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

Part 4: UV Disinfection

Lignes directrices pour l'évaluation des performances des techniques de traitement des systèmes de réutilisation de l'eau —

Partie 4: Désinfection aux UV

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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).

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*.

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.

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Introduction

The rapidly growing global market for water reuse technologies inevitably demands standards which are applicable on a world-wide basis. Many regions in the world are facing water shortages, and there is great interest in the use of technologies that can treat wastewater and make the reclaimed water available for a wide range of reuse applications that can satisfy non-potable water demands, thereby conserving precious potable water supplies. Simultaneously, the implementation of water reuse schemes is raising public and regulatory concerns regarding potential human health, environmental and societal impacts. This has led to an increasing need to specify various aspects of water reuse projects and there is a growing need on behalf of regulators, reuse technology suppliers, and users of those technologies for international standardization. Without ISO water reuse standards, a great number of opportunities for sustainable development based on water reuse will be lost.

Standardization needs include objective specification and evaluation of levels of service and water reuse system performance dependability including safety, environmental protection, resilience and cost-effectiveness considerations. Hence, appropriate methods are needed to evaluate the performance of treatment technologies for water reuse systems.

The performance of treatment technologies for water reuse, inter alia, should be evaluated properly in order to select most appropriate technologies in an unbiased way to achieve the objectives of the water reuse project. Despite considerable research and development on treatment technologies, such scientific knowledge is largely held within commercial interests. Performance evaluations are also useful for assessing the efficiency of existing water reuse systems and operations, including the identification of continuous improvement opportunities. To address these challenges, this document provides methods and tools, which can be accepted by most stakeholders, to evaluate the performance of treatment technologies for water reuse systems from multitude of applications.

Based on the discussion in the meetings of ISO/TC 282/SC 3, ISO 20468-1 titled “Guidelines for performance evaluation of treatment technologies for water reuse systems – Part 1: General” has been developed to establish the standard of generic aspects for performance evaluation which can be applied to a variety of wastewater treatment technologies and their combinations, while descriptions specific to the representative technologies should be included in individual standards being submitted subsequently to ISO 20468-1. In this context, this document stipulating specific ways of performance evaluation of UV treatment technology for water reuse systems, based on ISO 20468-1 as the generic standard is established herein.

In non-potable water reuse systems, UV technology is used mainly for disinfection as indicated in Table A.1 and works well with secondary or tertiary treated water as shown in ISO 20468-1:2018, Figure 1.

This guideline is intended as an integrated part of a framework for UV systems, consistent with other items in the work of TC 282. This framework includes several important aspects such as design, validation and verification (ISO 9000) and evaluation.

Guidelines focused on UV System Design, Validation and Evaluation are found in ISO 16075-5:2021, Clause 7.

Guidelines focused on UV system Design, Verification and Evaluation are found in ISO 20468-4.

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

Part 4:
UV Disinfection

1 Scope

This document provides guidelines for performance evaluation methods of UV disinfection for full scale water reuse systems. It deals with the methods of measurement of typical parameters which indicate performance of UV disinfection systems.

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
biodosimetry
procedure of measuring the UV *reduction equivalent dose* (3.1.7) of a specific microorganism in a UV unit and a comparing the results to the known UV dose-response curve of this microorganism determined by bioassay (typically collimated beam methods)

3.1.2
challenge microorganism
microorganism used for a *biodosimetry* (3.1.1)

Note 1 to entry: Common challenge microorganisms include Bacteriophages MS2, Qβ and T1UV as well as *Bacillus subtilis* spores

3.1.3
computational fluid dynamics-intensity
simulation method to model a UV unit by performing a combination of computational fluid dynamics (CFD) and optical analysis

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3.1.4
lamp protection component
apparatus for protecting the light source, including a lamp protection sleeve, tube or other component

Note 1 to entry: Lamp protection sleeve – the quartz tube or thimble that surrounds and protects the UV lamp. The exterior is in direct contact with the water being treated

3.1.5
low pressure lamp
mercury-vapour lamp that operates at an internal pressure of 0,13 Pa to 1,3 Pa (2×10^{-5} psi to 2×10^{-4} psi) and electrical input of 0,5 watts per centimetre (W/cm)

Note 1 to entry: This results in essentially monochromatic light output at 253,7 nm.

3.1.6
medium pressure lamp
mercury-vapour lamp that operate at an internal pressure of 13 kPa to 1,300 kPa (2 psi to 200 psi) and electrical output of 50 W/cm to 300 W/cm

Note 1 to entry: This results in a polychromatic (or broad spectrum) light output at multiple wavelengths, generally between 200 nm to 400 nm.

3.1.7
reduction equivalent dose
dose of UV in a given device which is determined by *biodosimetry* (3.1.1)

Note 1 to entry: See "UV dose" and "biodosimetry".

Note 2 to entry: This UV dose is determined by measuring the inactivation of a challenge microorganism after exposure to UV light in a UV unit and comparing the results to the known UV dose response curve of the same challenge organism determined via Bench scale collimated beam testing.

3.1.8
UV dose
UV fluence
amount of UV energy given as the time integral of the fluence rate or irradiance (W/m^2)

Note 1 to entry: This is given in units of mJ/cm^2 or J/m^2.

3.1.9
UV irradiance
UV fluence rate
UV intensity
UV output emitted from a given light source and entering a unit area of the irradiated surface. The value is typically given in W/m^2 or mW/cm^2

Note 1 to entry: The terms UV irradiance, fluence rate or intensity are often used to mean the same thing.

Note 2 to entry: For details, refer to Bolton and Linden 2003.

3.1.10
UV intensity sensor
UV irradiance (3.1.9) meter or radiometer instrument to measure *UV irradiance* (3.1.9)

3.1.11
UV transmittance
fraction of photons in the UV spectrum transmitted through a material such as water or quartz

Note 1 to entry: It is preferable that an online UVT sensor be installed and used to verify UVT.

Note 2 to entry: The wavelength of the UVT (unit %) should be specified, often using a path-length of 1 cm. The measurement is calibrated compared to ultra-pure water (ISO 3696 grade 1 or equivalent).

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Note 3 to entry: UVT is related to the UV absorbance (A) by the following equation (for a 1- cm path length): % UVT = 100×10^{-A}.

3.2 List of abbreviated terms

AOPs	advanced oxidation processes
BOD	biochemical oxygen demand
CFD-I	computational fluid dynamics-intensity
E. coli	Escherichia coli
LCC	life cycle cost
PCD	pitch circle diameter
POPs	persistent organic pollutants
RED	reduction equivalent dose
TDS	total dissolved solids
TSS	total suspended solids
UV	ultraviolet
UVT	ultraviolet transmittance

4 Purpose and function of UV disinfection

4.1 Purpose

To conduct water reuse, secondary or tertiary treated wastewater requires disinfection and sometimes further treatment by more advanced processes. The treated and disinfected wastewater is then used for various applications such as, urban, agricultural, industrial recreational and environmental uses.

4.2 Function

UV light has been proven effective against microorganisms including bacteria, protozoa and viruses (see Annex A). UV disinfection is achieved mostly by the absorption of photons by the genome of microorganisms, resulting in the formation of damage such as pyrimidine dimers on DNA or RNA. Such lesions hinder the self-replication in the microorganisms and thus deprives the infectivity. Accordingly, UV disinfection does not require chemical addition and results in limited by-product formation.

5 System configuration

5.1 General

A UV disinfection system for water reuse can consist of the following components and systems may have several of each component based on the disinfection application requirements.

— UV unit;

— influent water quality monitoring devices;

— flow meter;

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