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Water reuse in urban areas — Guidelines for centralized water reuse system —

Part 2: Management of a centralized water reuse system

Réutilisation d'eau dans les zones urbaines — Lignes directrices concernant les systèmes de réutilisation de l'eau —

Partie 2: Gestion d'un système centralisé de réutilisation de l'eau

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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 on 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 the following URL: www.iso.org/iso/foreword.html.

This document was prepared by Technical Committee ISO/TC 282, *Water reuse*, Subcommittee SC 2, *Water reuse in urban areas*.

A list of all parts in the ISO 20760 series can be found on the ISO website.

Introduction

With economic development, climate change and increases in population and rapid urbanization, water has become a strategic resource especially in arid and semi-arid regions. Water shortages are considered as one of the most serious threats to sustainable development of society. To address these shortages, reclaimed water is increasingly being used to satisfy water demands and this strategy has proven useful in increasing the reliability of long-term water supplies in many water-scarce areas.

The role of water reuse is growing for urban areas in many countries including landscape irrigation, industrial uses, toilet and urinal flushing, firefighting and fire suppression, street cleaning, environmental and recreational uses (ornamental water features, water bodies' replenishment, etc.) and car washing. These centralized water reuse systems have been developed to the degree that they are now considered as an effective component of urban water management and are used in many cities and countries.

The essential components of a centralized water reuse system include wastewater collection systems (sewers and pumping stations), water source, a wastewater treatment facility, reclaimed water storage, a reclaimed water distribution system, and a water quality monitoring system. The management concepts and principles are suggested to be implemented throughout the whole system, from the source water to the end users. Each component should be characterized and managed with appropriate strategies.

This document provides management concepts and principles for centralized water reuse system in urban areas. It considers and addresses the critical issues or factors during management, which will facilitate water authorities and reclaimed water providers to conduct cost-effective approaches for safe and reliable fit-for-purpose water reuse. For details on the design of a centralized water reuse system, see ISO 20760-1.

Water reuse in urban areas — Guidelines for centralized water reuse system —

Part 2: Management of a centralized water reuse system

1 Scope

This document provides guidelines for the management of centralized water reuse systems and water reuse applications in urban areas.

This document is applicable to practitioners and authorities who intend to implement management concepts, principles and supports on centralized water reuse in a safe, reliable and sustainable manner.

This document addresses centralized water reuse systems in their entirety and is applicable to any water reclamation system component (e.g. source water, treatment, storage, distribution, operation and maintenance and monitoring).

This document provides:

— standard terms and definitions;

— principles and methodology of reclaimed water management;

— management issues in each system component of a centralized water reuse system;

— specific aspects for consideration and emergency response.

Monitoring parameters and regulatory values of a centralized water reuse system are out of the scope of this document.

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 20670:—[1], *Water reuse — Vocabulary*

3 Terms and definitions

For the purposes of this document, the terms and definitions given in ISO 20670 and the following apply.

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

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

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

1) Under preparation. Stage at the time of publication: ISO/DIS 20670:2017.

3.1
reliability
<asset, process> probability that a device, system, or process will perform its prescribed function without failure for a given time when operated correctly in a specified environment

[SOURCE: ISO 24512:2007, 2.38]

3.2
water reuse in urban areas
beneficial use of reclaimed water for non-potable and/or indirect potable applications in urban areas

EXAMPLE Landscape uses, street cleaning, firefighting, industrial applications, environmental enhancement, recreational applications, flushing and other domestic uses, etc.

4 Overview of management issues of a centralized water reuse system

4.1 General

The system analysis and management of a centralized water reuse system should have an understanding of the entire system, which generally includes several aspects:

a) water supply needs;

b) assessment of the reclaimed water system (e.g. environmental sustainability and health risk);

c) preventive maintenance measures for reclaimed water management;

d) operational procedures and process control;

e) verification of reclaimed water quality to ensure public health protection while providing environmental benefits;

f) social and public aspects on water supply needs and the water quality needs;

g) incident and emergency management.

The management framework can be supplemented with supporting recommendations and should be periodically reviewed and modified. The planning of review periods should take into account the influencing technical and environmental factors. As the wastewater production of an area differs (e.g. seasonal and tourist activities, cultural influence, etc.) the management practices and review periods should be adjusted. Water reuse management should be consistent with the overall water resources management objectives, which can be defined through an integrated planning process, such as the River Basin Management Plans defined under the Water Framework Directive in European Union. The application of an integrated or global water management approach is a means of improving water resource management and reducing waste streams and water reuse can be a key factor in this holistic planning method[11] [12] [13].

For instance, a centralized water reuse management plan can be developed considering the following issues:

a) management principles and objectives;

   — risk and health issues;

   — site conditions and urban planning;

   — demands and expectations of the users and other stakeholders;

   — financial capability and environmental benefits to initiate an urban water reuse system development;

b) management considerations for each system component;

— source water, treatment systems, storage systems, distribution systems, water quality monitoring, etc.;

c) corrective actions:

— deficiencies identified through the planning and operational processes;

— unintended use control such as cross-connections and unintended discharges;

— control and improvement of the quality of the source water (secondary effluents) delivered by the wastewater treatment plant in cooperation with the users and stakeholders;

d) preventive maintenance measures:

— staff responsibility to develop new user agreements, utilities, onsite design and retrofit needs, public education programs, etc.;

e) social and public aspects:

— affordability and acceptance of the service to users;

— public consultation (e.g. a communication plan and a feedback system);

— public awareness on pollution prevention;

— cultural aspects;

— notification signs to make sure the public is aware of reclaimed water use.

4.2 Water demand

The water consumption and the ratio between planned demand and current uptake should be followed and analysed on a regular basis. New demands for reclaimed water should also be assessed including the type and location of potential end users that may be served by reclaimed water and the ability to economically meet their demands. The reclaimed water supply characteristics can include quantity, quality, diurnal and seasonal variations, weather, delivery pressures, water flow rates, existing and potential new customers.

4.3 System components

A centralized water reuse system is generally comprised of five essential components, source, treatment, storage, distribution and monitoring. Effective management should have an understanding of the reclaimed water system from the source to the end user. Each part of the system should be characterized and managed with appropriate strategies. For instance, the strategies should establish goals for treatment process effectiveness and efficiency, storage specificities, distribution system performance, etc. Regular monitoring is suggested to determine compliance with the goals and take appropriate actions if goals are not achieved. However, the detailed needs can depend on the complexity of the system. For example, the storage system(s) can be located before and/or after the distribution system depending on the distribution system hydraulic design and should equalize reclaimed water quantity and system pressures.

4.4 Possible models of the reclaimed water system and use needs

There are different models of a reclaimed water reuse system from a simple usage pattern to more complicated ones for single and/or multiple application purposes. The management of a system should take into account end use needs to maximize reliability to all customers, such as:

— assessment of the suitability of reclaimed water (e.g. quantity, quality and location) to end-user purpose;

— installation of additional equipment (e.g. a booster pumping station to increase system pressures);

— prevention of inappropriate use of reclaimed water.

Specifically, risk assessment and good operation practices should be developed and implemented. In all cases, special considerations can be given to financial, public health, environmental and public awareness issues.

5 Principles and methodology of reclaimed water management

5.1 Principles

When managing the centralized water reuse system, the basic principles include safety, effectiveness, reliability, efficiency and economic viability. In particular, water quality safety and reliability should be analysed in each system component to protect human health and the environment[14]. Specific risk management principles include the following.

— Protection of public and environmental health is of paramount importance and should never be compromised.

— Protection of public and environmental health depends on implementing a preventive risk management approach.

— Application of corrective actions and preventive measures for water quality should be commensurate with the source of reclaimed water and the intended uses.

5.2 Risk management

Depending on the system scale and end use applications, risk management approaches can be considered for certain applications (e.g. car washing, toilet flushing, recreational uses, etc.). For instance, a Hazard Analysis and Critical Control Point (HACCP) plan for monitoring the performance of ultrafiltration (UF) membranes towards the removal of human pathogens may be daily pressure decay tests and/or inline turbidity monitoring. For end uses without direct/close human contact, simplified risk assessment, water safety and/or other methodologies/tools should be considered, see ISO 20761, ISO 20426, ISO 22000 and References [15], [16], [17], [18] and [19]. Corrective actions can be programmed into the system if any of the critical control points (CCPs) are out of range. It is recommended for operators to implement preventive measures and control to ensure the effectiveness and efficiency of the processes, anticipate potential problems and respond before problems become critical.

6 Management of source water

A source water management program is recommended to be carried out by proponents or authorized practitioners[20]. The program should be consistent with facilities management practices to measure and monitor the quality of reclaimed water. For example, an early warning system can be included in the program which can provide timely information to detect sudden changes in source water quality (e.g. heavy rains, flooding or industrial accidents)[21]. Knowledgeable decisions or responses can be made concerning changing treatment and operational methods or closing intakes. Accordingly, a source control program (e.g. wastewater treatment plants may have an agreement with industries to prevent hazards entering the wastewater collection system, see ISO 24511) can be implemented to document contaminant concentrations and diversion alternatives.

In addition, a response and management plan for mitigating reclaimed water shortages can be developed and maintained depending on whether reclaimed water supply is critical to customers. The plan should include provisions of backup water resources for short-term essential services and strategies to allow seasonal or interruptible reclaimed water use, or scheduling deliveries (e.g. defined watering schedule).

7 Management of reclaimed water treatment systems

The management of a reclaimed water treatment system should be undertaken in a manner that optimizes the use of equipment and resources involved, while protecting public health. Treatment operation and management objectives should be clearly defined based on the specific needs, intended uses, financial and environmental concerns and other factors.

A multiple barrier approach together with a monitoring, sampling and testing plan should be developed throughout the treatment processes, reclaimed water applications and additional measures. The multiple barrier approach highlights the use of combined measures to reduce the risks in management wherein each provides a specific level of contaminant reduction consistent with the demanded water quality applicable to intended uses. Funds and a schedule for preventive maintenance should be established at project inception for long term operational sustainability and protection of public health. Corrective actions and preventive maintenance measures can be developed to improve the management of noncompliance of reclaimed water quality. A minimum technological need (e.g. a disinfection program) that sufficiently protects public health and safety should also be implemented and maintained[22]. For example, some jurisdictions specify a treatment process that should contain a minimum of secondary treatment, tertiary filtration and disinfection prior to unrestricted urban reuse for water safety management, see ISO 20468-1. Relevant information regarding the recommended water quality criteria for water reuse applications in several countries can be found in ISO 20761:—[2], Annex C and References [19], [23] and [24]. As another consideration, treatment process by-passing situations should be managed since the wastewater flow around a process stage(s) during emergencies or excess wet weather flow periods for combined sewerage systems can lead to reduced effluent quality. Solutions can be considered, including diversion of untreated or partially treated bypass flows away from the reclaimed water product and/or storage of effluent for reprocessing through the water reclamation facility and/or alternative disposal routes for the treated effluent if quality is not suitable for the intended reuse, etc.

A detailed and reliable management procedure of treatment system performance normally includes:

a) individual evaluation of multiple barriers that mitigate the key contaminants for the intended use(s);

b) principles for setting specific parameter value;

c) risk management;

d) certification of operators;

e) protocols for preventive and corrective actions.

8 Management of reclaimed water storage systems

Reclaimed water storage facilities are essential components in a water reuse system. Sufficient storage should be designed and operated to meet water demands and reduce pressure fluctuations. The management of reclaimed water storage system should consider the following aspects:

a) emergency storage for fire flows, as applicable;

b) operational and seasonal storage;

c) ability to divert reclaimed water that does not meet water quality demands to interim storage for retention, retreatment or disposal;

d) water quality control (e.g. best management practices to maintain reclaimed water quality during storage);

e) system leakage and facility corrosion control;

f) funds, responsibilities and a schedule for preventive maintenance.

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9 Management of reclaimed water distribution systems

9.1 General

A reclaimed water delivery program should be established to schedule and/or control reclaimed water deliveries to users. The program can describe the distribution system operation and management objectives, system pressure, colour-coding, labelling, backflow and cross-connection control, consideration of alternative supplies, pipe separation, distribution storage, service connections and system leakage. Distribution system operation and management objectives should be clearly defined in the plan based on the proven and prudent engineering practices and state of the art experience, types of reclaimed water customers, intended uses, public attitudes towards reclaimed water use, safety targets and other factors. Funds and a schedule for preventive maintenance should be established for long term operational sustainability and protection of public health. In addition to conveyance by pipelines, hauling of reclaimed water to potential users can be considered as an alternative option for the reclaimed water distribution system[25] [26].

Contingency or emergency management plans for line breaks or leakage should be developed to ensure that the public and environment are protected.

9.2 Delivery pressure and flow rate of reclaimed water

The distribution system should be operated and maintained at adequate pressures and flow rates to meet customer demands and intended end uses in the service area. For example, some jurisdictions specify a lower pressure in the reclaimed water pipeline compared to drinking water pipeline of a dual distribution system as one of the measures for backflow prevention. Pressure monitoring should be carried out.

9.3 Water quality in distribution systems

The reclaimed water in the distribution system should be protected from biological and chemical contamination while maximizing the water stability. The suitability and acceptability of reclaimed water quality for different types of end uses should be evaluated based on specific demands, treatment approaches, budgetary impacts, etc. Relevant information regarding water reuse for irrigation can be found in ISO 16075-1, ISO 16075-2, ISO 16075-3 and ISO 16075-4.

It should also be made clear to customers that the quality of reclaimed water varies with its intended use. For reclaimed water quality control, a strategy (e.g. Quality assurance/Quality control sampling) can be developed to ensure the distribution system meets and maintains all applicable standards. Periodic monitoring, sampling and/or testing of reclaimed water in the distribution system is recommended (e.g. a sampling to check the presence of indicator bacteria and/or residual chlorine in the distribution system). To guarantee the health and water quality stability, disinfection techniques (e.g. chlorination) and cleaning of equipment and/or pipelines should be considered for large distribution networks and/or for specific applications with high potential health risks[27].

9.4 Colour-coding, water signs and labels

Pipelines, valves, outlets and appurtenances related to reclaimed water distribution should be coloured differently from the drinking water system. Above-ground appurtenances should be properly labelled to indicate they are in service for reclaimed water. Buried appurtenances can also be painted, labelled or wrapped appropriately with the visible surface valve covers painted and labelled to reflect a reclaimed water supply. Adding specific wording and international symbols for non-potable-water systems can also improve the safety level of the dual distribution system.

9.5 Backflow and cross-connection control

Adequate pipeline separation should be provided between reclaimed water and drinking water lines and between reclaimed water and wastewater lines. A backflow and cross-connection control program should be developed, documented and maintained. The program should include strategies for system

isolation and protection from contamination. Testing of monitoring instrumentation (e.g. a pressure test or a dye test) should be done periodically. Any consideration of alternative water supplies should include procedures to avoid cross-connections such as air gaps or other approved backflow prevention devices between alternative water supply and reclaimed water system. Furthermore, to reduce the risk of backflow, the reclaimed water system can be operated at a lower pressure than the drinking water system if applicable.

9.6 System leakage and corrosion control

Activities and programs (e.g. a leakage monitoring and detection program) should be implemented to minimize water loss and pipeline corrosion in the distribution system. The implementation of remediation measures should also be included if leakage and/or corrosion are detected (if deemed necessary based on assessments). The program can also include an annual water audit (e.g. the degree of compliance with the provisions of the approved reclaimed water management plan, planned corrective actions have been taken in relation to recommendations made in previous audits, preventive actions have been taken in relation to incidents) to evaluate the system compliance and conditions. Broken sprinkler heads, leaks, unreliable valves, or other components should be repaired as quickly as possible.

Chemical compounds, organic matter and other contaminants in the reclaimed water may cause biofilm growth and corrosion in pipes. Sulfates in reclaimed water can also induce corrosion and odours. Proper pipe material such as metallic, cement or plastic pipes should be selected depending on the stability and the reliability and economics of water supply as well as end use applications.

9.7 Service connections

The standard service connection details of reclaimed water in the service area should be developed. For example, when property provided with a reclaimed water service connection is subdivided, additional reclaimed water service lines and water meters can be considered for subdivided areas. Some programs can include policies and procedures for voluntary or mandatory connection and/or use and a plan for periodic review to facilitate retrofits with reclaimed water in the service area to ensure ongoing compliance. The inspection of facilities is also critical for the safe operation of a dual water distribution system. Multilevel site inspections can be conducted before a user site is connected to the reclaimed water system.

10 Water quality monitoring

10.1 General

In the context of reclaimed water management, a sound monitoring program should be developed including the following aspects:

a) have clearly defined monitoring objectives;

b) be carefully designed to ensure the objectives will be met;

c) identify what data will be gathered and how to obtain and use such data;

d) use sampling and analytical techniques (standard methods and procedures when available) that are reliable and adequate in terms of accuracy and precision;

e) conduct quality control, quality assurance and compliance reporting;

f) oversight by responsible authorities (if applicable);

g) analyse and report data to produce valuable information.

Based on different objectives of monitoring, the types of monitoring generally include: baseline monitoring, validation monitoring, operational monitoring and verification monitoring. Not all types of monitoring are compulsory to be included for the management of a centralized water reuse

system. Besides, if the monitoring cannot cover every system component, it should be undertaken at representative locations at sufficient sites to provide statistical confidence in the results.

10.2 Baseline monitoring

Baseline monitoring aims at gathering information on the source of reclaimed water (e.g. the variations of water quantity, types and concentrations of relevant parameters) and provides a basis for suitable fit-for-purpose application. Baseline sampling and/or available data analysis should be undertaken before establishing a centralized water reuse system.

10.3 Validation monitoring

Validation monitoring is to test that centralized water reuse systems can operate within the designated key performance indicators (e.g. each system configuration is functioning and safe) while producing the demanded water quality or achieving the target process performance. It should also include specific testing of emergency and response plans.

Validation monitoring can be completed before reclaimed water is supplied (which is linked to commissioning), or can be combined with verification monitoring in initial periods of post-commissioning test to assess how the system will perform. Further validation should also be considered for variations such as seasonal changes, new processes or configurations (e.g. impacts of changes to treatment processes on downstream filtration or disinfection) to confirm that a modified system will achieve the results.

10.4 Operational monitoring

Operational monitoring is to conduct routine monitoring of control parameters and key performance indicators in order to confirm that the system and processes are under control. A properly designed operational monitoring program can provide timely information of any problems of the system, allowing corrective actions to be taken shortly. Specific areas targeted for operational monitoring can include the treatment system, storage system, distribution system and/or end use sites, if applicable. However, for each system, the key indicators of system performance will be different and should be dictated by the system designers and suppliers. For example, for UV disinfection in the treatment system, key performance indicators (related with turbidity and UV transmissivity and intensity) are likely to be included. Appropriate actions should be implemented if goals are not achieved at present or when plant operators or managers noticing that the goals are unlikely to be achieved in the near future. For locations where high risks are detected or high failures are occurring, more frequent monitoring should be conducted.

Online monitoring facilities are recommended to be equipped for providing monitoring data on system performance. Well-defined procedures for calibration, verification and data collection for any remote or online measurement devices should be established. Operational monitoring can also include off-line periodic monitoring (e.g. membrane integrity tests). For parameters that cannot be measured online, a routine sampling plan should be developed where sampling procedures should follow standard procedures and/or good practices. Apart from daily, weekly, or monthly analyses, periodic (e.g. quarterly or annually) analyses with more complexity can be further applied to confirm whether the parameters or performance indicators are adequate to detect potential problems.

When monitoring results indicate potential noncompliance of the system, operational noncompliance control should be carried out. Corrective action plans or defined actions should be in place, which can include recommendations for additional analyses and the increase of sampling and monitoring frequency.

10.5 Verification monitoring

Verification monitoring is to ensure that the produced water quality is suitable for distribution in accordance with its intended use. Verification monitoring focuses only on produced water quality and ensures that the target hazards are not detected above the set limits.

Verification monitoring can provide confidence to reclaimed water users and regulators in terms of the supplied water quality and the system functionality as a whole. It can also provide an indication of problems and be a trigger for immediate short-term corrective actions. An entity or agency would take responsibility for monitoring the centralized water reuse system and a local authority is responsible for reviewing the verification monitoring results and reports (i.e. for the oversight).

11 Management of incidents and emergencies

An incident and emergency response plan should be established to deal with changes, emerging issues or new institutional arrangements that can compromise reclaimed water quality. Key areas to be addressed in incident and emergency response plans include:

a) emergency contact lists and predetermined agreements on leading agencies for decisions on potential health or environmental impacts;

b) criteria for defining incidents and emergencies;

c) response actions, such as the increased monitoring frequency;

d) plans for alternative water supplies;

e) notifications, including timeframes;

f) communication protocols and strategies, including notification procedures;

g) mechanisms for increased health or environmental surveillance.

Appropriate documentation, reporting and update of the incident or emergency should also be established. Operators should learn as much as possible from the incident to improve preparedness and planning for future incidents.

12 Supporting recommendations

In addition to system analysis and management, the sustainable management of a centralized water reuse system should also consider the following supporting issues.

a) Employee awareness and training (e.g. operator and contractor training program). All staff members involved in the operation and maintenance of the centralized water reuse system should be properly trained. The training should focus on relevant policies as well as cross-connection control, site inspection, treatment and water quality issues. The training programs should begin prior to the operating process.

b) Customer agreements and contracts.

c) Community involvement (e.g. public information and education, customer training, customer relations and customer inquiry tracking and response plans). Public education might include a reuse brochure and information on the community website or workshops. As for indoor residential uses such as toilet flushing, adequate training of the household residents with respect to the use of the reclaimed water system is paramount to avoid potential problems.

d) Research and development (e.g. emerging water quality issues, new processes, new analytical methods and improved assessment of potential impacts of reclaimed water on public health and the environment, etc.).

e) Documentation and reporting (e.g. maintenance of an adequate record-keeping system to provide evidence of control and conformity).

f) Oversight (e.g. management and arrangement by responsible agency or agencies).

13 Review

The management protocols should be reviewed regularly, including evaluation and audit processes to ensure that the management system is functioning satisfactorily. It also provides a basis for review, revision and continuous improvement.