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Evaluation methods for industrial wastewater treatment reuse processes

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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 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.

The committee responsible for this document is Technical Committee *[or Project Committee]* ISO/TC *[or ISO/PC]* 282, *Water reuse*, Subcommittee SC 4, *Industrial water reuse*.

This second/third/… edition cancels and replaces the first/second/… edition (ISO 2020#:2020), which has been technically revised.

The main changes compared to the previous edition are as follows:

— xxx xxxxxxx xxx xxxx

A list of all parts in the ISO 2020# series can be found on the ISO website.

Introduction

Reuse of industrial wastewater is an important strategy for reducing freshwater consumption and wastewater generation. Treated industrial wastewater can be used for various purposes [6, 9, 13]. The dominant industrial applications are cooling water for power generation, boiler feed water, equipment cleaning and general process water uses. Reused water may also be applied for non-industrial applications most typically including toilet and urinal flushing, and landscape irrigation [8, 12, 13].

Currently, various methods are applied to evaluate the resource use, energy and environmental performance respectively, which can be also used in industrial systems, including Life Cycle Assessment (ISO 14040-2006), Environmental Risk Assessment (IEC ISO 31010-2009), Best Available Technology (Directive 2010/75/EU), Ecological Footprint (ISO 14046-2014), Circular Economy (BS 8001:2017) and other methods [1-2,15-16]. The primary evaluation criteria selection for industrial wastewater treatment reuse processes has historically been based on a cost-benefit analysis, however, economic factors are no longer the main decision factor, nowadays, industries take into consideration a number of sustainable factors, including economics, environment, social and technology characteristics [2,7-9,14-17].

The evaluation of wastewater treatment reuse processes requires systematic methods to evaluate the performance expectations of alternative wastewater treatment reuse processes [2, 9, 17].

This document provides guidelines for assessing wastewater treatment reuse processes through enhanced information analysis, to ensure protection of environmental and human health, to promote the transition of the circular economy and improve water management.

Evaluation methods for industrial wastewater treatment reuse processes

1 Scope

This document specifies the principles and framework for comprehensive evaluation of industrial wastewater treatment reuse processes, including:

a) establishing goals and scope; b) illustrating the evaluation procedure; and c) determination of evaluation indicators (technology indicator/sub-indicators, environment indicator/sub-indicators, resource indicator/sub-indicators, economy indicator/sub-indicators).

This document describes how to comprehensively evaluate industrial wastewater treatment reuse processes using the proposed calculation approaches and recommended indicators. It does not specify methodologies for single evaluation indicators.

The document is intended to provide assistance to a broad range of industrial wastewater treatment and reuse project stakeholders including professionals (planning, management, designers, and operators), administrative agencies (monitoring, assessment, regulation and administration) and local authorities.

This document is applicable to

a) evaluating comparing and selecting industrial wastewater treatment reuse processes,

b) implementing continuous improvements,

c) upgrading processes and improving performance for existing treatment and reuse facilities.

The intended application of the comprehensive evaluation result is considered within the goal and scope definition.

2 Normative references

The following documents, in whole or in part, are normatively referenced in this document and are indispensable for its application. 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

3.1 Terms and definitions

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 http://www.iso.org/obp

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

3.1.1
Delphi method
an information-gathering technique used as a way to reach consensus of experts on a subject.

Note 1: The Delphi method is applied as consensus tool for determining weights of indicators/sub-indicators in this document.

Note 2: A facilitator uses a questionnaire to solicit ideas about the important project points related to the subject. The responses are summarized and are then recirculated to the experts for further comment. Consensus may be reached in a few rounds of this process.

[SOURCE: ISO/IEC/IEEE 24765:2017(en), 3.1102]

3.1.2
indicator
quantitative or qualitative measure of impacts.

[SOURCE: ISO 19208:2016(en), 3.8]

3.2 Abbreviated terms

BOD_5	5-day biochemical oxygen demand
COD	chemical oxygen demand
ELR	environment load ratio
ESI	energy sustainability index
EYR	the energy yield ratio
GHG	greenhouse gas
GWP	global warming potential
LCY	local currency
PAC	poly-aluminum chloride
PAM	polyacrylamide
TDS	total dissolved solids
TSS	total suspended solids

4 Evaluation principles

4.1 Comprehensiveness

The evaluation system provides a multi-criteria analysis framework to evaluate alternatives using parameters that are relevant to the proposed processes. The analysis considers all attributes of multiple indicators (technology, environment, resource, and economy) and address specific requirements by using sub-indicators based on the evaluation indicators, which are consistent with factors involved in a Sustainability Analysis to a certain extent [2, 7]. Other social or political criteria can be taken into account according to local policy or regulations [8].

a) Technology

Address the technological parameters of the industrial wastewater treatment processes applied for water reuse.

b) Environment

Address the environmental parameters and impacts of the industrial wastewater treatment processes applied for water reuse system.

c) Resource

Address the resource recovery, allocation and utilization for water reuse.

d) Economy

Address the economic impacts of the industrial wastewater treatment processes applied for water reuse.

4.2 Operability

The selection of evaluation indicators is general, reasonable and attainable, so that the evaluation indicators are concise, clear and easy to get. It is also in line with the actual needs to manage the water environment.

4.3 Relevance

The evaluation process and parameters of the industrial wastewater treatment reuse processes should be extracted in a relevant manner and appropriately quantified.

4.4 Transparency

Due to the inherent complexity for evaluation, transparency is an important guiding principle to ensure proper results. Calculating process of sub-indicators should be recorded and available for clarification when requested.

5 Evaluation procedure

5.1 General

General framework sees Figure 1.

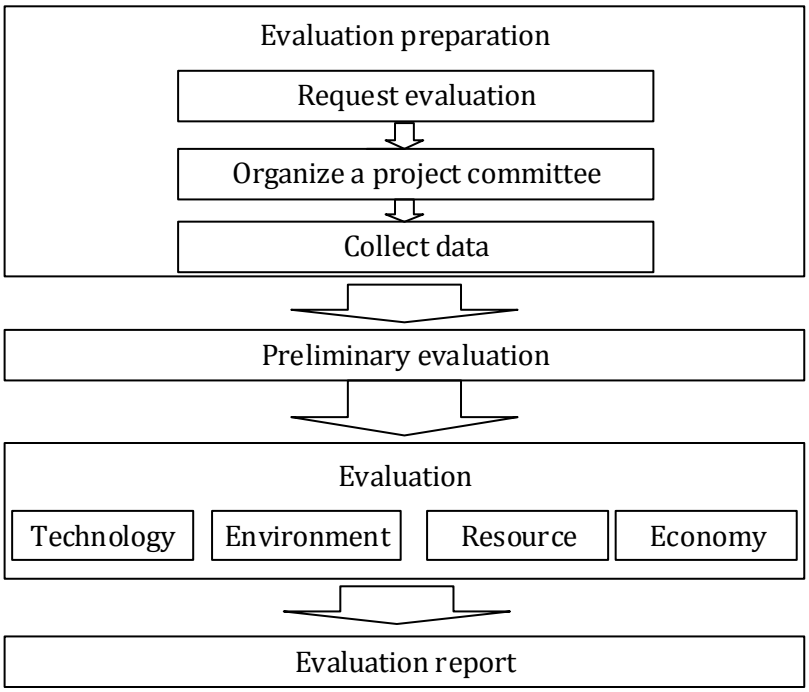

Figure 1 Framework of evaluation procedure

5.2 Procedure description

(1) Evaluation preparation

Step 1: Request evaluation

The enterprises, industry managers or related organizations develop evaluation requirements and submit the relevant documents. The documents can include, but not limited to the following:

a) The basic information form, which includes:

— The actual position of enterprises;

— Major processes and equipment;

— Water quality parameters of industrial influents and effluents;

— Type of reuse and reuse demands;

b) Record files of major pollutants emissions;

c) Record files of resources and energy consumption;

d) Assessment reports of environmental impact;

e) Assessment reports of public safety impact;

f) Other essential documents.

Note: Data (list b, c) can be obtained from relevant research reports and references or statistics for new projects without record files. Reports (list d) include the assessment of freshwater consumption and

possible effects of respective direct reduction in the effluent quality, i.e., possible increase of pollutants concentration.

Step 2: Organize a project committee

Establish a project committee which may be composed of experts, skilled operators, industrial shareholders or managers, supervisors, etc. The project committee is asked to undertake the following objectives, respectively.

a) Carry out the evaluation task;

b) Supervise field surveys and sampling tests;

c) Validate the integrity and accuracy of the data on the base of the statistical reports and original records provided by the enterprises.

Step 3: Collect data

Collect raw and supporting data from related industries or enterprises via basic information surveys, please refer to Table D.4 in Annex D. Field surveys, sample tests, and enterprises' record files can be used to collect data if evaluated processes have adequate operational recording data. Research reports and references analysis also can be used to collect data if it is a new process and/or new project with little or no existing operating record.

Note: Step 1, step 2 and step 3 are recommended steps of evaluation preparation whose main task is to collect data. Other optional steps are also allowed to carry out the evaluation preparation as long as they satisfy the need of collecting adequate information.

(2) Preliminary evaluation

The preliminary evaluation procedure is as following:

a) Analyze and summarize the existing treatment and reuse technologies globally according to the category of industrial wastewater, and determine which technologies or processes are evaluated.

b) Make a simple primary selection of the above processes. The main considerations include:

— Whether the processes achieve the required constituent removal performance.

— According to "Guidelines for Water Reuse 2012"[9] and relevant standards (e.g., ISO 20468-1) to determine whether the technology can meet its corresponding reuse water quality requirements [2,3].

— Whether it is convenient for updating construction considering site, public facilities and other conditions.

— Other necessary conditions and considerations.

c) The project committee (see step 2 in 5.2) combined with stakeholders, engineers, technicians and relevant experts to discuss, and distinguish the two major categories: preliminary feasible processes and infeasible processes based on the actual situation of the enterprises. The former processes are selected for further evaluation.

(3) Evaluation

The preliminary feasible processes are comprehensively evaluated from four aspects: technology indicator, environment indicator, resource indicator and economy indicator. See Clause 6.

Note: Besides, it is out of the scope of this document, the social effects including education, cultural values, operator training requirements, job creation and other social criteria should be taken into account according to local policy or regulations.

(4) Evaluation report

Step 1: Evaluation results analysis

Compare the comprehensive scores of proposed evaluated processes. Then, make the evaluation report by combining analysis of the evaluation results with consideration on the actual situation of the industrial enterprise. The whole processes that meet the requirements are identified along with the recommended processes, are referred as solutions available for users and decision makers.

Step 2: Prepare evaluation reports

The evaluation report should include the basic condition of the industrial enterprise, the relevant technical conditions, the evaluation process and results, etc.

6 Evaluation

6.1 Evaluation indicators

The evaluation system consists of four primary indicators: technology, environment, resource and economy. Each indicator category is divided into a few sub-indicators. The sub-indicators are refinement of the primary indicators. The overall indicator framework of evaluation system is shown in Table 1. The further details are given in Annex A; Calculation of the qualitative sub-indicators refers to Annex B.

Table 1 Example indicators of industrial wastewater treatment reuse processes

Indicators	Sub-indicators	Note	Related reference
Technology	Te1. Technology maturity	Qualitative	A.1.1
	Te2. Equipment utilization ratio	Quantitative	A.1.2
	Te3. Equipment readiness ratio	Quantitative	A.1.3
	Te4. Stability	Qualitative	A.1.4
	Te5. System management	Qualitative	A.1.5
	Te6. Maintainability and complexity of implementation	Qualitative	A.1.6
	……		
Environment	En1. Conventional pollutants removal rate	Quantitative	A.2.1
	En2. Other concerned pollutants removal rate	Quantitative	A.2.2
	En3. Sludge production rate	Quantitative	A.2.3
	En4. Total GHG emissions	Quantitative	A.2.4