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

Part 5:
Membrane filtration

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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).

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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 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

Guidelines for performance evaluation of water reclamation systems are essential for municipalities, utilities and reclaimed water users to meet water quality requirements without compromising public health. ISO 20468-1, *Guidelines for performance evaluation of treatment technologies for water reuse systems* specifies fundamental requirements for the overall water reuse system, which mainly focuses on the finished water quality. During the operation of a water reclamation system, performance evaluation at the point of individual water reclamation process helps to provide early warnings to operators to avoid adverse health impact on public health and to comply with the targets of final water quality. It is particularly important for membrane-based water reclamation processes that are often employed as the most important barriers for the removal of major constituents in wastewater (e.g. particulates, dissolved solids, and pathogens). In addition, guidelines for performance evaluation of individual treatment processes in terms of environmental and economic performances can also assist decisions on the appropriate selection of water reclamation technologies, which is of paramount importance in water reuse. This document is intended to provide stakeholders typical performance evaluation approaches designed for membrane filtration technologies. In addition, this document is expected to assist the development and operation of water reuse projects, in which process designers, plant managers, and operators are involved. Similar to ISO 20468-1, this document is mainly comprised of functional and non-functional requirements for the performance evaluation of membrane filtration technologies.

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

Part 5:
Membrane filtration

1 Scope

This document provides guidelines for performance evaluation methods of water reclamation systems using membrane technologies. This document provides guidance in ensuring treated wastewater quality levels at the point of exit from the membrane filtration processes. It also provides potential methods for evaluating the environmental and economic performance of membrane filtration processes in water reuse. This document helps plant designers, operators and end users to effectively design and operate the membrane-based water reclamation 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 20670:2018, *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
backwash
reverse flow of water with/without air across a membrane (i.e. from permeate side to feed side)

Note 1 to entry: It is designated to remove the deposited foreign substances (foulants) from the membrane.

3.1.2
bubble point pressure
pressure differential at which bubbles first appear on one surface of an immersed porous membrane, as pressure is applied to the other side

3.1.3
cleaning
operation during which membrane is cleaned using a membrane cleaning system with or without chemical reagents

EXAMPLE backwashing, flushing, chemical cleaning.

[SOURCE: AWWA B110-09]

3.1.4
concentrate
rejected stream exiting a membrane module under a *cross-flow* (3.1.5) mode

Note 1 to entry: Note to entry: Concentrate stream contains increased concentrations of constituents over the feed stream due to the accumulation of rejected constituents by membranes in the feed stream.

3.1.5
cross-flow
flow orientation through a membrane module in which the fluid on the upstream side of the membrane moves parallel to the membrane surface

Note 1 to entry: Fluid on the downstream side of the membrane moves away from the membrane in the direction normal to the membrane surface.

[SOURCE: AWWA B130-13]

3.1.6
dead-end flow
flow through a membrane module in which the only outlet for the upstream fluid is through the membrane

[SOURCE: ASTM D6161-19]

3.1.7
feed
input solution entering the inlet of a membrane module or system

3.1.8
flux
membrane throughput, usually expressed in volume of *permeate* (3.1.17) per unit time per unit membrane surface area such as litres per square meters per hour (l/m^2/hr) at a given temperature or normalized temperature (more often 20 °C)

Note 1 to entry: It can also be expressed in number of moles, volume or mass of a specified component per unit time per unit membrane surface area.

3.1.9
fouling
processes leading to deterioration of membrane flux due to surface or internal blockage of the membrane

[SOURCE: AWWA B130-13]

3.1.10
integrity test
non-destructive physical test that can be correlated to the membrane retention capability of the membrane system to ensure that membrane system is free of physical defect

3.1.11
membrane integrity
relative degree to which a membrane successfully rejects or retains specific target constituents while allowing water to pass through

3.1.12
membrane bioreactor (MBR)
integrated wastewater treatment process combining a suspended growth biological treatment and a membrane filtration system (UF/MF membrane) replacing conventional secondary clarifier

Note 1 to entry: MF or UF membrane is submerged in biological reactor (submerged MBR). Another configuration has pressurized membrane modules externally coupled to the bioreactor, with the biomass recirculated between the membrane modules and the bioreactor by pumping (side-stream MBR).

3.1.13
microfiltration (MF)
pressure driven membrane based separation process designed to remove particles and macromolecules in the approximate range of 0,05 to 2 µm

[SOURCE: ASTM D6161-19]

3.1.14
molecular weight cut-off
rating of a membrane based on the size of uncharged solutes that is typically 90 % retained by a membrane

Note 1 to entry: It is also referred to as nominal molecular weight cut-off (NMWCO).

Note 2 to entry: MWCO is typically expressed in Daltons.

[SOURCE: AWWA B130-13]

3.1.15
nanofiltration (NF)
cross-flow (3.1.5) process with pore sizes designed to remove selected salts and most organics above about 300 molecular weight range

Note 1 to entry: Nanofiltration (NF) is sometimes referred as loose RO.

Note 2 to entry: Nanofiltration (NF) is a pressure driven separation process in which particles and dissolved molecules smaller than about 2 nm are rejected.

[SOURCE: ASTM D6161-19]

3.1.16
permeate
portion of the feed stream which passes through a membrane

[SOURCE: ASTM D6161-19]

3.1.17
permeability
ability of a membrane barrier to allow the passage or diffusion of a substance (i.e., a gas, a liquid, or solute), also a numerical value used to measure water flow through a MF/UF/NF/RO membrane, usually expressed in volume of *permeate* (3.1.17) per unit membrane surface area per unit time per unit pressure such as litters per square meter per hour per bar (l/m^2/hr/bars) at a given temperature and typically corrected (normalized) to a constant temperature (20 °C or 25 °C)

Note 1 to entry: It is also referred to as specific flux.

[SOURCE: AWWA M53]

3.1.18
pore size
size of the openings in a porous membrane, expressed either in a nominal (average) or absolute (maximum) value, typically measured in µm

3.1.19
reverse osmosis (RO)
separation process where one component of a solution is removed from another component by flowing the feed stream under pressure across a semipermeable that causes selective movement of solvent against its osmotic pressure difference

Note 1 to entry: Reverse Osmosis (RO) removes ions based on electro chemical forces, colloids, and organics down to 150 molecular weight. May also be called hyperfiltration.

[SOURCE: ASTM D6161-19]

3.1.20
silt density index (SDI)
index for the fouling capacity of water in reverse osmosis systems, measuring the rate at which a 0,45-micrometre filter is plugged when subjected to a constant water pressure of 206,8 kPa (30 psi)

[SOURCE: ASTM D4189-07 (2014)]

3.1.21
transmembrane pressure
hydraulic pressure differential (net driving force) across the membrane

[SOURCE: ASTM D6161-10]

3.1.22
ultrafiltration (UF)
pressure driven process employing semipermeable membrane under hydraulic pressure gradient for the separation components in a solution

Note 1 to entry: Note to entry: The pores of the membrane are of a size smaller than 0,1 µm, which allows passage of the solvent(s) but will retain non-ionic solutes based primarily on physical size, not chemical potential.

[SOURCE: ASTM D6161-19]

3.2 List of abbreviated terms

BOD	Biochemical oxygen demand
COD	Chemical oxygen demand
LCC	Life cycle cost
MBR	Membrane bioreactor
MF	Microfiltration
MLSS	Mixed liquor suspended solids
MWCO	Molecular weight cut off
NF	Nanofiltration
NTU	Nephelometric turbidity units
RO	Reverse osmosis
SDI	Silt density index
SS	Suspended solids
TMP	Transmembrane pressure

TOC Total organic carbon

TSS Total suspended solids

UF Ultrafiltration

4 Concepts of membrane filtration technology for water reuse

4.1 General

This clause outlines the fundamentals of membrane filtration technologies in water reuse. Membrane filtration is a viable and recognized technology as physical barrier in water reuse with its high separation performance. Many of recent water reclamation schemes have employed membrane filtration processes in combination with other processes for the removal of multiple constituents in wastewater (see Table 1.)

Table 1 — Membrane types and targeted contaminants

Type	TMP, approximate range (MPa)	Contaminants targeted for removal
MF	< 0,2	0,07 – 1,0 µm diameter particle: TSS, Turbidity, at least 4-log reduction in protozoa, bacteria, but not viruses
UF	0,05 – 0,5	0,008 – 0,05 µm: TSS, turbidity, macromolecules, colloidal particles, at least 4 to 6-log reduction in protozoa, bacteria, and 1 to 6-log reduction in viruses
NF	0,5 - 3	0,001 to 0,02 µm: Pesticides and other macromolecules (high molecular weight) organics, color, colloids, all pathogen groups and polyvalent cations.
RO	0,5 - 7	0,0001 to 0,002 µm: dissolved salts, colloids, low molecular weight organics, color, TDS, mono and multi valent ions (e.g. chlorides, sulfates, nitrate, sodium, boron, metals, other ions)

4.2 Membrane type and treatment objectives

Membrane type is typically classified into four categories depending on levels of their pore size for MF and UF membranes and their separation capabilities for NF and RO membranes (see Table 1). Driving force of solution through these membranes is a pressure difference across feed and permeate streams.

MF/UF membrane filtration processes in water reuse are generally used to remove suspended particles including particulates, and colloids. In water reclamation, MF/UF processes effectively work as an alternative process of secondary clarifiers and media filters that are a subsequent process of biological treatment. With their high separation capability for particles, they are often used as a pre-treatment of NF/RO process for fouling mitigation. MF membranes can achieve high removal of suspended solids, large pathogens (i.e. bacteria and protozoa) and some viruses. UF membranes, which have smaller nominal pore size than MF membranes, are in addition capable of removing small constituents in wastewater such as viruses and macromolecules.

MF/UF incorporated with a biological process is referred to as a MBR process.

NF/RO membranes have capabilities for producing high-quality reclaimed water which is suitable for many industrial uses and many applications with a high likelihood of human contact. NF membranes can effectively remove multivalent ions including heavy metals and most micropollutants (e.g. >200–300 molecular weight). RO membranes can remove monovalent ions including sodium and chloride ions and low molecular weight micropollutants (e.g. <200–300 molecular weight). NF/RO membrane spiral wound elements are typically housed in a pressure vessel and their processes are usually operated continuously; thus, it is required to undergo sufficient pre-treatment to mitigate membrane fouling (e.g. target SDI in RO feed <3). Downstream to the pressure driven membrane process, disinfection

