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

Part 6: Ion exchange and electrodialysis

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

Partie 6: Échange d'ions et électrodialyse

Reference number
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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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This document was prepared by Technical Committee ISO/TC 282, *Water reuse*, Subcommittee SC 3, *Risk and performance evaluation of water reuse system*.

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.

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Introduction

"Ion exchange" for purification with ion exchange resin and "Electrodialysis" for desalination and concentration with ion exchange membrane are classified as "Advanced treatment" in ISO 20468-1[4]. Raw water compositions and treated water targets are extremely diverse. Such diversity impedes making world-wide guidelines for ion exchange and electrodialysis.

Ion exchange resin (IER) provides a medium for ion exchange. Target ions in solution are trapped within the medium causing other ions contained within the medium to be released into solution. The most common applications are water softening and water purification.

Electrodialysis (ED) is an ion-separation process that utilizes an electrical potential difference across ion exchange membrane as the driving force for moving ion in a solution. The membrane is selective in that it only permits the passage of either anions or cations but not both and can be used to reject opposite charged ions.

The ISO 20468 series is intended to provide international standards for an objective evaluation of the performance of ion exchange and electrodialysis. It introduces the concepts of "Functional requirements" and "Non-functional requirements," which are suggested and defined in ISO 20468-1, also used for other water reuse technologies that may be used in combination or alternatively, such as membrane, UV, and ozone disinfection and distillation.

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

Part 6: Ion exchange and electrodialysis

1 Scope

This document provides guidelines on methods for evaluating the performance of ion exchange and electrodialysis for water reuse including ion exchange resin and ion exchange membrane.

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:

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

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

3.1 Terms and definitions

3.1.1
anion exchange membrane
polymer sheet that contain positively charged functional groups in its polymer matrix designed to conduct anions while blocking other ions

3.1.2
anion exchange resin
polymer beads that contain positively charged functional groups in its polymer matrix capable of undergoing exchange reactions with anions

3.1.3
bed
packed layers of *ion exchange resins* (3.1.19)

3.1.4
block
unit composed of *cell pairs* (3.1.8) and intermediate frame at both ends

Note 1 to entry: Cell-pairs are stacked from several pairs up to thousands of pairs inside an electrodialyser ion exchange.

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Note 2 to entry: A large number of cell pairs stacked in series causes problems such as non-uniform hydraulic pressure and increased leak current in an electrodialyser. To prevent such problems, a large electrodialyser is separated with an intermediate frame (Figure 8).

3.1.5
cation exchange membrane
polymer sheet that contain negatively charged functional groups in its polymer matrix designed to conduct cations while blocking other ions

3.1.6
cation exchange resin
polymer beads that contain negatively charged functional groups in its polymer matrix capable of undergoing exchange reactions with cations

3.1.7
cell
thin sheet compartment, through which desalinate (feed water) or concentrate passes

Note 1 to entry: D-cell means a desalinate cell and C-cell means a concentrate cell.

3.1.8
cell pair
series of D-*cell* (3.1.7), *cation exchange membrane* (3.1.5), C-*cell* (3.1.7), and *anion exchange membrane* (3.1.1) that are layered in order to constitute a cell pair

Note 1 to entry: A cell pair is the basic unit for desalination and concentration in electrodialysis.

3.1.9
chelating resin
polymer beads that contain functional groups in its polymer matrix capable of forming chelates with metal ions

3.1.10
current efficiency
ratio of the theoretical to actual current required to transport ions across an *ion exchange membrane* (3.1.18)

3.1.11
direct current
unidirectional flow or movement of electrical charge carriers (which are usually electrons)

3.1.12
electrodeionization
water treatment technology that utilizes electricity, *ion exchange membranes* (3.1.18) and *ion exchange resin* (3.1.19) in order to desalinate ions from one solution to another solution in a very low concentration

3.1.13
electrodialysis
water treatment technology that uses *ion exchange membranes* (3.1.18) in order to move ions from one solution to another solution by using electrical potential difference

3.1.14
electrodialysis reversal
type of *electrodialysis* (3.1.13) process that periodically reverses the electrodes polarity, alternating concentrated and diluted streams, and continuously self-cleaning the scale components

3.1.15
heterogeneous ion exchange membrane
ion exchange membrane (3.1.18) that is obtained by mixing *ion exchange resin* (3.1.19) and thermoplastic resin, and has heterogeneous structure

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3.1.16
homogeneous ion exchange membrane
ion exchange membrane (3.1.18) that is uniformly configured except for reinforcement

3.1.17
ion exchange capacity
total quantity of ion exchangeable groups in *ion exchange resin* (3.1.19)

3.1.18
ion exchange membrane
polymer sheet that contain negatively or positively charged functional groups in its polymer matrix designed to conduct cations or anions while blocking opposite charged ions

3.1.19
ion exchange resin
polymer beads that contain charged functional groups in its polymer matrix capable of undergoing exchange reactions with anions or cations

3.1.20
limiting current density
current density beyond which water dissociation will occur

Note 1 to entry: In electrodialysis, ions in a solution migrate from the bulk solution to the surface of an ion exchange membrane and form a boundary layer having a concentration difference. As current density increases, the concentration difference of the boundary layer also increases, and the concentration on the surface of the ion exchange membrane reaches zero. This current density is defined as "Limiting current density (LCD)," and is an important indicator for deciding the operating current of an electrodialyser. Operation beyond LCD causes water to dissociate into hydrogen ions (H^+) and hydroxyl ions (OH^-) at the ion exchange membrane-surface and consumes applied current ineffectually.

3.1.21
mixed bed
mixture of *anion exchange resin* (3.1.2) and *cation exchange resins* (3.1.6)

3.1.22
particle size and particle size distribution
diameter of *ion exchange resin* (3.1.19) beads and its distribution

3.1.23
perfect beads content
non-cracked and non-broken bead content in *ion exchange resin* (3.1.19) beads

3.1.24
reaction rate
ion exchange reaction rate of *ion exchange resin* (3.1.19)

3.1.25
regeneration
regeneration of *ion exchange resin* (3.1.19) is a reversal of the exchange reactions with high concentrations of a regenerate

3.1.26
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 membrane 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]

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3.1.27
selectivity coefficient
equilibrium constant for ion exchange reaction in *ion exchange resins* (3.1.19)

3.1.28
stack
entire body of electrodialyser, assembled with multitude of *cell pairs* (3.1.8) or several *blocks* (3.1.4) between anode *cell* (3.1.7) and cathode *cell* (3.1.7), and pair of end plates for tightening

3.1.29
strongly acidic cation exchange resins
resins that have strongly acidic functional groups

3.1.30
strongly basic anion exchange resins
resins that have strongly basic functional groups

3.1.31
transport number
fraction of current carried by a given ion for total current carried by all ions

3.1.32
tower
vessels with packed layers of *ion exchange resins* (3.1.19) and/or degassers

3.1.33
uniform particle size ion exchange resin
ion exchange resin (3.1.19) that has narrow *particle size distribution* (3.1.22)

3.1.34
water extractable residue
water soluble extractable residue from *ion exchange resins* (3.1.19)

3.1.35
water recovery rate
ratio between treated water quantity and feed water quantity to electrodialyser

3.1.36
weakly acidic cation exchange resins
cation exchange resins (3.1.6) that have weakly acidic functional group

3.1.37
weakly basic anion exchange resins
anion exchange resins (3.1.2) that have weakly basic functional group

3.2 List of Abbreviated terms

AC	Alternating current
AEM	Anion exchange membrane
AER	Anion exchange resin
CEM	Cation exchange membrane
CER	Cation exchange resin
CR	Chelating resin
DC	Direct current

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