INTERNATIONAL STANDARD

ISO 22449-2

First edition
2020-05

Use of reclaimed water in industrial cooling systems —

Part 2: Guidelines for cost analysis

Utilisation de l'eau recyclée dans les systèmes de refroidissement industriels —
Partie 2: Lignes directrices relatives à l'analyse des coûts

Reference number
ISO 22449-2:2020(E)

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Published in Switzerland

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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 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 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 4, *Industrial water reuse*.

A list of all parts in the ISO 22449 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

Large amounts of water resources are used in industrial development. Industrial cooling water use accounts for a high proportion of industrial water use. Industrial water reuse is one of the promising ways to solve water shortages and to provide a new water source for cooling systems. The quality of reclaimed water is of great importance for the design and operation of industrial cooling systems. Industrial wastewater must meet the requirements of the cooling systems before it can be used as make-up water. Consequently, the primary cost consideration is related to the costs of treating industrial wastewater. In addition, for new-built cooling systems based on life-cycle consideration, the capital cost, operating cost and maintenance cost need to be considered.

This document provides a comparative cost analysis method for cooling systems using reclaimed water. It will be conducive to establishing an effective and unified cost analysis method in different countries for further cost comparison. This document is intended to lead the use of reclaimed water in industries worldwide, promoting the reuse of water resources, improving water-use efficiency and putting into practice the concept of the industrial circular economy.

Use of reclaimed water in industrial cooling systems —

Part 2: Guidelines for cost analysis

1 Scope

This document provides guidelines for cost analysis of the use of reclaimed water in industrial cooling systems.

This document is intended for new-built industrial cooling systems using reclaimed water as make-up water, in which the reclaimed water originates from industrial wastewater and is generated through wastewater treatment systems for reuse. The source of industrial wastewater is from all the production plants inside the enterprise.

In this document, the levelized cost of cooling water (LCOCW) is used to compare and determine which industrial cooling system is more expensive per-kilowatt-hour heat removed.

Use of reclaimed water will have a direct impact on the operating cost of cooling systems and the environment. External benefits, including positive externalities and negative externalities, are provided in Annex A, which considers environmental, social and financial elements.

This document is intended for all types of stakeholders involved in reclaimed water use in new-built industrial cooling systems.

This document aims to ensure consistency within any organization engaged in reclaimed water reuse.

This document provides a broad framework within which costs for new-built industrial cooling systems using reclaimed water can be assessed. The currency used is local currency (LCY).

2 Normative references

There are no normative references in this document.

3 Terms, definitions and abbreviated terms

3.1 Terms and definitions

For the purposes of this document, the following terms and definitions 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/

3.1.1
capital cost
capital expenditure
money used to purchase, install and commission a capital asset

[SOURCE: ISO 15663-3:2001, 2.1.3, modified — preferred term changed from capital expenditure to capital cost.]

3.1.2
disposal cost
money used to demolish and rehabilitate a capital asset at the end of its life

3.1.3
heat rejection capacity
amount of heat which can be rejected by a cooling system

Note 1 to entry: Measured in kW (1 000 Watts, thermal or electric).

3.1.4
operation and maintenance cost
cost incurred in running and managing the facility, plus labour, material and other related costs incurred to retain a building or its parts in a state in which it can perform its required functions

[SOURCE: ISO 15686-5:2017, 3.1.9 and 3.1.11]

3.1.5
replacement cost
anticipated cost to major system components that are required to maintain the operation of a facility

3.2 Abbreviated terms

The abbreviated terms in Table 1 apply.

Table 1 — Abbreviated terms

Abbreviation	Full term
EPCM	engineering procurement construction management
LCY	local currency
LCOCW	levelized cost of cooling water

4 Guidelines for the cost analysis

4.1 General

The scope of the costs includes the costing associated with wastewater treatment systems and industrial cooling systems.

This document includes:

— principles of the cost analysis;

— cost calculation method;

— cost analysis indexes.

The flow diagram and components of a cooling system using solely reclaimed water as make-up water are shown in Figure 1.

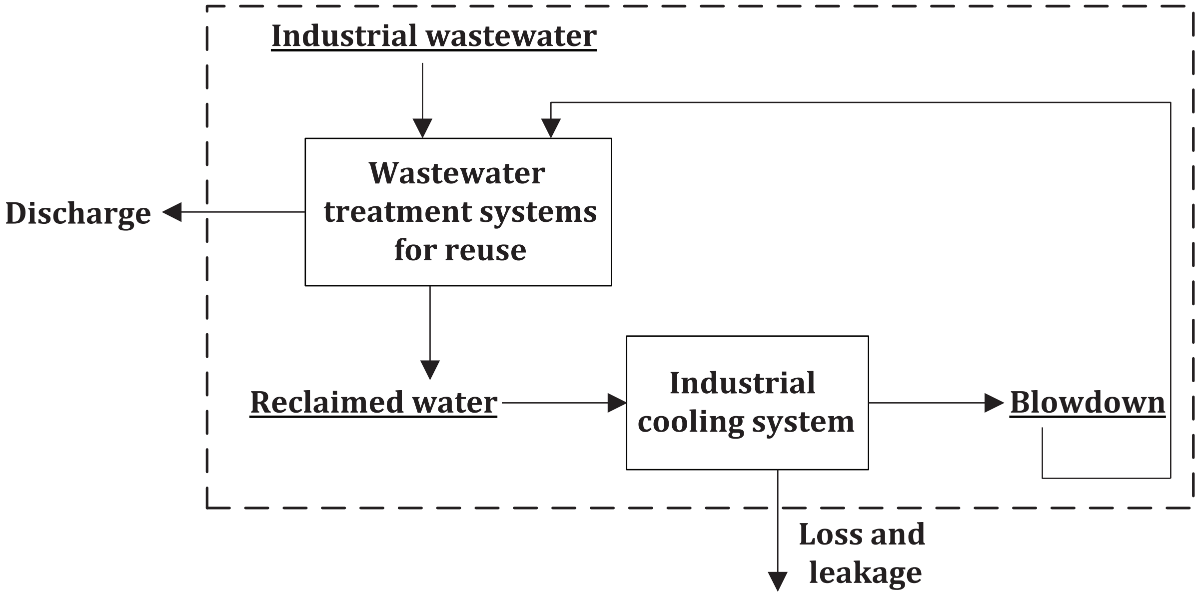

Figure 1 — Flow diagram and components of a cooling system using reclaimed water

4.2 Principles of the cost analysis

Cost analysis should observe the following principles[5]:

a) Life-cycle cost analysis should be used as the cost analysis method, and the calculation period for the analysis should include the construction period, operation period and disposal period.

b) The cost analysis should take the following items into account: the capital cost during the construction period; the operation, maintenance and replacement cost during the operation period; and the disposal cost during the disposal period.

c) The scope of cost includes the costs associated with the wastewater treatment system and industrial cooling system.

4.3 Cost calculation method

4.3.1 Capital cost

4.3.1.1 Principles of capital cost calculation

Capital cost calculation should observe the following principles:

a) The scope of capital cost covers the relevant equipment, buildings and supporting facilities of the industrial cooling system and the wastewater treatment system.

b) The capital cost calculation should be based on the whole system, and the cost should cover the whole construction period from initial work to the completion of construction and commissioning.

c) The capital cost should be annualized based on the construction schedule during the construction period.

4.3.1.2 Capital cost calculation

4.3.1.2.1 Construction and building cost

The construction and building cost includes:

a) construction labour cost (all salaries and wages paid to construction workers, supervisory staff and overhead personnel);

b) construction material cost (all construction material purchased by the contractor or the owner for use on the construction project);

c) construction equipment usage cost (the construction contractor's equipment usage operating cost for the installation of all bulk materials and equipment).

4.3.1.2.2 Equipment cost

Equipment cost consists of the purchase cost of all process, non-process or fixed equipment purchased by the contractor or owner, but excludes freight cost and duties. It is calculated according to the equipment list and the quotations from vendors.

A good choice of material for equipment can deal with complex water quality of reclaimed water for new-built cooling water systems. It can affect the operation regarding the required amount of direct energy consumption, the occurrence of controlled (wastewater treatment) and uncontrolled (leakage) emissions to the environment and the direction of heat emissions. The selected materials will require a certain level of investment. Annex B, Table B.1, describes materials commonly used in cooling systems and the effects of water quality on the material.

4.3.1.2.3 Subcontract cost

Subcontract cost includes all lump sum/unit rate subcontracts let by the contractor or the owner which are not included in the engineering procurement construction management (EPCM).

4.3.1.2.4 Indirect cost

The indirect cost consists of the EPCM cost, the cost for temporary construction facilities and temporary utilities, catering and lodging cost, vendor representatives cost, spare parts for start-up, pre-commissioning and commissioning, first fills, third-party engineering services/testing/inspection, freight and duties/taxes.

4.3.1.2.5 Owner's cost

The owner's cost consists of the owner's labour cost and expenses during construction, consultants' costs, payment of licenses and royalties, land acquisition costs, environmental evaluation cost, insurance, tests and study cost.

4.3.1.2.6 Contingency cost

Contingency cost is a provision of funds for unforeseen or inestimable costs within the defined project scope relating to the level of engineering effort undertaken and estimate/engineering accuracy. Contingency cost of each sub-item of the system is determined according to the risk level, and the total contingency cost is summarized finally.

4.3.1.2.7 Capital cost of the system

The capital cost of the system is the total of the above-mentioned items, calculated according to Formula (1):

$$C = C_1 + C_2 + C_3 + C_4 + C_5 + C_6 \tag{1}$$

where

C is the capital cost, in LCY;

C_1 is the constructing and building cost, in LCY;

C_2 is the equipment cost, in LCY;

C_3 is the subcontract cost, in LCY;

C_4 is the indirect cost, in LCY;

C_5 is the owner's cost, in LCY;

C_6 is the contingency cost, in LCY.

4.3.2 Operation and maintenance cost

4.3.2.1 Principles of operation and maintenance cost calculation

a) The scope of operation and maintenance cost calculation covers all costs for the operation of the wastewater treatment system and the industrial cooling system.

b) The operation and maintenance cost calculation should include the cost of the whole cooling system and the calculation period should cover the whole period from the operation to the end of life of the system.

c) The operation and maintenance cost should be calculated annually.

4.3.2.2 Operation and maintenance cost calculation

4.3.2.2.1 Electricity cost

Electricity cost is the cost incurred due to the electricity consumption during system operation. The electricity of common electrical equipment in Table 2 consumed for the wastewater treatment system and the industrial cooling system is included in the consumption. The cost for electricity is calculated according to Formula (2) and Formula (3).

$$O_1 = A \cdot f_1 \tag{2}$$

where

O_1 is the electricity cost, in LCY/a;

f_1 is the unit price of electricity, in LCY/(kW·h);

A is the electricity consumed by the system, in kW·h/a.

$$A = \sum_{j=1}^{n} \left(N_j \cdot P_j \cdot T_j \right) \tag{3}$$