastewater or for the control, collection, storage, transport and use of stormwater and for providing the associated services

Note 1 to entry: Some key features of a water utility are:

— its mission, to provide drinking water services or wastewater services or the control, collection, storage, transport and use of stormwater services or a combination thereof;

— its physical area of responsibility and the population within this area;

— its responsible body;

— the general organization with the function of operator being carried out by the responsible body, or by legally distinct operators;

— the type of physical systems used to provide the services, with various degrees of centralization.

Note 2 to entry: Drinking water utility addresses a utility dealing only with drinking water; wastewater utility addresses a utility dealing only with wastewater; stormwater utility addresses a utility dealing only with stormwater.

Note 3 to entry: When it is unnecessary or difficult to make a distinction between responsible body and operator, the term "water utility" covers both.

Note 4 to entry: In common English, "water service" can be used as a synonym for "water utility", but this document does not recommend using the term in this way.

3.23
waterworks
asset system for collecting, treating, pumping and storing *drinking water* (3.4)

Note 1 to entry: asset types can include catchments, impounding reservoirs, dams, springs, wells, intakes, transmission mains, filters, tanks, dosing equipment, metering and ancillary infrastructure.

Note 2 to entry: Pumping stations and reservoirs can be sited either in the waterworks or in the *drinking water distribution network* (3.5).

4 Principles

Compliance with the requirements for monitoring of drinking water quality and operational parameters is predominantly achieved using spot sampling and laboratory analysis. The use of MDs for the continuous monitoring of the drinking water distribution network can be an effective means for the real-time identification of changes indicating potential contamination of drinking water quality or events interfering with the operation of a drinking water system. Such real-time identification of events can improve drinking water supply integrity.

Some MDs can measure several parameters at the same time and can use data analysis tools to facilitate the reading and understanding of the measurements.

The use of MDs for the continuous monitoring of the drinking water system can provide an effective supplementary measure within the organization and management of water services.

Although the cost of acquiring MDs will typically be reduced with wider uptake, it should be recognized that their deployment can be costlier than using sampling and laboratory analysis. Any decision made to apply MDs should be based on a cost-benefit analysis to ensure that no unjustified cost is transferred to users. While their deployment should reduce the risk of harm for users, it will not remove the risk entirely. The installation of MDs should be carefully planned and should only be considered if the water utility has high confidence that the MDs will reliably detect the chosen parameter(s) to be monitored. A risk evaluation should be carried out to evaluate the significance of false-positive and false-negative results from the MD.

The use of MDs can be justified if the system is of added value for risk management and more cost-effective than the conventional monitoring methods.

Guidance is given on how to deploy a continuous monitoring system. In order to select the location for MDs properly, the identification of critical control points in the drinking water system is important. Generally, MD deployment is more likely in larger water mains than further downstream in the narrow pipes serving individual locations.

Avoidance of harm to service users is the primary reason for the deployment of MDs to detect hazards arising in the drinking water distribution network. Continuous monitoring can reduce the risk of harm to users and improve response capability by providing real-time indication of a potentially hazardous event in a drinking water distribution network.

Research into water security has identified the following critical factors:

— efforts to determine which MDs are useful for detection;

— methods to minimize the time from an event's occurrence to its detection;

— determination of the size of the populations affected;

— minimization of the size of the affected population;

— demand for water that would occur prior to detection and maximization of the likelihood of detection.

