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Performance evaluation of treatment technologies for water reuse systems —

Part 9: Guidelines and requirements for electro-chlorination

Évaluation des performances des techniques de traitement des systèmes de réutilisation de l'eau —

Partie 9: Lignes directrices et exigences relatives à l'électrochloration

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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 document 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 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.

Introduction

Chlorination is usually used as the final process in the treatment for water reuse, as mentioned in ISO 20468-1. The chlorination process is used to add and maintain the minimum level of chlorine in a water reuse distribution system. The chlorination process controls contamination sources with residual chlorine to prevent the regrowth of microorganisms and contamination during the distribution of reclaimed water. The advantages of the conventional chlorination process are its low price and strong persistence, which distinguish it from other oxidizer-based disinfectants. However, a disadvantage of chlorine is that it generates disinfection by-products. Water quality regulations are being strengthened in this regard. In addition, the major disadvantage of chlorine is that it is a toxic substance, which puts a burden on transport, storage and maintenance.

Electro-chlorination is drawing attention as a solution to the problems of conventional chlorination methods. It is a technology that generates sodium hypochlorite (NaOCl) through an electrochemical reaction produced by flowing electric current. The generated sodium hypochlorite controls the organic contaminants and pathogenic microorganisms present in the water. However, despite the safety of the electrolysis method, the sterilization and disinfection efficiency cannot be stably maintained because the residual chlorine concentration is not constant, and the maintenance cost, including electricity cost, is high. In addition, the maintenance and storage of the resulting sodium hypochlorite represent challenges.

This document presents evaluation methods of electro-chlorination and provides guidelines for the performance evaluation of this method.

Performance evaluation of treatment technologies for water reuse systems —

Part 9:
Guidelines and requirements for electro-chlorination

1 Scope

This document provides guidelines and requirements to evaluate the performance of the method to produce sodium hypochlorite (NaOCl) by electro-chlorination (EC), and to evaluate its disinfection performance for water reuse treatment. It provides a system for evaluating water quality to verify the performance of EC through general parameters, such as the concentration of residual chlorines obtained by electrolysis.

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 terminology databases for use in standardization at the following addresses:

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

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

3.1 Terms and definitions

3.1.1
electrolysis
process that uses electric energy to cause nonspontaneous electrochemical reactions that result in the decomposition of substances

Note 1 to entry: *Sodium hypochlorite (NaOCl)* (3.1.11) is generated by an oxidation-reduction reaction, which is caused when an *electrode* (3.1.3) is inserted into an *electrolyte* (3.1.2) (e.g. NaCl) aqueous solution and electricity is supplied from the outside.

3.1.2
electrolyte
medium in which an electric current is transported by ions

[SOURCE: ISO 8044:2020, 7.1.1]

3.1.3
electrode
electronic conductor in contact with an *electrolyte* (3.1.2)

[SOURCE: ISO 8044:2020, 7.1.2, modified — Note 1 to entry was removed.]

3.1.4
cathode
electrode (3.1.3) at which a *cathodic reaction* (3.1.6) predominates

[SOURCE: ISO 8044:2020, 7.1.3]

3.1.5
anode
electrode (3.1.3) at which an *anodic reaction* (3.1.8) predominates

[SOURCE: ISO 8044:2020, 7.1.4]

3.1.6
cathodic reaction
transfer of negative charge from the electronic conductor to the *electrolyte* (3.1.2)

EXAMPLE $\frac{1}{2}O_2 + H_2O + 2e^- \rightarrow 2OH^-$

Note 1 to entry: Current enters the electronic conductor from the electrolyte. A cathodic reaction is a *reduction* (3.1.7) process.

[SOURCE: ISO 8044:2020, 7.1.6]

3.1.7
reduction
process in which a reactant accepts one or more electrons

[SOURCE: ISO 8044:2020, 7.1.7]

3.1.8
anodic reaction

transfer of positive charge from the electronic conductor to the *electrolyte* (3.1.2)

Note 1 to entry: Current enters the electrolyte from the electronic conductor. An anodic reaction is an *oxidation* (3.1.9) process.

[SOURCE: ISO 8044:2020, 7.1.9, modified — "electrode reaction equivalent to" was removed from the beginning of the definition; the example of corrosion was removed from the note to entry.]

3.1.9
oxidation
process in which a reactant loses one or more electrons

[SOURCE: ISO 8044:2020, 7.1.10]

3.1.10
electro-chlorination
EC
process of generating *sodium hypochlorite (NaOCl)* (3.1.11) by *electrolysis* (3.1.1) in salt water

Note 1 to entry: Sodium hypochlorite generated through electro-chlorination can be used as a disinfectant for water reuse treatment.

3.1.11
sodium hypochlorite
NaOCl
oxidizer produced by electrolyzing salt (NaCl) and water

3.1.12
electrolyser
reactor used to make *sodium hypochlorite (NaOCl)* (3.1.11) in the *electro-chlorination* (3.1.10) process

3.1.13
free chlorine
chlorine present in the form of hypochlorous acid, hypochlorite ion or dissolved elemental chlorine

Note 1 to entry: In this document, the *sodium hypochlorite (NaOCl)* (3.1.11) is mainly referred to as free chlorine.

[SOURCE: ISO 7393-2:2017, 3.1, modified — The original Note 1 to entry was removed and a new Note 1 to entry was added.]

3.2 List of abbreviated terms

DC	direct current
EC	electro-chlorination
NaCl	sodium chloride
Cl_2	chlorine gas
H_2O	water
NaOCl	sodium hypochlorite
HOCl	hypochlorous acid
OCl^-	hypochlorite ion
Na^+	sodium ion
Cl^-	chloride ion
ClO_3^-	chlorate
BrO_3^-	bromate
TSS	total suspended solids
TDS	total dissolved solids
POPs	persistent organic pollutants
UF	ultrafiltration
NF	nanofiltration
RO	reverse osmosis
AOP	advanced oxidation processes

4 System components

4.1 Principles of electro-chlorination

Electro-chlorination (EC) is a disinfection technology for reclaimed water that produces chlorine-based oxidizer from salt water (e.g. NaCl aqueous solution) using the electrochemical principle. When NaCl is used as the electrolyte, the Cl^- are oxidized at the anode to generate Cl_2. At the cathode, H_2O is reduced instead of Na^+ with large ionization tendency to generate hydrogen gas (H_2). In particular, when electrolysis is

performed in NaCl solution, a chlorine-based oxidizer (free chlorine) with a strong oxidizing power, such as NaOCl, HOCl, or OCl^-, is generated. The schematic diagram in Figure 1 shows an example of EC system containing the following elements.

a) NaOCl generating system, including:
   1) fresh water intake;
   2) NaCl storage tank;
   3) NaCl dissolution tank;
   4) NaCl solution storage tank;
   5) electrolyser for producing NaOCl;
   6) hydrogen gas exhaust vent;
   7) DC power supply;
   8) control panel.

b) NaOCl storage and injection system, including:
   1) cooling device;
   2) NaOCl storage tank;
   3) NaOCl injection pump.

c) Monitoring system, including:
   1) a measuring point for chlorine concentration (with generated NaOCl) in the storage tank;
   2) a measuring point for chlorine concentration in the disinfectant reactor;
   3) a measuring point for chlorine concentration after disinfection;
   4) a measuring point for water quality before disinfection;
   5) a measuring point for water quality after disinfection.