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**Water reuse-Guideline for Water Balance Analysis**

Draft stage

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Foreword

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

The main changes are as follows:

— xxx xxxxxxx xxx xxxx

A list of all parts in the ISO ##### 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](https://www.iso.org/members.html).

Introduction

Type text.

Water reuse-Guideline for Water Balance Analysis

# Scope

This document specifies the water balance diagrams and equations, as well as the procedures and methods. This document is applicable to organizations or systems in all areas of industry, services, and agriculture, including, but not limited to, organizations such as parks, enterprises, commercial complexes, and hotels, as well as systems for circulating cooling water, irrigation, and water reuse.

# Normative references

There are no normative references in this document.

# Terms and definitions

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

water balance analysis

A process of systematically measuring, accounting, and calculating the water volume of a water-use organization or system based on the principle of water quantity and quality balance, analyzing issues, and proposing recommendations for the continuous improvement of water reuse on a gradient basis.

3.2

quantity of water intake

The amount of water obtained from various sources or pathways.

Note: Includes both conventional water intake and non-conventional water utilization.

3.3

quantity of water use

The sum of water intake and reused water within a water-use organization or system. Includes regional water usage including transmission losses.

3.4

quantity of series water

The amount of water generated or used during production processes within a designated water-use organization or system, then used in another organization or system.

3.5

quantity of recirculating water

The amount of water previously used within a designated water-use organization or system during production processes, then recirculated for the same process.

3.6

quantity of reused water

The volume of wastewater generated by a water-use organization or system, treated and reused after processing.

3.7

water loss

Water lost due to leakage, splashing, evaporation, and adsorption during water treatment, distribution, use, and discharge processes.

3.8

water-use unit

According to the characteristics of water use, water demand and the purpose of analysis, the water use area, water use system or equipment and other parts with relative independence are divided into different management or monitoring units.

3.9

quantity of water drainage

The volume of water discharged into natural water bodies or outside the water-use organization or system after completing production processes and activities (and discharged from the organization or system into wastewater systems).

3.10

quantity of water consumption

The amount of water consumed and lost in various forms during production and business activities that cannot return to surface water bodies or groundwater aquifers.

3.11

quantity of recycled water

The volume of water reused internally by water users.

Note: Includes directly reused water or water reused after treatment.

# Basic Principles

## General principles

The characteristics of a good water balance analysis rely on a number of principles:

——Clear purpose: Water balance analysis should have a clear purpose for the analysis, e.g., to assess water use efficiency, optimize water use systems, reveal water reuse pathways, identify leaks, etc. The scope of the analysis, its accuracy and data collection methods are determined according to the purpose;

——Water-use organization or system boundaries are clear: Water balance analysis should define the boundaries of water-use organization or systems. Water-use organization or system boundaries should include all water intake and discharge points, as well as water sources and discharge points associated with the organization or system;

——Accurate and reliable data: the water balance analysis shall be conducted using calibrated instruments and equipment to ensure the accuracy of the data. Use reasonable measurement methods and frequencies to ensure data reliability. Record all measurement data and conduct necessary analysis and verification;

——Water quantity and quality balance: water balance analysis should ensure that the total amount of incoming water in the organization or system is equal to the sum of the total amount of outgoing water and the water storage variable. If the water quantity is not balanced, corresponding measures should be actively taken to adjust; based on the water quality requirements of different segments, optimize the efficiency of reuse of water, which can be achieved in different ways, such as direct reuse, simple treatment reuse, or in-depth treatment reuse, etc., to ensure that the flow of water throughout the entire organization or system is efficient and free of wastage;

——Continuous improvement: Water balance analysis should be conducted periodically to track changes in water use. Based on the results of the analysis, water conservation measures, such as stepwise utilization of reused water, should be developed and implemented to continuously improve water use efficiency;

——Other principles: The water balance analysis should comply with relevant laws and regulations and standard codes. Ensure the safety and environmental protection of the analysis process. Keep the analysis results confidential and prevent information leakage.

## Water Balance Diagrams and Equations

The basic diagram of the water balance is shown in Figure 1, representing the inflow (input) and outflow (output) of water in a relatively independent or complete water organization or system, irrespective of its chemical composition and physical state. Specific requirements are as follows:

——On the left side of the rectangle, arrows indicate water input, with labels and symbols above the arrows indicating the quantity of water; On the right side of the rectangle, arrows indicate water output or consumption, with labels and symbols above the arrows indicating the quantity of water; Arrows pointing downwards represent water discharge, with labels and symbols to the right or above the arrow indicating the quantity of water.

——The upper part of the rectangle denotes recirculating water, with arrows on the right indicating recirculating water output and arrows on the left indicating recirculating water input. Labels above the horizontal part of the arrows indicate the quantity of water and symbols.

——Solid lines represent input water quantities, dashed lines represent output water quantities, and dotted lines represent recirculating water quantities.



Vt

1. Basic Diagram of Water Balance

Calculate water inputs using Formula (1) and water outputs using Formula (2), and see the water balance equation in Formula (3).

Input expression:

** （1）

Output expression:

 （2）

Water balance equation:

 （3）

where

|  |  |  |
| --- | --- | --- |
|  | *Vcy* | is the input recycled water volume, measured in cubic meters (m³); |
|  | *Vcy’* | is the output recycled water volume, measured in cubic meters (m³); |
|  | *Vi* | is the water intake volume, measured in cubic meters (m³); |
|  | *Vs* | is the input series water volume, measured in cubic meters (m³); |
|  | *Vs’* | is the output series water volume, measured in cubic meters (m³); |
|  | *Vt* | is the water usage volume, measured in cubic meters (m³); |
|  | *Vco* | is the water consumption volume, measured in cubic meters (m³); |
|  | *Vd* | is the drainage volume, measured in cubic meters (m³); |
|  | *Vl* | is the leakage and loss volume, measured in cubic meters (m³). |

# Water Balance Analysis Program and Methodology

## Work Procedure

The water balance analysis for water-use organization or systems includes four stages: preparation, measurement, summarization, and analysis & evaluation, ultimately culminating in a water balance analysis report.

## Preparation Stage

### Gather relevant documents such as water supply network diagrams, drainage network diagrams, production process flowcharts, and a list of water-use equipment to thoroughly understand the water usage links, processes, and equipment within the analysis system.

### Collect and organize the following technical water use data:

——Composition of water sources and their volume, quality, temperature, and pressure parameters;

——Drainage water volume and quality parameters;

——Water supply and drainage network diagrams;

——Water supply network materials, inlet water pressure, and quality parameters;

——Water metering equipment system diagram;

——Daily records of water supply, usage, and drainage, and related summary tables;

——Actual and planned water use in recent years;

——Water-saving technology improvements in water use in recent years;

——Recent water balance analysis documents.

### Based on the water technology data, organize, fill out, and verify basic tables such as the Water Source Situation Table, Annual Water Use Table, Operation Statistics Table, Water Metering Instruments Statistics Table, and Water Metering Instruments Equipment Table for the water-use organization or system. For table examples, see Appendix B.

### Investigate the water metering equipment availability and metering rate at each water supply and usage point of the water-use organization or system; create system diagrams for water metering equipment and water supply and drainage networks. The requirements for water meter installation rate in water-use organization or systems can be found in Table 1.

1. Requirements for Water Meter Installation Rate in Water-Use Organization or Systems

|  |  |  |  |
| --- | --- | --- | --- |
| Item | Water-use organization or system | Secondary water-use organization or system | Major water-use equipment or systems |
| Water Meter Installation Rate | 100% | ≥95% | ≥85% |
| Note 1: Major water equipment (water systems) refers to single devices or sets of water systems with a water consumption rate of not less than 1 m³/h.  2: For closed-loop water equipment or systems, where recycled water volume can be calculated based on parameters like available pump power or flow rate, separate water meter installations may not be required. | | | |

### Based on the water supply and drainage network diagrams and water use processes of the water-use organization or system, draw water usage flowcharts within the water-use organization or system, including primary water-use organization or system (level one), secondary water-use organization or system (level two), and major water-use equipment or systems (level three) water usage flowcharts.

### Develop a water balance analysis plan for the water-use organization or system. The analysis plan should include:

——Basis, purpose, content, and method of the analysis;

——Basic water usage information of the water-use organization or system;

——Water balance system, unit division, and measurement point setup;

——Task division and responsibilities for the analysis;

——List of analysis instruments and equipment;

——Water balance analysis and safety training;

——Test timing and work arrangements, etc.

### Extract technical water use data from the water-use organization or system, prepare various record and statistics blank forms, with form examples found in Appendix B. Each water-use unit can develop various records and statistical forms tailored to its specific water use processes and technologies. However, these forms should comprehensively and accurately reflect the water usage situation of the water-use organization or system, including but not limited to:

——Water Source Situation Table;

——Annual Water Use Table;

——Water Balance Analysis Statistics Table for the water-use organization or system;

——Water Balance Analysis Table for the water-use unit;

——Water Metering Instruments Equipment Situation Table;

——Water Metering Instruments Reading Record Table.

## Actual Measurement Stage

### Division of Water Use Units

Based on water usage characteristics and analysis requirements, areas with relatively independent water usage, major water-use equipment, or systems are divided into several water use units.

### Selection of Analysis Period

A stable and representative period is selected, with continuous analysis for no less than 7 days, recording at least once every 24 hours, and obtaining no fewer than 8 test data points. If the water usage pattern of the organization or system is regular, the analysis water volume period and interval can be reasonably determined based on the characteristics of the organization or system.

### Testing Parameters

#### Water volume parameters that need to be tested and calculated include: intake volume Vi, circulating water volume Vcy (Vcy'), serial water volume Vs (Vs'), consumption water volume Vco, drainage volume Vd, and loss volume Vl, etc.

#### Water quality testing at the organization's or system's main water use points, drainage points, and water reuse points should be determined based on the specific conditions of the local area and the water-use organization or system.

#### The water temperature should be measured at the supply network, inlet and outlet of circulating water, and serial water control points that require specific water temperatures.

#### Pressure testing of the supply network, steam network, circulating water network, and endpoints of the water use organization or systems should be determined based on the specific conditions of the water-use organization or system.

### Testing Methods

#### The actual water volume should be measured using methods suitable for the organization or system’s water usage characteristics, such as metering, volumetric, velocity, weir measurement, and portable ultrasonic flowmeter methods.

#### For water-use units with complete technical data and stable, reliable water metering devices such as water meters, electromagnetic flow meters, orifice flow meters, vortex street flow meters, water quantity values can be obtained by statistical analysis of historical data.

#### For water-use equipment with stable water quotas and reliable operation, the water quota and actual operational efficiency values can be used.

#### The method for calculating water consumption in open-loop cooling water systems can refer to Appendix C.

#### In conditions where water use can be halted, an appropriate time should be chosen to perform either a full static or partitioned static test. If flow readings are present on the water metering device, it indicates leakage in the network; the test duration should be no less than 30 minutes. If water usage cannot be halted, dynamic testing can be utilized when equipped with water metering devices of the same accuracy level and a 100% equipment rate, using the difference in readings between upstream and downstream metering devices to analyze network leakage.

#### Water quality testing should be based on the unit's water quality requirements to select appropriate test indicators, such as chemical oxygen demand (COD), total suspended solids (TSS), pH, conductivity, turbidity and heavy metal content. Portable water quality analyzer can be used for real-time monitoring, or laboratory analysis methods for sample analysis to ensure that the water quality meets the appropriate standards.

### Initial and Progressive Balancing

#### After analyzing each unit, an immediate primary balance of water volume should be performed for each main water-use device within the unit, and remeasurement should be done promptly for any imbalances. After all analyzing is completed, error analysis and data correction should be carried out promptly, and the water balance of the water-use organization or system should be finalized.

#### In stable production or operational conditions of the water-use organization or system, the water usage should be progressively divided into multiple water use units. Representative analysis periods should be selected, and water balance analysis should be conducted progressively from bottom to top and from local to whole.

## Summary Stage

### Water balance analysis data of the water-use organization or system are primarily recorded in tables, as shown in 5.2.7.

### Fill in the water balance analysis tables for each water use units sequentially according to the water flow process, and create corresponding water balance diagrams, ensuring one table and one diagram for each.

### Compile the water balance analysis tables of each water-use units, fill in the statistical table of water balance analysis for the water-use organization or system, and create an overall water balance diagram.

## Analysis and Evaluation Stage

### Based on the water balance analysis results of the water-use organization or system, evaluate the water level, efficiency, and processes of the water-use organization or system based on water evaluation indicators, and analyze further with parameters like water temperature, pressure, and quality.

### Based on the results of the water balance analysis analysis of the water-use organization or system, propose continuous improvement plans including:

— Revealing potential water reuse pathways;

— Improving and perfecting the daily water measurement statistics system and methods of the water-use organization or system to enhance the precision of water usage statistics;

— Analyzing and calculating the water-saving benefits and costs of related water-saving retrofit projects;

— Comparing with the water quota or the water usage level of similar water-use organization or system to propose improvement measures and explore potential water savings

1. (informative)  
     
   Symbols for Input Water Quantity, Output Water Quantity, and Recirculating Water Quantity

The symbols for input water quantity, output water quantity, and recirculating water quantity should comply with the specifications in Table A.1.

1. Symbols for input water quantity, output water quantity, and recycled water quantity in water units

|  |  |  |  |
| --- | --- | --- | --- |
| Serial Number | Symbol | Name | Category |
| 1 | Vi | quantity of water intake | quantity of conventional water source intake |
| quantity of unconventional water source intake |
| 2 | D | steam | steam |
| 3 | VSA(Z) | external steam supply | external steam supply |
| 4 | VSA | external water supply | external water supply |
| 5 | Vbr | steam condensate | steam condensate |
| 6 | Vd | quantity of water drainage | quantity of external water drainage |
| quantity of cooling water drainage |
| quantity of boiler blowdown |
| 7 | Vco | quantity of water consumption | quantity of water consumption |
| quantity of cooling water makeup |
| 8 | Vl | quantity of water loss | quantity of water loss |
| 9 | Vcy | quantity of recycled water | quantity of recirculating water |
| 10 | Vs | quantity of series water |
| 11 | VPr | quantity of reused water |
| 12 | Vcr | quantity of cooling water | quantity of direct cooling water |
| 13 | Vdr | quantity of indirect cooling water |
| 14 | Vz | quantity of once through cooling water |

1. (informative)  
     
   **Formats for Water Balance Analysis Tables**

The formats for the water balance analysis tables are presented from Table B.1 to Table B.6.

1. Water Source Situation

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Serial Number | Water Source Category | Design Capacity  m3/d | Actual Capacity  m3/d | Water Pipeline Specifications × Quantity  mm | pH value | Water Temperature  ℃ | Turbidity  NTU | Hardness（as CaCO3）  mg/L | Other | Main Usage | Planned Water Usage Indicators  m3/a | Remarks |
|  |  |  |  |  |  |  |  |  |  |  |  |  |
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|  |  |  |  |  |  |  |  |  |  |  |  |  |
| Total |  |  |  |  |  | | | | | | | |
| Note: 1."Water Source Category" column: When a water-use organization or system has multiple water sources, they are reported separately as conventional and unconventional sources. Conventional sources include surface water, groundwater, tap water, purchased softened water, purchased steam, etc. Unconventional sources include seawater, brackish water, urban sewage reclaimed water, mine water, etc.  2.When there are multiple water pipelines, list their diameters sequentially.  3.The remarks column should include water resource fees, water production costs, pipeline materials, installation lifespan, pipeline specifications, and pipeline lengths. | | | | | | | | | | | | |

1. Annual Water Usage

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Year | Water Intake Quantity  10,000 m³ | | | Direct Cooling Recirculating Water Volume  10,000 m³ | Indirect Cooling Recirculating Water Volume  10,000 m | Other Recirculating Water Volumes  10,000 m | Steam Condensate Reuse Volume  10,000 m | Reused Water Volume  10,000 m | Other Series WaterVolumes  10,000 m | Drainage Water Volume  10,000 m | Leakand Loss Water Volume  10,000 m | Water Consumption Volume  10,000 m | Water Intake per Unit of Product  10,000 m | Recycled Rate  % | Direct Cooling Water Circulating Rate  % | Indirect Cooling Water Circulating Rate  % | Steam Condensate Reused Rate  % | Wastewater Reused Rate  % | Leakage Rate  % | Compliance Discharge Rate  % | Unconventional Water Replacement Rate  % | Other |
|  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| Note 1: "Water Intake Quantity" column: Fill in the blank spaces according to different water source categories of this water-use organization or system.  2: If there is once through cooling water usage in the water consumption, please add the once through cooling water usage column accordingly. | | | | | | | | | | | | | | | | | | | | | | |

1. Water Balance Analysis Statistics Table for the Water-use Organization or System

TDate: \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_　　　　　　　　　　　　　　　　 　　 Unit: m3/d

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Serial Number | Water-use unit Name | Water Intake | | | | | | | Recycled Water Volume | | | | | | Other Water Volumes | | |
| Conventional Source | | | | Unconventional Source | | | Direct Cooling Recirculating Water Volume | Indirect Cooling Recirculating Water Volume | Other Recirculating Water Volumes | Steam Condensate Reuse Volume | Reused Water Volume | Other Series WaterVolumes | Drainage Water Volume | Leakage and Loss Water Volume | Water Consumption Volume |
|  |  |  |  |  |  |  |
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| Total Water Quantity | |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| Calculation of Water Intake | |  | | | | | | | | | | | | | | | |
| Total Water Usage Calculation | |  | | | | | | | | | | | | | | | |
| Note 1: The "Water Intake" column should be filled according to the water source category and name of the water-use organization or system.  2: The average values from the water balance analysis tables of each water-use unit are included in this statistical table. | | | | | | | | | | | | | | | | | |

1. Water Balance Analysis Table for Water-use Units

Unit: m3/d

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Date | Process or Equipment Name | Input Water Volume | | | | | | | | | | | | Output Water Volume | | | | | | | | | | |
| Water Intake | | | | Recirculating Water | | | Series Water | | | | | Recirculating Water | | | Series Water | | | | | Drainage Water Volume | Leakage and Loss Water Volume | Water Consumption Volume |
|  |  |  |  | Direct Cooling Recirculating Water | Indirect Cooling Recirculating Water |  | Steam Condensate Reuse Volume | Resued Water |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| Note: Blank spaces for water intake, circulating water, and series water should be completed based on the situation of each water-use unit, with reference to the entries in the table. | | | | | | | | | | | | | | | | | | | | | | | | |

1. Water Metering Instruments Equipment Situation Table

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Water Metering Equipment | Item | Water-use organization or system | Secondary water-use organization or system | Major water-use equipment or systems | Total |
| Required Quantity |  |  |  |  |
| Equipped Quantity |  |  |  |  |
| Equipment Rate (%) |  |  |  |  |
| Other Metering Equipment | Item | Required Quantity | Equipped Quantity | Equipment Rate (%) |  |
|  |  |  |  |  |
| Note |  | | | | |

1. Water Metering Instruments Reading Record

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Serial Number | Management Number | Location | Water Source Type | Measurement Range | Model/Specifications | Accuracy Grade | Factory Number | Installation Pipe Diameter (mm) | Verification/Calibration Interval | Status (Qualified/For Use/Discontinued) |
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1. (informative)  
     
   Open-Loop Cooling Water System Water Consumption Calculation
   1. Open-Loop Cooling Water System Water Consumption Calculation

To calculate the water consumption of an open-loop cooling water system, you can use the following formula:

………………………………………（C.1）

where

*Vco,cold*——Water consumption of the open-loop cooling water system (in cubic meters per hour, (m3/h))

*F*——Blowdown water volume (in cubic meters per hour, (m3/h))

*G*——Evaporative loss volume (in cubic meters per hour, (m3/h))

* 1. Estimation of Blowdown Water Volume in Open-Loop Cooling Water Systems

When it's difficult to measure the blowdown water volume directly, it can be estimated using:

……………………………………………（C.2）

where

*F*——Blowdown water volume (in cubic meters per hour, (m3/h))

*R*——Circulating cooling water volume (in cubic meters per hour, (m3/h))

*K*——Blowdown loss coefficient (selected based on cooling structure type, as detailed in Table C.1)

1. **Blowdown Loss Coefficients (K)**

|  |  |  |  |
| --- | --- | --- | --- |
| Cooling Structure Type | Mechanical Ventilation Style Cooling Tower (With Water Collector) | Wind Tunnel Style (Hyperbolic) Cooling Tower | |
| With Water Collector | Without Water Collector |
| *K* | 0.2％～0.3％ | 0.1％ | 0.3％～0.5％ |
| Note: Refer to relevant standards for the drift loss coefficient of other types of cooling towers. | | | |

* 1. Calculation of Evaporative Water Volume in Open-Loop Cooling Water Systems

The evaporative water volume can be calculated using:

………………………………………（C.3）

where

*G*——Evaporative loss water volume (in cubic meters per hour, (m3/h))

*R*——Circulating cooling water volume (in cubic meters per hour, (m3/h))

*S*——Evaporation loss coefficient (varies by temperature, see Table C.2)

**—— Difference in temperature of cooling water inlet and outlet (in degrees Celsius, °C)

1. **Evaporation Loss Coefficients (S)**

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Temperature  °C | －10 | 0 | 10 | 20 | 30 | 40 |
| *S/*（1/℃） | 0.0008 | 0.001 | 0.0012 | 0.0014 | 0.0015 | 0.0016 |

Bibliography

[1] ISO #####‑#, *General title — Part #: Title of part*

[2] ISO #####‑##:20##, *General title — Part ##: Title of part*