INTERNATIONAL STANDARD

ISO 20468-3

First edition
2020-06

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

Part 3: **Ozone treatment technology**

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

Partie 3: Technique de traitement à l'ozone

Reference number
ISO 20468-3:2020(E)

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Published in Switzerland

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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 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 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.

Introduction

The rapidly growing global market for water reuse technologies inevitably demands standards which are applicable on a world-wide basis. Many regions in the world are facing water shortages, and there is great interest in the use of technologies that can treat wastewater and make the reuse water available for a wide range of reuse applications that can satisfy non-potable water demands, thereby conserving precious potable water supplies. Simultaneously, the implementation of water reuse schemes is raising public and regulatory concerns regarding potential human health, environmental and societal impacts. This has led to an increasing need to specify various aspects of water reuse projects and there is a growing need on behalf of regulators, reuse technology suppliers, and users of those technologies for international standardization. Without ISO water reuse standards, a great number of opportunities for sustainable development based on water reuse will be lost.

Standardization needs to include objective specification and evaluation of levels of service and water reuse system performance dependability, including safety, environmental protection, and resilience and cost-effectiveness considerations. Hence, appropriate methods are needed to evaluate the performance of water reuse systems.

The performance of treatment technologies for water reuse, inter alia, should be evaluated properly in order to select the most appropriate technologies in an unbiased way to achieve the objectives of the water reuse project. Despite considerable research and development on treatment technologies, such scientific knowledge is largely held within commercial interests. Given less than ideal communication between producers and users of reuse technologies with regards to treatment performance, clear information as to what to measure on the one hand and what level of performance is required on the other is currently missing. To address these challenges, this document provides methods and tools, which can be accepted by most stakeholders, to evaluate the performance of treatment technologies for water reuse systems from multitude of applications.

Based on the discussion in the meetings of ISO/TC 282/SC 3, ISO 20468-1 titled “Guidelines for performance evaluation of treatment technologies for water reuse systems — Part 1: General” has been developed to establish the standard of generic aspects for performance evaluation. In this context, this document stipulating specific ways of performance evaluation of ozone treatment technology, commonly known as ozonation, for water reuse systems, based on ISO 20468-1 as the generic standard, is established herein.

Ozone (O_3) is an allotrope of oxygen (O_2) and is the second strongest oxidiser after fluorine. Its strong oxidative decomposition power makes it effective as a disinfectant and in removal of oxidizable constituents in water. There are cases where ozonation at high doses is used to remove micro-pollutants in wastewater for environmental protection.

In various types of water reuse systems, the disinfection and the removal of colour and odour are essential. Then it can be said that ozone technology plays an important role to improve these water qualities for the purpose of water reuse, working well with secondary or tertiary treated water as shown in Figure 1 of ISO 20468-1:2018 and in Annex A.

In this guideline, the dedicated features to ozone technology for water reuse are described and the requirements for proper and accurate evaluation of ozone system for water reuse are offered.

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

Part 3: Ozone treatment technology

1 Scope

This document specifies performance evaluation methods of treatment technology using ozone for water reuse systems. It deals with how to measure typical parameters which indicate performance of ozone treatment technology.

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 following 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 https://www.iso.org/obp

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

3.1 Terms and definitions

3.1.1
ambient ozone concentration
concentration of ozone existing in the air or surrounding the ozone treatment apparatus

3.1.2
exhaust residual ozone concentration
ozone concentration (3.1.6) at the outlet of an off-gas ozone treatment unit

3.1.3
generated ozone amount
mass of ozone generated in a unit time

3.1.4
generated ozone concentration
ozone concentration (3.1.6) in the gas phase at the outlet of an ozone generator

3.1.5
off-gas ozone concentration
ozone concentration at the outlet of an ozone contactor

3.1.6
ozone concentration
volume, mass or mole of ozone in a unit volume or mass of gas or liquid

3.1.7
ozone concentration monitor
instrument capable of measuring ozone concentration in samples continuously

3.1.8
ozone demand
amount of ozone consumed to oxidize material in water

3.1.9
ozone dose
mass of ozone injected into a unit volume of water

Note 1 to entry: Ozone dose is expressed in units of mass-per-volume concentration (g/m^3 or mg/l).

3.1.10
residual ozone concentration
dissolved ozone concentration measured after a given contact time

Note 1 to entry: It is expressed in mg/l.

3.1.11
transferred ozone dose
mass of ozone applied into a unit volume of water

Note 1 to entry: Transferred ozone dose is expressed in units of mass-per-volume concentration (g/m^3 or mg/l).

3.2 Abbreviated terms

CT product of residual concentration and time

EPDM ethylene propylene diene monomer

FRP fiber-reinforced plastic

GHG greenhouse gases

LOX liquid oxygen

LRVs log-reduction values

PTFE polytetrafluoroethylene

SS stainless steel

UV ultraviolet

4 System configuration

4.1 General

The ozone system for water treatment consists of:

— a feed gas supply unit

— an ozone generation unit

— an ozone contact unit

— an off-gas ozone treatment unit

Depending on the water treatment efficiency and performance to be achieved, pre-treatment and/or post-treatment can be added to the ozone system. For example, sand filtration as the typical pre-treatment process to remove suspended impurities including ozone scavengers and inorganic matter enhances treated water quality and reduces ineffective ozone consumption. On the other hand, post-treatment such as biological activated carbon process removes residual particles and dissolved matter which are not decomposed and/or are generated as by-products during ozonation. In order to retain bactericidal effects after ozonation, post disinfection such as chlorine disinfection can be added.

4.2 Ozone system for water treatment

4.2.1 Feed gas supply unit

The feed gas supply unit is using either air or oxygen gas to the ozone generation unit. An air-fed ozone system uses compressed air directly from the atmosphere. An oxygen-fed ozone system uses LOX or concentrated oxygen fed by an oxygen concentrator. Typically, the oxygen concentrator increases oxygen concentration by adsorbing nitrogen selectively from air.

4.2.2 Ozone generation unit

The ozone generation unit typically consists of:

— ozone generator(s)

— a power supply

— a cooling system

Corona discharge is currently the most common ozone generation method.

4.2.3 Ozone contact unit

The ozone contact unit typically consists of:

— an ozone dissolution system

— ozone contactor(s)

The ozone contactor is a vessel where ozone is dissolved in water and reacts with target substance(s), followed by the ozone dissolution system which dissolves ozone gas in water. Mass transfer of ozone is a critical aspect of water ozonation. Dissolution devices include bubble diffusion, down flow tube injection, venturi injection, radial diffuser, static mixers and mechanical agitation. These applicable dissolution devices should be selected depending on the space limitation for system installation, electric power charge and ozone transfer efficiency. The method of ozone gas dissolution used also depends on system design and method of ozone generation used.

4.2.4 Off-gas ozone treatment unit

Since ozone is a very strong oxidant, any unreacted ozone in the off-gas can be harmful to the environment and endanger human health. Consequently, it shall be converted to oxygen and neutralized before the off-gas is released to atmosphere.

The off-gas ozone treatment unit typically consists of an off-gas ozone destruction unit and an off-gas ozone suction unit. The off-gas ozone suction unit withdraws off-gas ozone from the ozone contactor and draws it into the off-gas ozone destruction unit. The off-gas ozone destruction unit converts ozone residual exhausted from the ozone contactor to oxygen by using such methods as activated carbon, catalyst media and heat, or combination of heat and catalyst media.

4.2.5 Ozone measuring system

Various types of ozone monitors are available for measuring ozone concentrations. The typical configuration of ozone treatment system as well as the monitoring points of ozone concentration are shown in Figure 1.

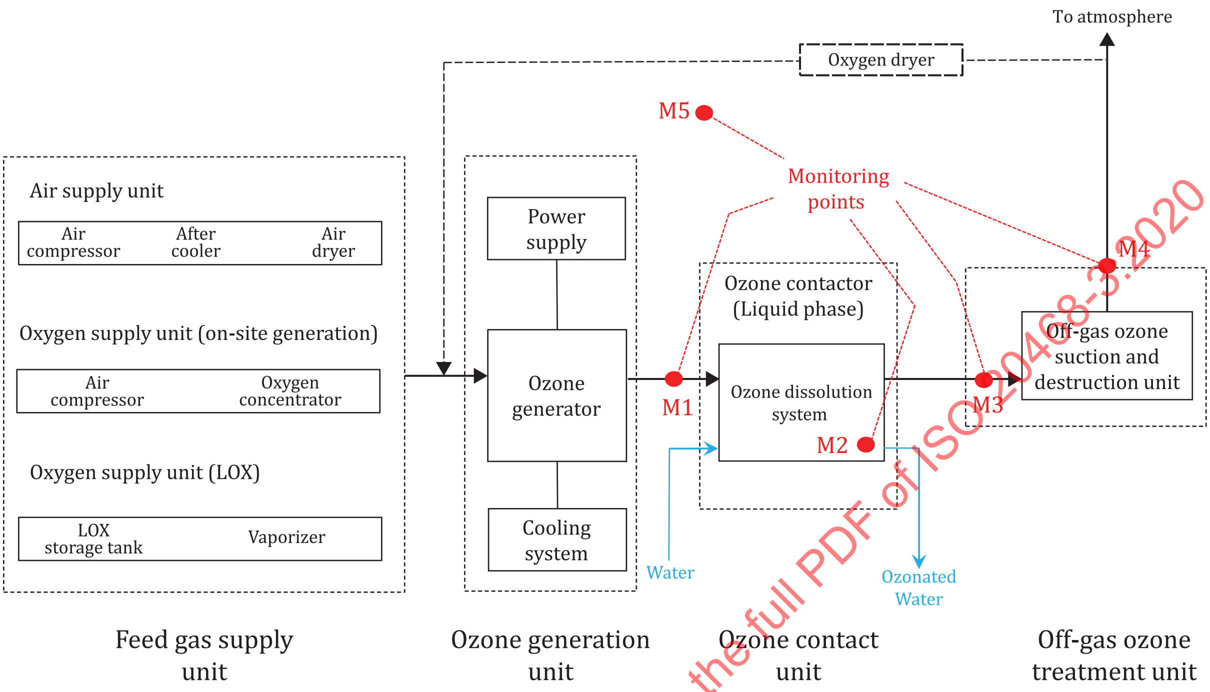

Figure 1 — Typical configuration of ozonation system and ozone concentration monitoring points

The high concentration ozone monitor, residual ozone concentration monitor and off-gas ozone concentration monitor are installed to measure ozone concentration at key locations in the ozonation system for the purpose of controlling ozone generation and dose. Specific descriptions about ozone generation control methods are shown in Annex D.

The exhaust and ambient ozone monitors measure ozone concentrations to verify safe operating conditions. The control system works automatically for system shutdown or stopping ozone production if necessary.

5 Principles and general guidelines for performance evaluation

5.1 General

Based on the principles and general guidelines for performance verification described in ISO 20468-1:2018[1], this document also specifies two kinds of performance requirements:

— functional requirements

— non-functional requirements

5.2 Functional requirements

5.2.1 General

Functional requirements consist of two parts; water quality based performance and process-based performance, both of which strongly influence the conformity of produced water quality to water reuse regulations and related standards.

Water quality based performance for ozone treatment includes the potential reduction of disease causing microorganisms that can be present and the removal of specific constituents such as colour and odour (Annex A). They are generally expressed as a logarithmic-scale reduction and a residual constituent concentration in the treated reuse water, respectively. On the other hand, ultra-violet absorbance and ultra-violet transmission can be used as surrogate indicators to check the removal efficacy of dissolved organic carbon. These water quality parameters and indicators should be in accordance with the water reuse regulations and standards stipulated in respective countries (examples in Annex B).

The reduction in, or residual concentration of, *Escherichia coli*, enterococci bacteria, thermo-tolerant coliform bacteria and total coliform bacteria can be used as potential indicators of microorganisms to assess the effectiveness of ozone disinfection in reducing pathogenic microorganisms that can be present in the source water. Quantification of these microbial indicators can be carried out by using analysis methods stipulated in ISO 6222:1999[2].

The reduction of concentration in pharmaceutical and personal care products and other contaminants of emerging concern, as well as colour and odour, can also be functional requirements for some reuse applications. Colour and odour can be quantified by the methods stipulated in Standard Methods for the Examination of Water and Wastewater[3]. The analytical methods and water quality parameters should be required by the regulations in respective countries.

The CT approach could be used for wastewater ozonation but is much less relevant than in drinking water. It is noted that a sufficient ozone dose to achieve the targeted water quality should be transferred to the effluent resulting in detection of residual ozone concentration.

Ideally, supplied ozone should be used completely in the reactor. However, if the off-gas ozone concentration indicates zero, it is practically impossible to correctly estimate transferred ozone dose. Therefore, the concentration of off-gas ozone before the destruction should be as low as possible by providing just enough amount of ozone for treatment.

On the other hand, process-based performance for ozone treatment is concerned with the functional performance of main units of ozone treatment system such as ozone generators and contactors and is assessed by monitoring the ozone concentration in different points (Annex C and D). The dependability of these units is also important as a part of process-based performance since failure in ozone generators and/or contactors can lead to releasing insufficient transferred ozone into water.

Failure in off-gas ozone treatment units can raise an issue of undestroyed ozone gas leaking to rooms, with the possibility of personnel injury and/or property damage in the worst-case situation. Therefore, the dependability of off-gas ozone treatment units should be included into non-functional requirements.

5.2.2 Performance evaluation procedures

5.2.2.1 STEP1 — Setting performance criteria and objectives

An ozone treatment system is expected to improve water quality parameters such as *E. coli*, thermo-tolerant coliforms, colour and odour. The water quality standards for these parameters as water-quality based performance criteria should be set for the purpose of water reuse.

Those reuse water quality parameters are standardized in some countries for landscape, amenity and other purposes, as illustrated in Annex B.

The values of the reclaimed water quality parameters should be some of the values that presented in Annex A of ISO 20761:2018[4].

In addition, to ensure the functionality and reliability of water reclamation processes for pathogen control in the case of high risk of exposure, the health risk management strategy can also include targets for log-reduction values (LRVs). Other water quality parameters can be relevant for specific non-potable water applications, such as those described in ISO 16075-1, ISO 16075-2, ISO 16075-3:2015, ISO 16075-4:2016[5] for irrigation. Further information on the risk assessment and management approach can be found in ISO 20426:2018[6], ISO 20761:2018 and in Australian Guidelines for Water Recycling[7].

On the other hand, in order to meet the target water quality consistently, the ozone system is required to be operated properly. From this viewpoint, the parameters of operational conditions should be included into process-based performance indicators.

5.2.2.2 STEP 2 — Performance evaluation

Water quality based performance of ozone treatment system for water reuse can be evaluated by periodically measuring residual concentrations of the target constituents. The residual concentrations should be assessed frequently enough to ensure operating parameters and regulatory and aesthetic reuse water quality objectives are consistently met. The monitoring program and sampling frequency should be in accordance with the standards in respective countries.

At the same time, it is important to measure the ozone concentration. Figure 1 shows the typical configuration of ozone treatment system as well as monitoring points of ozone concentration as operating conditions; ozone concentration at M1 and M3 points should be monitored as shown in Annex C to effectively evaluate the treatment system performance. When those concentrations meet the target values, it is confirmed that the appropriate amount of ozone is supplied and consumed in the ozone contactor to achieve the functional requirement on water quality.

Furthermore, the following parameters are also expected to function well as process-based performance indicators:

a) Generated ozone amount

Generated ozone amount is calculated by the following formula.

(Generated ozone amount) = (Generated ozone concentration) × (Ozone gas flow rate)

The value of generated ozone amount should be larger than ozone demand.

b) Ozone dose

Ozone dose is calculated by ozone gas flow rate, water flow rate and generated ozone concentration.

(Ozone dose) = (Ozone gas flow rate) × (Generated ozone concentration) / (Water flow rate)

Ozone dose should be controlled to provide sufficient amount of ozone to achieve targeted water quality.

c) Transferred Ozone dose

Transferred ozone dose is calculated by ozone gas flow rate, water flow rate, generated ozone concentration and off-gas ozone concentration.

(Transferred ozone dose) = (Ozone gas flow rate) × (Generated ozone concentration – Off-gas ozone concentration) / (Water flow rate)

In case that off-gas ozone concentration is sufficiently low, ozone dose would be equal to transferred ozone dose.

d) Mass transfer efficiency

Mass transfer efficiency shows how much ozone is transferred into water out of generated ozone amount. Specifically, it is calculated by generated ozone concentration and off-gas ozone concentration.

(Mass transfer efficiency) = (Generated ozone concentration – Off-gas ozone concentration) / (Generated ozone concentration) × 100

This value is normally between 80 to less than 100 %, depending on dissolution methods.

5.2.2.3 STEP 3 — Diagnosis of causes for unsatisfactory performance

If one or more operating objectives or water quality requirements are not being attained, the ozone system may be malfunctioning, and corrective measures are required. Possible failures may be decreased ozone generation or degradation of mass transfer efficiency:

a) Decrease in ozone generation

- — check whether ozone concentration monitor (M1) works properly.
- — check feed gas quality (Oxygen purity, dew point) and flow rate.
- — check the ozone generator and/or the control panel whether any error messages are indicated.

b) Degradation of mass transfer efficiency

- — check damage on diffusers (in case of diffusers used).
- — check failure on a booster pump (in case of injectors used).
- — check damage on injectors or static mixers (in case of injectors used).
- — check whether the ratio of gas flow rate to water flow rate is being maintained within the required range of ratio depending on the dissolution devices.

In the case that no failures are found on ozone generation and mass transfer efficiency:

- — check the water quality and quantity under treatment and adjust the ozone supply to satisfy the ozone demand.
- — check upstream secondary and tertiary treatments to improve the water quality prior to ozonation to satisfy the design bases.

5.3 Non-functional requirements

5.3.1 Performance characteristics

The following two performance characteristics are provided.

a) Environmental and economic key factors (5.3.2)

b) Safety requirements (5.3.3)

5.3.2 Environmental and economic key factors

Environmental and economic factors for an ozonation system include:

- — Electric power consumption for oxygen and ozone generation.
- — Electric power consumption for ozone transfer, if needed.
- — Electric power consumption for the off-gas ozone destruction/treatment unit.
- — Supplied oxygen consumption.

These key factors are closely connected to producing GHG (e.g. CO_2) and should therefore be managed to reduce the GHG direct and indirect emissions (see ISO 20468-2:2019[8] for GHG emission calculation).

5.3.2.1 Electric power consumption

Daily ozone demand depends on the load of substances to be treated. Then, taking into account annual load fluctuations, the annual power consumption should be calculated by providing ozone demands for low, middle and high loads, for example, multiplying them by the respective number of days and summing them up.

Based on the daily ozone demand, the power consumption of a feed gas supply unit, an ozone generation unit, an ozone contact unit and an off-gas ozone treatment unit are calculated to find a daily operating cost.

Regarding ozone transfer, electric power consumption for injection pumps, motorized valves should be summed up. In addition, regarding off-gas treatment, electric power consumption to run heaters and suction blowers should be included.

5.3.2.2 Oxygen consumption

The amount of feed oxygen gas depends on gaseous ozone concentration and the ozone demand. Then, the annual oxygen consumption is calculated by seasonal oxygen consumption which are computing by dividing ozone demands for low, middle and high loads by feed-gas ozone concentration, multiplying them by the respective number of days and summing them up.

5.3.3 Safety requirements

Each unit described in Clause 4 is essential to the proper operation and performance of an ozone system. As each unit has unique functions and operations, there can be a wide range of causes for system failure. From the viewpoint of protecting human health and safety, however, ozone gas leak is the most serious problem and therefore, the safety of ozone treatment system should be evaluated by the following methods.

a) Usage of ozone resistant materials for piping and fittings

Evaluate whether ozone resistant materials such as 304 SS, 316L SS, EPDM, PTFE and FRP are used, for the parts and locations in a treatment apparatus where ozone gas and/or ozonated water comes into contact with, such as equipment, pipes, valves, sensors, joints, instruments, sealants and gaskets. See JIS B 9946[9].

b) Safety and equipment protection

Appropriate safety measures, which may include emergency shutdown, shall be implemented when ambient ozone is detected in the ozone water treatment system and its surroundings. If the concentration raises higher than a certain level, ozone generation should be stopped immediately and automatically, and alarm to operators and maintenance personnel.

In order to confirm the performance of off-gas ozone treatment unit and ozone leakage from all units, exhaust residual ozone concentration (M4) and/or ambient ozone concentration (M5), as shown in Figure 1 and Annex C, shall be measured. The need for the monitoring shall be determined by the parties involved, and appropriate measurement methods shall be selected. Thus, M4 and M5 are safety and equipment protection points rather than the process monitoring points.

Evaluate whether ozone concentration is monitored at the appropriate points in the treatment apparatus and its surroundings, in order to check the operational state of a total ozone treatment system. In addition, evaluate whether the ozone monitors and detectors equipped in a treatment apparatus satisfy the appropriate specifications. JIS B 9946 is cited as a reference.

c) Maintenance and calibration

Evaluate whether the following items are satisfied:

— maintenance schedule is prepared and carried out.

— maintenance parts are stocked.

Inspection and calibration of the treatment apparatus, ozone monitors and detectors are included into maintenance work.

Annex A
(informative)

Main treatment technologies and target constituents for water reuse

Table A.1 indicates main treatment technologies and target constituents after BOD removal for water reuse systems. It is summarized by focusing on typical technologies for advanced treatment and disinfection described in ISO 20468-1:2018[8] with related functions required for water reuse.

Table A.1 — Main treatment technologies and target constituents/parameters (After BOD removal)

Required functions		Separation	Disinfection			Desalination	Oxidation or others		
Target constituents /parameters Technologies		Turbidity or TSS	Pathogens			Conductivity or TDS	Colour	Odour	POPS (Persistent organic pollutants)
			Bacteria	Viruses	Protozoa				
Membrane filtration	MF	✓	✓		✓				
	UF	✓	✓	✓	✓				
	NF/RO		✓	✓		✓	✓	✓	✓
Ion exchange	Resin					✓	✓		
	Membrane					✓			
UV			✓	✓	✓				
Ozone			✓	✓	✓		✓	✓	✓
AOPs			✓	✓	✓		✓	✓	✓

Annex B
(informative)

Reuse water quality parameters

Reuse water quality parameters for landscape, amenity and other purposes are standardized in some countries, as illustrated in Table B.1 through Table B.5.

Table B.1 — Water quality standard for water reuse (Japan)[10]

	Location where this standard is applied to	Flushing water	Sprinkling water	Water for landscape use	Water for recreational use
Escherichia coli	Exit of treatment facility for reuse	Not detectable[a)]	Not detectable[a)]	Refer to remarks[a)]	Not detectable[a)]
Turbidity		(Control target value) 2 degrees or less	(Control target value) 2 degrees or less	(Control target value) 2 degrees or less	2 degrees or less
pH		5,8 to 8,6	5,8 to 8,6	5,8 to 8,6	5,8 to 8,6
Appearance		Should not be distasteful	Should not be distasteful	Should not be distasteful	Should not be distasteful
Chromaticity		—[b)]	—[b)]	40 degrees or less[b)]	10 degrees or less[b)]
Odour		Should not be distasteful[c)]	Should not be distasteful[c)]	Should not be distasteful[c)]	Should not be distasteful[c)]
Residual Chlorine	Responsibility demarcation point	(Control target value) Free residual chlorine: 0,1 mg/l or more; or combined residual chlorine: 0,4 mg/l or more[d)]	(Control target value[d)]) Free residual chlorine: 0,1 mg/l or more; or combined residual chlorine: 0,4 mg/l or more[e)]	Refer to remarks[d)]	(Control target value[d)]) Free residual chlorine: 0,1 mg/l or more; or combined residual chlorine: 0,4 mg/l or more[e)]
Facility Standards	—	Sand filtration facility or facility with function equivalent to sand filtration or better should be installed	Sand filtration facility or facility with function equivalent to sand filtration or better should be installed	Sand filtration facility or facility with function equivalent to sand filtration or better should be installed	Precipitation, sand filtration facility or facility with function equivalent to precipitation, sand filtration or better should be installed

Table B.1 *(continued)*

	Location where this standard is applied to	Flushing water	Sprinkling water	Water for landscape use	Water for recreational use
Remarks	—	a) Sample water amount should be 100 ml. (designated enzyme substrate culture medium method) b) Based on the intent of the users, standard values should be set as required. c) Based on the intent of the users, the odour intensity should be set as required. d) In cases where additional chlorine injected at the destination, the value may be based on individual agreement, etc.	a) Sample water amount should be 100 ml. (designated enzyme substrate culture medium method) b) Based on the intent of the users, standard values should be set as required. c) Based on the intent of the users, the odour intensity should be set as required. d) In cases where the residual effect of disinfection is not especially required, this value is not adopted. e) In cases where additional chlorine is injected at the destination, the value may be based on individual agreement, etc.	a) The present standard [coliform bacteria count: 1 000 CFU/100 ml is adopted pro tempore b) Based on the intent of the users, added standard values should be set as required. c) Based on the intent of the users, the odour intensity should be set as required. d) This value should not be stipulated, as treatment other than chlorine disinfection is carried out case by case from the viewpoint of ecological correctness and as the water may be used according to the prerequisite that humans should not touch it.	a) Sample water amount should be 100 ml. (designated enzyme substrate culture medium method) b) Based on the intent of the users, added standard values should be set as required. c) Based on the intent of the users, the odour intensity should be set as required. d) In cases where the residual effect of disinfection is not especially required, this value is not adopted. e) In cases where additional chlorine is injected at the destination, the value may be based on individual agreement, etc.

Table B.2 — Water quality standard for water reuse (India)[11]

	Parameter	Toilet flushing	Fire protection	Vehicle Exterior washing	Non-contact impoundments	Landscaping, Horticulture & Agriculture			
						Horticulture, Golf course	crops		
							Non edible crops	Crops which are eaten	
								raw	cooked
1	Turbidity (NTU)	<2	<2	<2	<2	< 2	AA	< 2	AA
2	SS	nil	nil	nil	nil	nil	30	nil	30
3	TDS	2100							
4	pH	6.5 to 8.3							
5	Temperature °C	Ambient							
6	Oil & Grease	10	nil	nil	nil	10	10	nil	Nil
7	Minimum Residual Chlorine	1	1	1	0.5	1	nil	nil	nil
8	Total Kjeldahl Nitrogen as N	10	10	10	10	10	10	10	10
9	BOD	10	10	10	10	10	20	10	20
10	COD	AA	AA	AA	AA	AA	30	AA	30
11	Dissolved Phosphorous as P	1	1	1	1	2	5	2	5
12	Nitrate Nitrogen as N	10	10	10	5	10	10	10	10
13	Faecal Coliform in 100 ml	Nil	Nil	Nil	Nil	Nil	230	Nil	230
14	Helminthic Eggs / litre	AA	AA	AA	AA	AA	<1	<1	<1
15	Colour	Colourless	Colourless	Colourless	Colourless	Colourless	AA	Colourless	Colourless
16	Odour	Aseptic which means not septic and no foul odour							

All units in mg/l unless specified; AA: as arising when other parameters are satisfied;
A tolerance of plus 5% is allowable when yearly average values are considered.

Table B.3 — Suggested treated wastewater quality according to chemical, physical and biological parameters[12]

Cat.	Type of treated wastewater	BOD[b), j)]		TSS		Turbidity[c)]		Thermo-tolerant coliforms[d)]		Intestinal nematodes[e), l)]		Potential uses without barriers	Potential corresponding treatment
		mg L^{-1}		mg L^{-1}		NTU		no./100 ml		Egg L^{-1}			
		Ave.	Max	Ave.	Max	Ave.	Max	95 %ile	Max	Ave.	Max		
A	Very high quality treated wastewater[d)]	≤5 mg/L	10 mg/L	≤5 mg/L	10 mg/L	≤2	5	≤10 or below the detection limit	100	—	—	Unrestricted urban irrigation [l)] and agricultural irrigation of food crops consumed raw	Secondary[f)], contact filtration or membrane filtration[g)] and disinfection[h)]

NOTE: With each type of treated-wastewater quality, the use of a higher quality treated wastewater is always possible.

a) The recommended limits are elaborated on the basis of international regulations, e.g. WHO (2006) and USEPA (2012) and apply to the reclaimed water at the outlet of the treatment facility. After storage in open reservoirs and for spray or localized irrigation, additional filtration could be necessary. Sampling frequency and the calculation of the average values are given in ISO 16075-4.

b) BOD is determined with a five-day test.

c) Continuous measurement of the turbidity can be implemented. The average value should be based on a 24-time period. If suspended solids are used in lieu of turbidity, the average TSS should not exceed 5 mg/L. If membrane filtration is used for treatment, the turbidity should not exceed 0,2 NTU.

d) Residual chlorine dosage between 0,2 mg/L and 1 mg/L that measured after 30 min contact time can be necessary for high and very high quality treated wastewater. If other method of disinfection achieving is used, it should also be monitored.

e) Intestinal nematodes (helminth eggs) might not be routinely monitored if it was demonstrated that the number of helminth eggs in untreated wastewater is consistently below 10 eggs/L.

f) Secondary treatment includes activated sludge, trickling filters, rotating biological contactors, biofilters, bioreactors, sequence batchreactors, etc.

g) Filtration includes microscreening, cartridge filtration, high rate sand filtration, dual media filtration, cloth filters, and disc filters without or with chemical addition (contact filtration) as well as membrane processes including membrane bioreactors.

h) Disinfection includes UV irradiation, ozonation, chlorination, or other chemical, physic chemical, or membrane processes.

i) High rate clarification includes coagulation, flocculation, and lamella settling.

j) Well-designed stabilization pond systems can meet coliform limits without additional disinfection. The soluble BOD values are considered.

k) The physical-chemical parameters (BOD, TSS) could be adjusted according to local wastewater treatment regulations with the possible addition of COD.

l) If there is a risk of aerosolization, the Legionella spp should be less than 1 000 CFU/L for Greenhouses.

Table B.3 *(continued)*

Cat.	Type of treated wastewater	BOD[b), j)]		TSS		Turbidity[c)]		Thermo-tolerant coliforms[d)]		Intestinal nematodes[e), l)]		Potential uses without barriers	Potential corresponding treatment
		mg L−1		mg L−1		NTU		no./100 ml		Egg L−1			
		Ave.	Max	Ave.	Max	Ave.	Max	95 %ile	Max	Ave.	Max		
B	High quality treated wastewater[d)]	≤10 mg/L	20 mg/L	≤10 mg/L	25 mg/L	—	—	≤200	1 000	—	—	Restricted urban irrigation and agricultural irrigation of processed food crops	Secondary[f)], filtration[g)] and disinfection[h)]
C	Good quality treated wastewater	≤20 mg/L	35 mg/L	≤30 mg/L	50 mg/L	—	—	≤1 000	10 000	≤1	—	Agricultural irrigation of non-food crops	Secondary[f)] and disinfection[h)]

NOTE: With each type of treated-wastewater quality, the use of a higher quality treated wastewater is always possible.

a) The recommended limits are elaborated on the basis of international regulations, e.g. WHO (2006) and USEPA (2012) and apply to the reclaimed water at the outlet of the treatment facility. After storage in open reservoirs and for spray or localized irrigation, additional filtration could be necessary. Sampling frequency and the calculation of the average values are given in ISO 16075-4.

b) BOD is determined with a five-day test.

c) Continuous measurement of the turbidity can be implemented. The average value should be based on a 24-time period. If suspended solids are used in lieu of turbidity, the average TSS should not exceed 5 mg/L. If membrane filtration is used for treatment, the turbidity should not exceed 0,2 NTU.

d) Residual chlorine dosage between 0,2 mg/L and 1 mg/L that measured after 30 min contact time can be necessary for high and very high quality treated wastewater. If other method of disinfection achieving is used, it should also be monitored.

e) Intestinal nematodes (helminth eggs) might not be routinely monitored if it was demonstrated that the number of helminth eggs in untreated wastewater is consistently below 10 eggs/L.

f) Secondary treatment includes activated sludge, trickling filters, rotating biological contactors, biofilters, bioreactors, sequence batchreactors, etc.

g) Filtration includes microscreening, cartridge filtration, high rate sand filtration, dual media filtration, cloth filters, and disc filters without or with chemical addition (contact filtration) as well as membrane processes including membrane bioreactors.

h) Disinfection includes UV irradiation, ozonation, chlorination, or other chemical, physic chemical, or membrane processes.

i) High rate clarification includes coagulation, flocculation, and lamella settling.

j) Well-designed stabilization pond systems can meet coliform limits without additional disinfection. The soluble BOD values are considered.

k) The physical-chemical parameters (BOD, TSS) could be adjusted according to local wastewater treatment regulations with the possible addition of COD.

l) If there is a risk of aerosolization, the Legionella spp should be less than 1 000 CFU/L for Greenhouses.

Table B.3 *(continued)*

Cat.	Type of treated wastewater	BOD[b), j)]		TSS		Turbidity[c)]		Thermo-tolerant coliforms[d)]		Intestinal nematodes[e), l)]		Potential uses without barriers	Potential corresponding treatment
		mg L^{-1}		mg L^{-1}		NTU		no./100 ml		Egg L^{-1}			
		Ave.	Max	Ave.	Max	Ave.	Max	95 %ile	Max	Ave.	Max		
D	Medium quality treated wastewater(11)	≤60 mg/L	100 mg/L	≤90 mg/L	140 mg/L	—	—	—	—	≤1	5	Restricted irrigation of industrial and seeded crops	Secondary[f)] or high rate clarification with coagulation, flocculation[i)]
E	Extensively treated wastewater	≤20 mg/L	35 mg/L	—	—	—	—	—	—	≤1	5	Restricted irrigation of industrial and seeded crops	stabilization ponds and wetlands [j)]

NOTE: With each type of treated-wastewater quality, the use of a higher quality treated wastewater is always possible.

a) The recommended limits are elaborated on the basis of international regulations, e.g. WHO (2006) and USEPA (2012) and apply to the reclaimed water at the outlet of the treatment facility. After storage in open reservoirs and for spray or localized irrigation, additional filtration could be necessary. Sampling frequency and the calculation of the average values are given in ISO 16075-4.

b) BOD is determined with a five-day test.

c) Continuous measurement of the turbidity can be implemented. The average value should be based on a 24-time period. If suspended solids are used in lieu of turbidity, the average TSS should not exceed 5 mg/L. If membrane filtration is used for treatment, the turbidity should not exceed 0,2 NTU.

d) Residual chlorine dosage between 0,2 mg/L and 1 mg/L that measured after 30 min contact time can be necessary for high and very high quality treated wastewater. If other method of disinfection achieving is used, it should also be monitored.

e) Intestinal nematodes (helminth eggs) might not be routinely monitored if it was demonstrated that the number of helminth eggs in untreated wastewater is consistently below 10 eggs/L.

f) Secondary treatment includes activated sludge, trickling filters, rotating biological contactors, biofilters, bioreactors, sequence batchreactors, etc.

g) Filtration includes microscreening, cartridge filtration, high rate sand filtration, dual media filtration, cloth filters, and disc filters without or with chemical addition (contact filtration) as well as membrane processes including membrane bioreactors.

h) Disinfection includes UV irradiation, ozonation, chlorination, or other chemical, physic chemical, or membrane processes.

i) High rate clarification includes coagulation, flocculation, and lamella settling.

j) Well-designed stabilization pond systems can meet coliform limits without additional disinfection. The soluble BOD values are considered.

k) The physical-chemical parameters (BOD, TSS) could be adjusted according to local wastewater treatment regulations with the possible addition of COD.

l) If there is a risk of aerosolization, the Legionella spp should be less than 1 000 CFU/L for Greenhouses.

Table B.4 — Guideline values for domestic reclaimed water used in toilet and urinal flushing[13]

Parameter	Units	Water quality parameters	
		Median	Maximum
BOD_5	mg/L	≤10	≤20
TSS[b]	mg/L	≤10	≤20
Turbidity[b]	NTU	≤2	≤5
Escherichia coli[c]	CFU/100 mL	Not detected	≤200
Thermotolerant coliforms[c]	CFU/100 mL	Not detected	≤200
Total chlorine residual[d]	mg/L	≥0,5	

[a] Unless otherwise noted, recommended quality limits apply to the reclaimed water at the point of discharge from the treatment facility or treatment unit. BOD_5 = five-day biochemical oxygen demand; TSS = total suspended solids; NTU = nephelometric turbidity unit; CFU = colony-forming unit.

[b] Measured prior to disinfection point. Only one of TSS and turbidity needs to be monitored in a given system.

[c] Only one of *Escherichia coli* and thermotolerant coliforms needs to be monitored in a given system. Further information is provided in Box 1.

[d] Measured at the point where the treated effluent enters the distribution/plumbing system.

Table B.5 — Suggested Guidelines for Water Reuse[14]

Types of Reuse	Treatment	Reclaimed Water Quality [2]	Reclaimed Water Monitoring	Setback Distances [3]	Comments
Urban Reuse All types of landscape irrigation, (e.g., golf courses, parks, cemeteries) – also vehicle washing, toilet flushing, use in fire protection systems and commercial air conditioners, and other uses with similar access or exposure to the water	• Secondary [4] • Filtration [5] • Disinfection [6]	• pH = 6-9 • ≤ 10 mg/l BOD [7] • ≤ 2 NTU [8] • No detectable fecal coli/100 ml [9,10] • 1 mg/l Cl_2 residual (minimum) [11]	• pH - weekly • BOD - weekly • Turbidity - continuous • Coliform - daily • Cl_2 residual - continuous	• 50 ft (15 m) to potable water supply wells	• See Table 2-7 for other recommended limits. • At controlled-access irrigation sites where design and operational measures significantly reduce the potential of public contact with reclaimed water, a lower level of treatment, e.g., secondary treatment and disinfection to achieve < 14 fecal coli/100 ml, may be appropriate. • Chemical (coagulant and/or polymer) addition prior to filtration may be necessary to meet water quality recommendations. • The reclaimed water should not contain measurable levels of viable pathogens. [12] • Reclaimed water should be clear and odorless. • A higher chlorine residual and/or a longer contact time may be necessary to assure that viruses and parasites are inactivated or destroyed. • A chlorine residual of 0.5 mg/l or greater in the distribution system is recommended to reduce odors, slime, and bacterial regrowth. • See Section 3.4.3. for recommended treatment reliability.
Restricted Access Area Irrigation Sod farms, silviculture sites, and other areas where public access is prohibited, restricted or infrequent	• Secondary [4] • Disinfection [6]	• pH = 6-9 • ≤ 30 mg/l BOD [7] • ≤ 30 mg/l TSS • ≤ 200 fecal coli/100 ml [9,13,14] • 1 mg/l Cl_2 residual (minimum) [11]	• pH - weekly • BOD - weekly • TSS - daily • Coliform - daily • Cl_2 residual - continuous	• 300 ft (90 m) to potable water supply wells • 100 ft (30 m) to areas accessible to the public (if spray irrigation)	• See Table 2-7 for other recommended limits. • If spray irrigation, TSS less than 30 mg/l may be necessary to avoid clogging of sprinkler heads. • See Section 3.4.3 for recommended treatment reliability.
Agricultural Reuse – Food Crops Not Commercially Processed [15] Surface or spray irrigation of any food crop, including crops eaten raw.	• Secondary [4] • Filtration [5] • Disinfection [6]	• pH = 6-9 • ≤ 10 mg/l BOD [7] • ≤ 2 NTU [8] • No detectable fecal coli/100 ml [9,10] • 1 mg/l Cl_2 residual (minimum) [11]	• pH - weekly • BOD - weekly • Turbidity - continuous • Coliform - daily • Cl_2 residual - continuous	• 50 ft (15 m) to potable water supply wells	• See Table 2-7 for other recommended limits. • Chemical (coagulant and/or polymer) addition prior to filtration may be necessary to meet water quality recommendations. • The reclaimed water should not contain measurable levels of viable pathogens. [12] • A higher chlorine residual and/or a longer contact time may be necessary to assure that viruses and parasites are inactivated or destroyed. • High nutrient levels may adversely affect some crops during certain growth stages. • See Section 3.4.3 for recommended treatment reliability.
Agricultural Reuse – Food Crops Commercially Processed [15] Surface Irrigation of Orchards and Vineyards	• Secondary [4] • Disinfection [6]	• pH = 6-9 • ≤ 30 mg/l BOD [7] • ≤ 30 mg/l TSS • < 200 fecal coli/100 ml [9,13,14] • 1 mg/l Cl_2 residual (minimum) [11]	• pH - weekly • BOD - weekly • TSS - daily • Coliform - daily • Cl_2 residual - continuous	• 300 ft (90 m) to potable water supply wells • 100 ft (30 m) to areas accessible to the public (if spray irrigation)	• See Table 2-7 for other recommended limits. • If spray irrigation, TSS less than 30 mg/l may be necessary to avoid clogging of sprinkler heads. • High nutrient levels may adversely affect some crops during certain growth stages. • See Section 3.4.3 for recommended treatment reliability.
Agricultural Reuse – Non-food Crops Pasture for milking animals; fodder, fiber, and seed crops	• Secondary [4] • Disinfection [6]	• pH = 6-9 • ≤ 30 mg/l BOD [7] • ≤ 30 mg/l TSS • < 200 fecal coli/100 ml [9,13,14] • 1 mg/l Cl_2 residual (minimum) [11]	• pH - weekly • BOD - weekly • TSS - daily • Coliform - daily • Cl_2 residual - continuous	• 300 ft (90 m) to potable water supply wells • 100 ft (30 m) to areas accessible to the public (if spray irrigation)	• See Table 2-7 for other recommended limits. • If spray irrigation, TSS less than 30 mg/l may be necessary to avoid clogging of sprinkler heads. • High nutrient levels may adversely affect some crops during certain growth stages. • Milking animals should be prohibited from grazing for 15 days after irrigation ceases. A higher level of disinfection, e.g., to achieve ≤ 14 fecal coli/100 ml, should be provided if this waiting period is not adhered to. • See Section 3.4.3 for recommended treatment reliability.

Table B.5 *(continued)*

Types of Reuse	Treatment	Reclaimed Water Quality [2]	Reclaimed Water Monitoring	Setback Distances [3]	Comments
Recreational Impoundments Incidental contact (e.g., fishing and boating) and full body contact with reclaimed water allowed	• Secondary [4] • Filtration [5] • Disinfection [6]	• pH = 6-9 • ≤ 10 mg/l BOD [7] • ≤ 2 NTU [8] • No detectable fecal coli/100 ml [9,10] • 1 mg/l Cl_2 residual (minimum) [11]	• pH - weekly • BOD - weekly • Turbidity - continuous • Coliform - daily • Cl_2 residual - continuous	• 500 ft (150 m) to potable water supply wells (minimum) if bottom not sealed	• Dechlorination may be necessary to protect aquatic species of flora and fauna. • Reclaimed water should be non-irritating to skin and eyes. • Reclaimed water should be clear and odorless. • Nutrient removal may be necessary to avoid algae growth in impoundments. • Chemical (coagulant and/or polymer) addition prior to filtration may be necessary to meet water quality recommendations. • The reclaimed water should not contain measurable levels of viable pathogens. [12] • A higher chlorine residual and/or a longer contact time may be necessary to assure that viruses and parasites are inactivated or destroyed. • Fish caught in impoundments can be consumed. • See Section 3.4.3. for recommended treatment reliability.
Landscape Impoundments Aesthetic impoundment where public contact with reclaimed water is not allowed	• Secondary [4] • Disinfection [6]	• ≤ 30 mg/l BOD [7] • ≤ 30 mg/l TSS • ≤ 200 fecal coli/100 ml [9,13,14] • 1 mg/l Cl_2 residual (minimum) [11]	• pH - weekly • TSS - daily • Coliform - daily • Cl_2 residual - continuous	• 500 ft (150 m) to potable water supply wells (minimum) if bottom not sealed	• Nutrient removal may be necessary to avoid algae growth in impoundments. • Dechlorination may be necessary to protect aquatic species of flora and fauna. • See Section 3.4.3 for recommended treatment reliability.
Construction Use Soil compaction, dust control, washing aggregate, making concrete	• Secondary [4] • Disinfection [6]	• ≤ 30 mg/l BOD [7] • ≤ 30 mg/l TSS • ≤ 200 fecal coli/100 ml [9,13,14] • 1 mg/l Cl_2 residual (minimum) [11]	• BOD - weekly • TSS - daily • Coliform - daily • Cl_2 residual - continuous		• Worker contact with reclaimed water should be minimized. • A higher level of disinfection, e.g., to achieve ≤ 14 fecal coli/100 ml, should be provided when frequent work contact with reclaimed water is likely. • See Section 3.4.3 for recommended treatment reliability.
Industrial Reuse Once-through cooling	• Secondary [4] • Disinfection [6]	• pH = 6-9 • ≤ 30 mg/l BOD [7] • ≤ 30 mg/l TSS • ≤ 200 fecal coli/100 ml [9,13,14] • 1 mg/l Cl_2 residual (minimum) [11]	• pH - weekly • BOD - weekly • TSS - daily • Coliform - daily • Cl_2 residual - continuous	• 300 ft (90 m) to areas accessible to the public	• Windblown spray should not reach areas accessible to workers or the public.
Recirculating cooling towers	• Secondary [4] • Disinfection [6] (chemical coagulation and filtration [5] may be needed)	• Variable depends on recirculation ratio (see Section 2.2.1) pH = 6-9 • ≤ 30 mg/l BOD [7] • ≤ 30 mg/l TSS • ≤ 200 fecal coli/100 ml [9,13,14] • 1 mg/l Cl_2 residual (minimum) [11]	• pH - weekly • BOD - weekly • TSS - daily • Coliform - daily • Cl_2 residual - continuous	• 300 ft (90 m) to areas accessible to the public. May be reduced or eliminated if high level of disinfection is provided.	• Windblown spray should not reach areas accessible to workers or the public. • Additional treatment by user is usually provided to prevent scaling, corrosion, biological growths, fouling and foaming. • See Section 3.4.3 for recommended treatment reliability.
Other Industrial Uses	Depends on site specific uses (See Section 2.2.3)				
Environmental Reuse Wetlands, marshes, wildlife habitat, stream augmentation	• Variable • Secondary [4] and disinfection [6] (minimum)	Variable, but not to exceed: • ≤ 30 mg/l BOD [7] • ≤ 30 mg/l TSS • ≤ 200 fecal coli/100 ml [9,13,14]	• BOD - weekly • TSS - daily • Coliform - daily • Cl_2 residual - continuous		• Dechlorination may be necessary to protect aquatic species of flora and fauna. • Possible effects on groundwater should be evaluated. • Receiving water quality requirements may necessitate additional treatment. • The temperature of the reclaimed water should not adversely affect ecosystem. • See Section 3.4.3 for recommended treatment reliability.

Table B.5 *(continued)*

Types of Reuse	Treatment	Reclaimed Water Quality [2]	Reclaimed Water Monitoring	Setback Distances [3]	Comments
Groundwater Recharge By spreading or injection into aquifers not used for public water supply	• Site-specific and use dependent • Primary (minimum) for spreading • Secondary [4] (minimum) for injection	• Site-specific and use dependent	• Depends on treatment and use	• Site-specific	• Facility should be designed to ensure that no reclaimed water reaches potable water supply aquifers • See Section 2.5 for more information. • For spreading projects, secondary treatment may be needed to prevent clogging. • For injection projects, filtration and disinfection may be needed to prevent clogging. • See Section 3.4.3 for recommended treatment reliability.
Indirect Potable Reuse Groundwater recharge by spreading into potable aquifers	• Secondary [4] • Disinfection [6] • May also need filtration [5] and/or advanced wastewater treatment [16]	• Secondary [4] • Disinfection [6] • Meet drinking water standards after percolation through vadose zone	Includes, but not limited to, the following: • pH - daily • Coliform - daily • Cl_2 residual - continuous • Drinking water standards - quarterly • Other [17] - depends on constituent • BOD - weekly • Turbidity - continuous	• 500 ft (150 m) to extraction wells. May vary depending on treatment provided and site-specific conditions.	• The depth to groundwater (i.e., thickness to the vadose zone) should be at least 6 feet (2 m) at the maximum groundwater mounding point. • The reclaimed water should be retained underground for at least 6 months prior to withdrawal. • Recommended treatment is site-specific and depends on factors such as type of soil, percolation rate, thickness of vadose zone, native groundwater quality, and dilution. • Monitoring wells are necessary to detect the influence of the recharge operation on the groundwater. • See Sections 2.5 and 2.6 for more information. • The reclaimed water should not contain measurable levels of viable pathogens after percolation through the vadose zone. [12] • See Section 3.4.3 for recommended treatment reliability.
Indirect Potable Reuse Groundwater recharge by injection into potable aquifers	• Secondary [4] • Filtration [5] • Disinfection [6] • Advanced wastewater treatment [16]	Includes, but not limited to, the following: • pH = 6.5 - 8.5 • ≤ 2 NTU 8 • No detectable total coli/100 ml [9,10] • 1 mg/l Cl2 residual (minimum) [11] • ≤ 3 mg/l TOC • ≤ 0.2 mg/l TOX • Meet drinking water standards	Includes, but not limited to, the following: • pH - daily • Turbidity - continuous • Total coliform - daily • Cl_2 residual - continuous • Drinking water standards - quarterly • Other [17] - depends on constituent	• 2000 ft (600 m) to extraction wells. May vary depending on site-specific conditions.	• The reclaimed water should be retained underground for at least 9 months prior to withdrawal. • Monitoring wells are necessary to detect the influence of the recharge operation on the groundwater. • Recommended quality limits should be met a the point of injection. • The reclaimed water should not contain measurable levels of viable pathogens after percolation through the vadose zone. [12] • See Sections 2.5 and 2.6 for more information. • A higher chlorine residual and/or a longer contact time may be necessary to assure virus and protozoa inactivation. • See Section 3.4.3 for recommended treatment reliability.
Indirect Potable Reuse Augmentation of surface supplies	• Secondary [4] • Filtration [5] • Disinfection [6] • Advanced wastewater treatment [16]	Includes, but not limited to, the following: • pH = 6.5 - 8.5 • ≤ 2 NTU [8] • No detectable total coli/100 ml [9,10] • 1 mg/l Cl2 residual (minimum) [11] • ≤ 3 mg/l TOC • Meet drinking water standards	Includes, but not limited to, the following: • pH - daily • Turbidity - continuous • Total coliform - daily • Cl_2 residual - continuous • Drinking water standards - quarterly • Other [17] - depends on constituent	• Site-specific	• Recommended level of treatment is site-specific and depends on factors such as receiving water quality, time and distance to point of withdrawal, dilution and subsequent treatment prior to distribution for potable uses. • The reclaimed water should not contain measurable levels of viable pathogens. [12] • See Sections 2.6 for more information. • A higher chlorine residual and/or a longer contact time may be necessary to assure virus and protozoa inactivation. • See Section 3.4.3 for recommended treatment reliability.

Table B.5 *(continued)*

Footnotes

1. These guidelines are based on water reclamation and reuse practices in the U.S., and they are especially directed at states that have not developed their own regulations or guidelines. While the guidelines should be useful in may areas outside the U.S., local conditions may limit the applicability of the guidelines in some countries (see Chapter 8). It is explicitly stated that the direct application of these suggested guidelines will not be used by USAID as strict criteria for funding.

2. Unless otherwise noted, recommended quality limits apply to the reclaimed water at the point of discharge from the treatment facility.

3. Setback distances are recommended to protect potable water supply sources from contamination and to protect humans from unreasonable health risks due to exposure to reclaimed water.

4. Secondary treatment processes include activated sludge processes, trickling filters, rotating biological contractors, and may include stabilization pond systems. Secondary treatment should produce effluent in which both the BOD and TSS do not exceed 30 mg/l.

5. Filtration means the passing of wastewater through natural undisturbed soils or filter media such as sand and/or anthracite, filter cloth, or the passing of wastewater through microfilters or other membrane processes.

6. Disinfection means the destruction, inactivation, or removal of pathogenic microorganisms by chemical, physical, or biological means. Disinfection may be accomplished by chlorination, UV radiation, ozonation, other chemical disinfectants, membrane processes, or other processes. The use of chlorine as defining the level of disinfection does not preclude the use of other disinfection processes as an acceptable means of providing disinfection for reclaimed water.

7. As determined from the 5-day BOD test.

8. The recommended turbidity limit should be met prior to disinfection. The average turbidity should be based on a 24-hour time period. The turbidity should not exceed 5 NTU at any time. If TSS is used in lieu of turbidity, the TSS should not exceed 5 mg/l.

9. Unless otherwise noted, recommended coliform limits are median values determined from the bacteriological results of the last 7 days for which analyses have been completed. Either the membrane filter or fermentation-tube technique may be used.

10. The number of fecal coliform organisms should not exceed 14/100 ml in any sample.

11. Total chlorine residual should be met after a minimum contact time of 30 minutes.

12. It is advisable to fully characterize the microbiological quality of the reclaimed water prior to implementa tion of a reuse program.

13. The number of fecal coliform organisms should not exceed 800/100 ml in any sample.

14. Some stabilization pond systems may be able to meet this coliform limit without disinfection.

15. Commercially processed food crops are those that, prior to sale to the public or others, have undergone chemical or physical processing sufficient to destroy pathogens.

16. Advanced wastewater treatment processes include chemical clarification, carbon adsorption, reverse osmosis and other membrane processes, air stripping, ultrafiltration, and ion exchange.

17. Monitoring should include inorganic and organic compounds, or classes of compounds, that are known or uspected to be toxic, carcinogenic, teratogenic, or mutagenic and are not included in the drinking water standards.