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Guidelines for performance evaluation of treatment technologies for water reuse systems —

Part 2: Methodology to evaluate performance of treatment systems on the basis of greenhouse gas emissions

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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).

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. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

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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 282, *Water reuse*, Subcommittee SC 3, *Risk and performance evaluation of water reuse systems*.

A list of all parts in the ISO 20468 series can be found on the ISO website.

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

The purpose of this document is to define a methodology more specifically for evaluating the environmental performance of treatment systems among treatment technologies for water reuse systems, which is covered in Clause 7 “Non-functional requirements” of ISO 20468-1:2018, *Guidelines for performance evaluation of treatment technologies for water reuse systems Part 1 General*.

Water reuse has been drawing attention for contributing to environmental protection, as well as providing solutions for water scarcity. For example, a water reclamation plant plays the additional role of removing pollutants such as emerging pollutants, pathogens, and toxic elements. Otherwise, water discharged into the environment can increase health risks and/or have negative impacts on ecosystems. Compared to conventional water supply systems, including waterworks consisting of dams and water conveyance facilities, water reuse systems can save operational energies and resources of constructions. In addition, water reuse can minimize environmental destruction during development.

In order to establish sustainable water reuse services, while protecting the environment, appropriate evaluation methods are needed. However, in the international community, there is no common approach to using parameters concerning the environment in evaluations of treatment technologies for water reuse systems. Although rules may be established for each region where water reuse systems are to be installed, having specialists work out rules and standardizing them through the ISO is more economical and convenient.

When discussing evaluations of environmental aspects, first of all, two aspects should be defined. One comprises boundary conditions that determine which areas are evaluated. The other is the evaluation parameter concerned.

Typical boundary conditions concerning environmental aspects in water reuse projects consist of intake, conveyance, treatment, reservoir, distribution, end-use, and final discharge into the environment. Taking into consideration the scope defined in Part 1, this document addresses treatment systems.

On the other hand, evaluation parameters concerning the environment attributable to treatment systems vary widely. For example, reclaimed water quality having adverse effects on a regional ecosystem and ground water can be one parameter for evaluation. Another can be the level of soil contamination caused by using reclaimed water. Moreover, the degree of noise and vibration from treatment systems can be utilized for evaluations because of the impacts on the environment. Greenhouse gas emissions in the course of plant operation should also be taken into consideration with more attention given to preventing global warming. Naturally, a treatment system should be evaluated by taking into account all of these parameters. However, an evaluation with so many parameters involves a great burden in terms of time and costs, and therefore lacks practicality at the moment.

In view of the conditions described above, this document provides guidelines for evaluating the performance of a treatment system using, as a parameter, greenhouse gas emissions in the course of system operation with the amount of reclaimed water produced. The reason why greenhouse gas emissions have been selected as a parameter is that it is a practical parameter on which many greenhouse-gas related standards have been established, such as ISO 14064-1. It is, however, important to note that this document is not intended to prevent evaluating other environmental parameters of treatment systems, including those described above, in water reuse projects. If such evaluations are necessary, other guidelines and/or expert judges should be referred.

The evaluation is also limited to the period during which the treatment system is being operated. This is because the systems are expected to operate for 20 years or more after construction, during which greenhouse gas emissions in the course of operation tend to be greater than the level at construction or when the system is being discontinued.

This document takes a simple and standard approach that can be applied anywhere. Therefore, this document includes how to estimate greenhouse gas emissions using typical activities, such as energy consumption or amount of consumables used in operations. In addition, CO_{2eq} emission intensity is defined to evaluate the environmental performance of a treatment system expressed as a value of the weight of greenhouse gas emissions divided by the amount of reclaimed water produced. As a result, there is no need to substantially change existing engineering duties. This will alleviate the burden on engineers.

It is expected that this document will contribute to the development of environmentally responsible treatment systems.

Guidelines for performance evaluation of treatment technologies for water reuse systems —

Part 2: Methodology to evaluate performance of treatment systems on the basis of greenhouse gas emissions

1 Scope

This document provides guidelines for evaluating the performance of treatment systems on the basis of greenhouse gas (GHG) emissions.

In order to estimate greenhouse gas emissions from a treatment system, this document covers the estimate, types of GHG emission and sources, emission factor for each GHG, and global warming potential. The weight of greenhouse gases to be used in an evaluation is equivalent to emissions during operation of a treatment system.

This document also defines a method for calculating carbon dioxide equivalent (CO_{2eq}) emission intensity, in which GHG emissions are divided by the volume of reclaimed water. It also includes a method for evaluating the performance of a treatment system using CO_{2eq} emission intensity.

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, *Water reuse — Vocabulary*

3 Terms, definitions, and abbreviated terms

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:

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

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

3.1 Terms and definitions

3.1.1
activity data
quantitative measure of activity that results in a GHG emission or removal

EXAMPLE The amount of imported electricity consumed, biologically treated sewage or water treatment chemicals consumed.

Note 1 to entry: See Reference [1].

3.1.2
anaerobic-aerobic activated sludge process
AO process
biological sewage treatment process with a sequence of anaerobic and aerobic (oxic) zones

3.1.3
anaerobic-anoxic-oxic activated process
A2O process
biological sewage treatment process with a sequence of anaerobic, anoxic and aerobic (oxic) zones

3.1.4
carbon dioxide equivalent
CO_{2eq}
conversion of individual GHG emissions or removals into climate impact, identified as tons equivalent of carbon dioxide (CO_{2eq})

Note 1 to entry: See Reference [2].

3.1.5
carbon dioxide equivalent (CO_{2eq}) emission intensity
value determined by dividing GHG emissions by amount of reclaimed water

3.1.6
emission factor
coefficient which quantifies emissions or removals per unit activity

Note 1 to entry: See Reference [2].

3.1.7
environmental performance
measurable results of treatment technologies in environmental aspects

3.1.8
greenhouse gas
GHG
carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)

Note 1 to entry: See Reference [1].

3.1.9
membrane bioreactor
MBR
treatment method in which bioreactor and membrane process are combined

3.1.10
recycled nitrification-denitrification process
RND process
biological nitrogen removal process utilizing nitrate recycle

3.2 Abbreviated terms

For the purposes of this document, the following abbreviated terms apply.

CO_2	carbon dioxide
CO_{2eq}	carbon dioxide equivalent
CH_4	methane
N_2O	nitrous oxide

GHG greenhouse gas

AO process anaerobic-aerobic activated sludge process

A2O process anaerobic-anoxic-oxic activated process

MBR membrane bioreactor

RND process recycled nitrification-denitrification process

N/A not applicable

ds dry solid

RO reverse osmosis

GWP global warming potential

STP sewage treatment plant

ID No. identification number

4 Symbols

The symbols used in this document are shown in Table 1.

Table 1 — Symbols

Symbol	Unit	Description
$E_{E,CO2,annual}$	tons of CO_2 per year	CO_2 emissions resulting from consumption of energy, including electricity, fuels, etc.
$E_{E,CH4,annual}$	tons of CH_4 per year	CH_4 emissions resulting from consumption of energy, including electricity, fuels, etc.
$E_{E,N2O,annual}$	tons of N_2O per year	N_2O emissions resulting from consumption of energy, including electricity, fuels, etc.
$E_{P,CH4,annual}$	tons of CH_4 per year	CH_4 emissions resulting from each biological treatment process
$E_{P,N2O,annual}$	tons of N_2O per year	N_2O emissions resulting from each biological treatment process
$E_{C,CO2,annual}$	tons of CO_2 per year	CO_2 emissions resulting from consumables and generation of waste
$E_{C,CH4,annual}$	tons of CH_4 per year	CH_4 emissions resulting from consumables and generation of waste
$E_{C,N2O,annual}$	tons of N_2O per year	N_2O emissions resulting from consumables and generation of waste
$E_{R,CO2eq,annual}$	tons of CO_{2eq} per year	Reduction of GHG emissions through the effective utilization of resources resulting from the production of reclaimed water (CO_2 equivalent)
$E_{T,CO2eq,annual}$	tons of CO_{2eq} per year	Total greenhouse gas emissions (CO_2 equivalent)
I_{CO2eq}	kg CO_{2eq} per m^3-reclaimed water	Carbon dioxide equivalent (CO_{2eq}) emission intensity
Q_{annual}	thousand m^3-reclaimed water per year	Annual volume of reclaimed water produced in a relevant water reclamation plant
$Q_{E,t}$	unit[a]	Amount of energy consumption, including electricity, fuels, etc.

[a] The unit varies according to the substance concerned. Definitions are given in Clause 7.

Table 1 *(continued)*

Symbol	Unit	Description
$Q_{P,t}$	unit[a]	Amount of treatment in each biological treatment process
$Q_{C,t}$	unit[a]	Amount of consumables and the weight of waste generated
$K_{E,CO2,t}$	tons of CO_2 per unit[a]	CO_2 emission factor resulting from consumed energy, including electricity, fuels, etc.
$K_{E,CH4,t}$	tons of CH_4 per unit[a]	CH_4 emission factor resulting from consumed energy, including electricity, fuels, etc.
$K_{E,N2O,t}$	tons of N_2O per unit[a]	N_2O emission factor resulting from consumed energy, including electricity, fuels, etc.
$K_{P,CH4,t}$	tons of CH_4 per unit[a]	CH_4 emission factor resulting from the biological treatment process
$K_{P,N2O,t}$	tons of N_2O per unit[a]	N_2O emission factor resulting from the biological treatment process
$K_{C,CO2,t}$	tons of CO_2 per unit[a]	CO_2 emission factor resulting from consumables and waste
$K_{C,CH4,t}$	tons of CH_4 per unit[a]	CH_4 emission factor resulting from consumables and waste
$K_{C,N2O,t}$	tons of N_2O per unit[a]	N_2O emission factor resulting from consumables and waste
$K_{GWP,t}$		Global warming potential (GWP)

[a] The unit varies according to the substance concerned. Definitions are given in Clause 7.

5 Principles

5.1 General

The following principles apply to evaluations of treatment systems using CO_{2eq} emission intensity.

5.2 Relevance

The activities of treatment systems, which are related to greenhouse gas emissions, should be extracted in a relevant manner and appropriately quantified.

5.3 Completeness

GHG emissions during production of reclaimed water should be calculated under conditions in which other environmental requirements (reclaimed water quality, noise and vibration, etc.) of the system comply with project requirements.

5.4 Consistency

In order to ensure an effective comparison, as much as possible, data should be acquired according to the same method from year to year. The method to be used should be established at the beginning of an evaluation for the same water reclamation plant.

5.5 Accuracy

Data acquisition should be free from bias, as much as possible, while minimizing uncertainty. For specified methods, refer to Clauses 6 and 7.

5.6 Transparency

The process for calculating the CO_{2eq} emission intensity and parameters used, such as emission factors and efficiency of equipment applied to a system, should be recorded and made available for clarification when requested.

6 Boundary conditions

6.1 General

When using this document in an evaluation of the environmental performance of a treatment system, the boundary conditions of the evaluation should be established according to the relevant project requirements. To facilitate a comparison of treatment systems, it is essential to define the boundary conditions of a performance evaluation, taking into consideration the processes of transforming raw water into reclaimed water and, if necessary, associated facilities inside the water reclamation plant. Unless otherwise specified, the boundary conditions should be defined referring to the example in Figure 1. To prevent the performance evaluation of the treatment system from being influenced by the location of a raw water intake point or distribution of reclaimed water, the boundary conditions of the performance evaluation should be limited to part of the treatment system and associated facilities inside the water reclamation plant. Then, tangible minimum boundary conditions should be established between the facility that receives the raw water to produce reclaimed water and the prescribed interface point to hand over reclaimed water produced through treatment processes. In addition, the relevant system, such as a sludge treatment system, may be included in the evaluation, taking into consideration project characteristics.

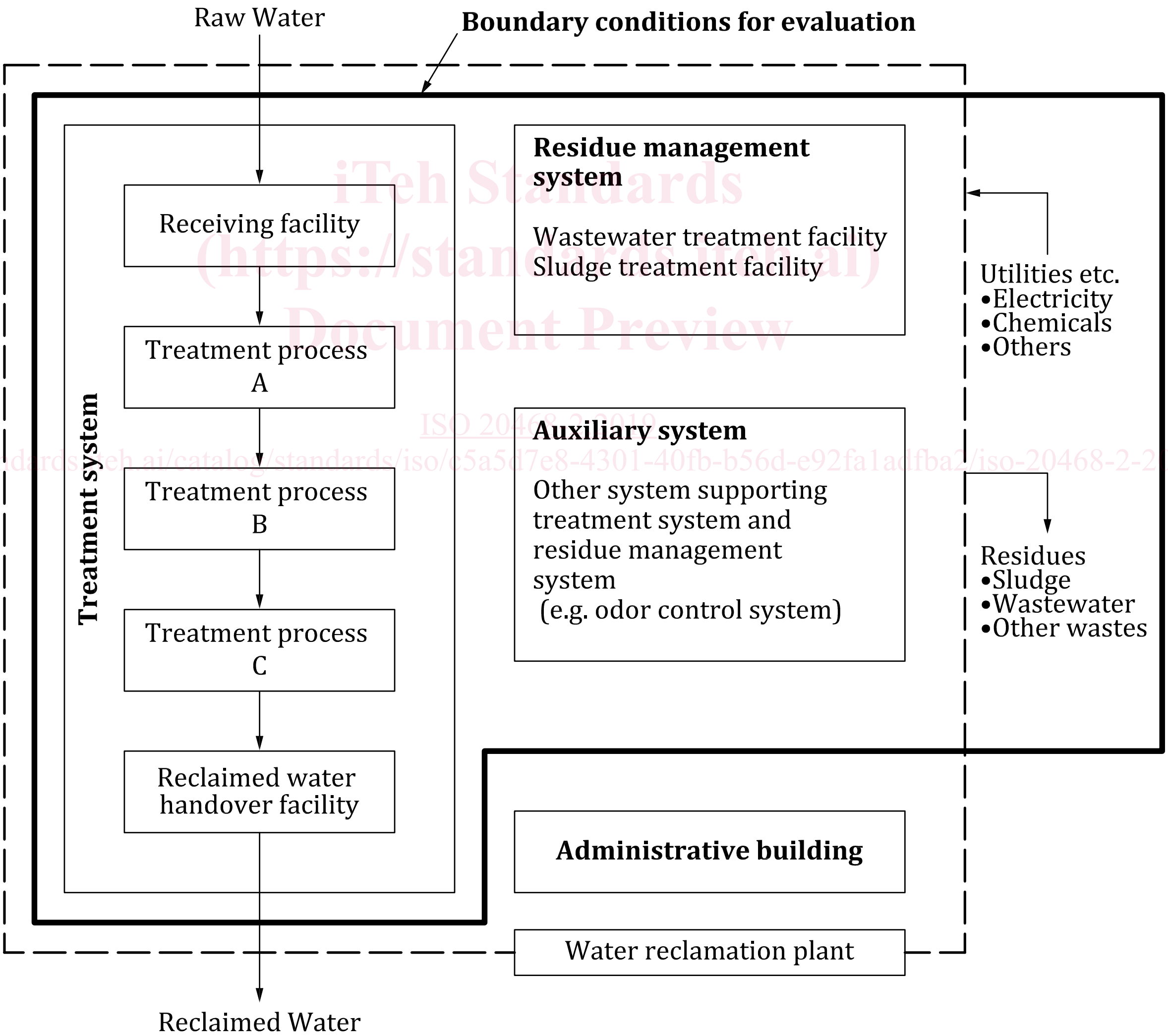

Figure 1 — Example of the boundary conditions of evaluation