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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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ISO copyright office  
CP 401 • Ch. de Blandonnet 8  
CH-1214 Vernier, Geneva  
Phone: +41 22 749 01 11  
Fax: +41 22 749 09 47  
Email: [copyright@iso.org](mailto:copyright@iso.org)  
Website: [www.iso.org](http://www.iso.org)

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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.

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](http://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](http://www.iso.org/patents)).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

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](http://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](http://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<sub>2eq</sub> 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.

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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

### 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<sub>2eq</sub>) 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<sub>2eq</sub> emission intensity.

### 2 Normative references

ISO 20468-2:2019

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<sub>2eq</sub>**

conversion of individual GHG emissions or removals into climate impact, identified as tons equivalent of carbon dioxide (CO<sub>2eq</sub>)

Note 1 to entry: See Reference [2].

3.1.5

**carbon dioxide equivalent (CO<sub>2eq</sub>) 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<sub>2</sub>), methane (CH<sub>4</sub>), and nitrous oxide (N<sub>2</sub>O)

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 <sub>2</sub>	carbon dioxide
CO <sub>2eq</sub>	carbon dioxide equivalent
CH <sub>4</sub>	methane
N <sub>2</sub> O	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](#).

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Table 1 — Symbols

Symbol	Unit	Description
$E_{E,CO_2,annual}$	tons of CO <sub>2</sub> per year	CO <sub>2</sub> emissions resulting from consumption of energy, including electricity, fuels, etc.
$E_{E,CH_4,annual}$	tons of CH <sub>4</sub> per year	CH <sub>4</sub> emissions resulting from consumption of energy, including electricity, fuels, etc.
$E_{E,N_2O,annual}$	tons of N <sub>2</sub> O per year	N <sub>2</sub> O emissions resulting from consumption of energy, including electricity, fuels, etc.
$E_{P,CH_4,annual}$	tons of CH <sub>4</sub> per year	CH <sub>4</sub> emissions resulting from each biological treatment process
$E_{P,N_2O,annual}$	tons of N <sub>2</sub> O per year	N <sub>2</sub> O emissions resulting from each biological treatment process
$E_{C,CO_2,annual}$	tons of CO <sub>2</sub> per year	CO <sub>2</sub> emissions resulting from consumables and generation of waste
$E_{C,CH_4,annual}$	tons of CH <sub>4</sub> per year	CH <sub>4</sub> emissions resulting from consumables and generation of waste
$E_{C,N_2O,annual}$	tons of N <sub>2</sub> O per year	N <sub>2</sub> O emissions resulting from consumables and generation of waste
$E_{R,CO_2eq,annual}$	tons of CO <sub>2eq</sub> per year	Reduction of GHG emissions through the effective utilization of resources resulting from the production of reclaimed water (CO <sub>2</sub> equivalent)
$E_{T,CO_2eq,annual}$	tons of CO <sub>2eq</sub> per year	Total greenhouse gas emissions (CO <sub>2</sub> equivalent)
$I_{CO_2eq}$	kg CO <sub>2eq</sub> per m <sup>3</sup> -reclaimed water	Carbon dioxide equivalent (CO <sub>2eq</sub> ) emission intensity
$Q_{annual}$	thousand m <sup>3</sup> -reclaimed water per year	Annual volume of reclaimed water produced in a relevant water reclamation plant
$Q_{E,t}$	unit <sup>a</sup>	Amount of energy consumption, including electricity, fuels, etc.
<sup>a</sup> The unit varies according to the substance concerned. Definitions are given in <a href="#">Clause 7</a> .		

**Table 1** (continued)

Symbol	Unit	Description
$Q_{P,t}$	unit <sup>a</sup>	Amount of treatment in each biological treatment process
$Q_{C,t}$	unit <sup>a</sup>	Amount of consumables and the weight of waste generated
$K_{E,CO_2,t}$	tons of CO <sub>2</sub> per unit <sup>a</sup>	CO <sub>2</sub> emission factor resulting from consumed energy, including electricity, fuels, etc.
$K_{E,CH_4,t}$	tons of CH <sub>4</sub> per unit <sup>a</sup>	CH <sub>4</sub> emission factor resulting from consumed energy, including electricity, fuels, etc.
$K_{E,N_2O,t}$	tons of N <sub>2</sub> O per unit <sup>a</sup>	N <sub>2</sub> O emission factor resulting from consumed energy, including electricity, fuels, etc.
$K_{P,CH_4,t}$	tons of CH <sub>4</sub> per unit <sup>a</sup>	CH <sub>4</sub> emission factor resulting from the biological treatment process
$K_{P,N_2O,t}$	tons of N <sub>2</sub> O per unit <sup>a</sup>	N <sub>2</sub> O emission factor resulting from the biological treatment process
$K_{C,CO_2,t}$	tons of CO <sub>2</sub> per unit <sup>a</sup>	CO <sub>2</sub> emission factor resulting from consumables and waste
$K_{C,CH_4,t}$	tons of CH <sub>4</sub> per unit <sup>a</sup>	CH <sub>4</sub> emission factor resulting from consumables and waste
$K_{C,N_2O,t}$	tons of N <sub>2</sub> O per unit <sup>a</sup>	N <sub>2</sub> O emission factor resulting from consumables and waste
$K_{GWP,t}$		Global warming potential (GWP)

<sup>a</sup> The unit varies according to the substance concerned. Definitions are given in [Clause 7](#).

## 5 Principles

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### 5.1 General

The following principles apply to evaluations of ~~treatment systems~~ using CO<sub>2eq</sub> emission intensity.

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### 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<sub>2eq</sub> 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.

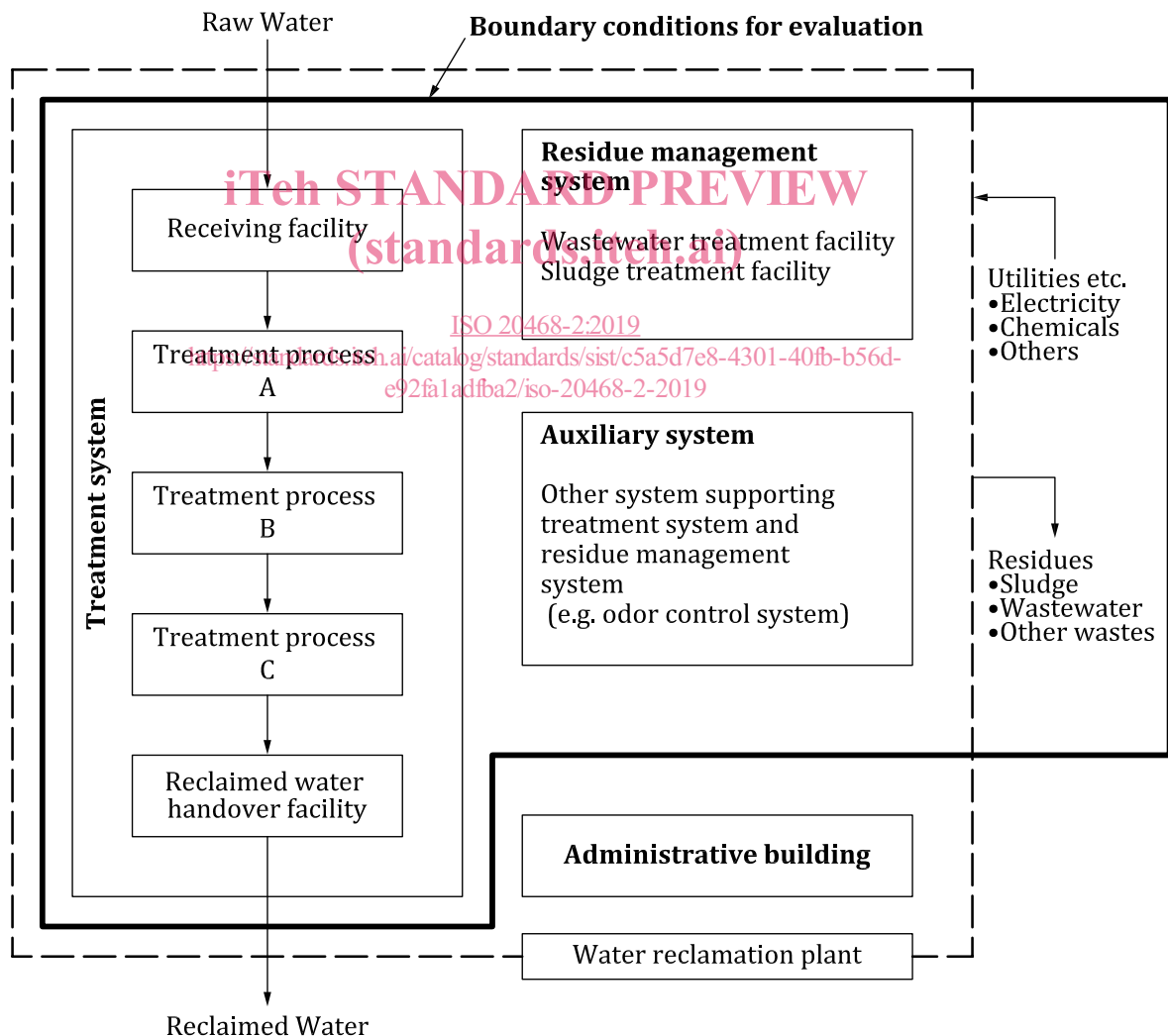


Figure 1 — Example of the boundary conditions of evaluation

## 6.2 Treatment system

An example of treatment system refers to a set of water treatment processes inside a water reclamation plant, in which raw water, such as raw sewage, preliminary, primary, or secondary treated wastewater, is transformed into reclaimed water. Normally, the treatment system consists of multiple treatment processes using physical, biological and/or chemical means. Because this document is not intended to specify the type and order of treatment processes such as A, B, and C in [Figure 1](#), they are to be replaced with adequate treatment processes according to the relevant project requirements. When evaluating the environmental performance of the treatment system by applying this document, a treatment system should at least be included in the boundary conditions.

## 6.3 Residue management system

Generally, treatment systems generate wastewater or sludge. The following facilities are needed to handle them:

- Wastewater treatment facility(s);
- Sludge treatment facility(s).

These facilities may be provided as a part of the project, or treatment work may be assigned to nearby plants already in service. GHG emissions from a residue management system may be included in the boundary conditions of an evaluation as required. It is essential to specify clearly whether or not such GHG emissions are included.

## 6.4 Auxiliary system

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Systems not included in the treatment system or the residue management system, but relate to producing reclaimed water are taken as an auxiliary system. The example is an odor control system. They may be included in the boundary conditions of the evaluation as required.

In principle, however, power consumed for lighting, air-conditioning, etc. not directly connected to the production of reclaimed water is not counted in the performance evaluation of this document.

## 7 Calculation

### 7.1 Calculation procedure

This clause describes how to calculate CO<sub>2eq</sub> emission intensity. The steps are as follows (see [Figure 2](#)):

- Step 1: Establish boundary conditions of evaluation (see [7.2](#));
- Step 2: Calculate annual amount of reclaimed water (see [7.3](#));
- Step 3: Calculate GHG emissions resulting from energy consumption, including electricity, fuels, etc. (see [7.5](#));
- Step 4: Calculate GHG emissions resulting from biological treatment processes (see [7.6](#));
- Step 5: Calculate GHG emissions resulting from consumables and generation of wastes (see [7.7](#));
- Step 6: Calculate GHG emissions reduced through the effective utilization of resources resulting from the production of reclaimed water (see [7.8](#));
- Step 7: Calculate total GHG emissions (see [7.9](#));
- Step 8: Calculate CO<sub>2eq</sub> emission intensity (see [7.10](#)).