भारतीय मानक

Indian Standard

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(पहला पुनरीक्षण)

Reverse Osmosis Based Point of Use Water Treatment System for Drinking Purposes — Specification

(First Revision)

ICS 130.060.01

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Water Purification Systems Sectional Committee, FAD 30

FOREWORD

This Indian Standard (First Revision) was adopted by the Bureau of Indian Standards, after the draft finalized by the Water Purification Systems Sectional Committee had been approved by the Food and Agriculture Division Council.

The quality of water available for human consumption has a bearing on health of the population/community. In highly populated countries like India, the quality of drinking water has deteriorated due to contamination of soil and water from agricultural run-offs and industrial effluents, and due to over exploitation of groundwater. Tapping of groundwater for domestic use has also increased in urban and semi-urban areas to meet the growing demand of water. Groundwater typically has higher concentrations of dissolved solids, namely minerals, and may contain harmful contaminants like heavy metals and naturally occurring elements like fluoride or arsenic in excess.

Reverse Osmosis (RO) technology combined with sediment and carbon filters has proved to be an effective water treatment method for removing various inorganic, organic, and microbiological contaminants from the water. Realizing this fact, many manufacturers and assemblers in the organized and unorganized sectors have entered the RO water treatment market. Taking cognizance of this trend, this Indian standard for RO-based water treatment systems was formulated establishing minimum requirements for design and construction, performance, and testing of materials that come in contact with treated water.

The standard was first published in 2015. This revision is undertaken to update the standard having regard to the available technology and corresponding recovery efficiency and output water quality reliability. In this revision, the following major changes have been incorporated:

a) In the terminology clause, new terms, ‘permeate’ and ‘reject water’ have been incorporated;
b) Requirement of recovery percentage has been increased from 20 percent to 40 percent in order to minimize water wastage;
c) Requirements for chemical reduction of contaminates, copper and pesticides have been updated;
d) For TDS display, hand held TDS meter and IoT enabled display methods have been incorporated as alternative options to inbuilt TDS display meter.
e) Methods of test for TDS, chemical, and microbiological reduction and recovery testing have been elaborated to incorporate details of influent challenge water preparation;
f) Clauses on electrical safety and power supply have been updated; and
g) Hydrostatic testing has been revised, to differentiate between different zones of pressurization in the complete RO system.

With the advancement of technology and based on availability of technical data on optimum recovery efficiency from further research and study, the specified value of recovery efficiency of 40 percent would be reviewed by the concerned technical committee of Bureau.

The composition of the committee responsible for formulation of the standard is listed in Annex G.

For the purpose of deciding whether a particular requirement of this standard is complied with, the final value, observed or calculated, expressing the result of a test or analysis, shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded-off value should be the same as that of the specified value in this standard.

Indian Standard

REVERSE OSMOSIS BASED POINT-OF-USE WATER TREATMENT SYSTEM FOR DRINKING PURPOSES — SPECIFICATION

(First Revision)

1 SCOPE

1.1 This standard covers reverse osmosis (RO) based point-of-use (PoU) water treatment system with a product water capacity of up to 50 litre per hour, that reduces total dissolved solids (TDS); and physical, chemical, and microbiological contaminants from specified concentrations in the feed water to the maximum allowable limits in the product water.

1.2 The standard does not cover requirements for consumables, such as filters and treatment media.

2 REFERENCES

The standards listed below contain provisions, which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below:

IS No.	*Title*
IS 302 (Part 1) : 2008	Safety of household and similar electrical appliances: Part 1 General requirements (*sixth revision*)
IS 3025	Method of sampling and test (physical and chemical) for water and wastewater:
(Part 16) : 2023	Filterable residue (total dissolved solids) at 180 °C (*second revision*)
(Part 34) : 1988	Nitrogen (*first revision*)
(Part 37) : 2022	Arsenic (*second revision*)
(Part 41) : 1992	Cadmium (*first revision*)
(Part 42) : 1992	Copper (*first revision*)
(Part 47) : 1994	Lead (*first revision*)
(Part 48) : 1994	Mercury (*first revision*)
(Part 52) : 2003	Chromium(*first revision*)
(Part 60/Sec 1) : 2023	Fluoride (*second revision*)
IS 4905 : 2015	Random sampling and randomization procedures (*first revision*)
IS 9845 : 1998	Determination of overall migration of constituents of plastics materials and articles intended to come in contact with foodstuffs — Method of analysis (*second revision*)
IS 10500 : 2012	Drinking water — Specification (*second revision*)
IS 15185 : 2016	Water quality — Detection and enumeration of *Escherichia coli* and coliform bacteria — Membrane filtration method for water with low bacterial background flora (*first revision*)

3 TERMINOLOGY

For the purpose of this standard, the following definitions shall apply.

3.1 Chemical Reduction — A reduction in the concentration of one or more specified organic or inorganic chemical contaminants by a system from feed water.

3.2 Contaminant — An undesirable physical, chemical, or microbiological substance or parameter in water that may have adverse effects on health or aesthetics, or both.

3.3 Drinking Water — Water from any source which is intended for human consumption, both drinking and cooking purposes (*see* IS 10500).

3.4 Feed Water — Water entering the system, which is to be treated by the system.

3.5 Influent Challenge Water — The standard test water with specified contaminants entering a system for evaluation.

3.6 Permeate — The portion of feed water that has been treated by passage through the RO membrane.

3.7 Point-of-Use (PoU) Drinking Water Treatment System — A plumbed-in or faucet-mounted system used to treat the feed water for direct consumption or use, hereinafter referred to as 'system'.

NOTE — PoU RO systems are not intended for distribution.

3.8 Production Rate — The volume of water produced by a system in litres per hour (lph).

3.9 Product Water — Water that has been treated by the system.

3.10 Recovery Rating — The ratio of product water to feed water, expressed as a percentage.

3.11 Reject Water — The portion of the feed water that is not converted to product water. It is also called the concentrate, as the solutes (contaminants) are concentrated in the reject water stream.

3.12 Reverse Osmosis (RO) — A pressure-driven membrane separation technique to reduce the concentration of dissolved solutes such as minerals, salts and organic species in water. Reverse osmosis uses an applied pressure to drive the transport of water across a semi-permeable membrane from a more concentrated solution (feed) to a more dilute solution (permeate).

NOTE — RO is often used in commercial and residential water treatment. It is also one of the methods used for the desalination of brackish water and seawater. In RO-based systems, typically, a spiral wound membrane element is used along with pretreatment filters consisting of sediment filters, activated carbon filters, etc.

3.13 RO Membrane — A semi-permeable barrier that allows the preferential passage of water. Commonly used reverse osmosis (RO) membranes include cellulose triacetate and aromatic polyamide polymers, popularly known as TFC (thin film composites).

4 CONSTRUCTION

4.1 Inlet Port

The system's inlet port shall be so designed that it can be suitably connected to the feed water source.

4.2 Method of Mounting

The system shall facilitate wall-mounting, countertop placement, or under-the-sink installation, etc.

4.3 Main Components

4.3.1 The RO system shall have the following components:

a) *Sediment Filter* — A filter required to remove physical impurities in the form of suspended solids like dust, dirt, silt and other fine particles from the feed water;

b) *Adsorption Media* — Required for the removal of chlorine and organic matter from water;

c) *Reverse Osmosis Membrane Element* — Should be able to reduce TDS, comprising of dissolved inorganic and organic contaminants;

d) *Booster Pump* — Should be able to provide the required operating pressure based on the RO membrane used;

e) *Reject Water Control Mechanism* — Required to control the reject water flow, thereby controlling the recovery rating or/and pressure;

f) *Power Supply*;

g) *Auto Shut-off Mechanism* — Required to prevent overflow and dry running of the pump; and

h) *TDS Display Meter* — Required to display the TDS value (mg/litre) of feed water and product water within a tolerance of ± 10% of TDS when tested as per IS 3025 part 16.

NOTES

1 If the system does not have an inbuilt/integrated TDS Display meter, the manufacturer shall provide hand held TDS meter with digital display, as an accessory along with the system. IOT enabled TDS display method may also be provided as an option.

2 The functioning of the TDS meter shall be ascertained periodically by the maintenance service provider and explicit instructions for calibration and maintenance of the TDS meter shall be provided by the manufacturer in the user manual.

4.3.2 The RO system may have the following additional components (non-exhaustive list):

a) *Flushing Mechanism*;

b) *Ultraviolet (UV) Disinfection Chamber/In Tank Sanitization*;

c) *Ultrafiltration (UF) Membrane*;

d) *TDS Control Valve* — A valve that splits the feed flow into two streams, one passing through the RO membrane and the second through an RO by-passing line. A blend of

RO permeate flow and bypass flow yields product water; and

e) The following post-membrane components/treatments may be incorporated:

1) *Mineraliser/Taste Enhancer Media* — Required to improve the taste of RO treated water; and

2) *Activated Carbon Media.*

NOTE — For systems where mineraliser/taste enhancer media is used, the manufacturer shall declare that the mineraliser/taste enhancer media being used will not cause any of the parameters in product water to exceed acceptable limits specified in IS 10500.

5 MATERIALS

5.1 Materials in contact with water shall comply with the overall migration limits of 60 mg/litre, *Max* for various plastic materials when tested by the method prescribed in IS 9845.

5.2 Materials of Construction

5.2.1 Those surfaces of the components of the RO system, which are expected to get wetted by the flow of water through the RO system, shall be made of corrosion-resistant materials or shall have corrosion-resistant treatment or coating of food-grade quality. The manufacturer shall provide evidence of the same.

5.3 Membrane Preservatives

5.3.1 The chemical preservatives used in the membrane shall be of food-grade quality and shall be declared by the manufacturer in the user guide for consumers.

5.3.2 The manufacturer shall also declare the flushing requirement at the time of installation, in the user guide.

6 PERFORMANCE REQUIREMENTS

6.1 General

The RO system shall be so designed and constructed that its intended purpose is accomplished when installed and operated in accordance with the manufacturer's instructions.

6.2 Reject Water Control Mechanism

6.2.1 A reject water control mechanism (flow restrictor) shall be provided as an integral part of the system to regulate the flow of reject water. The performance of the system (recovery rating) depends on the specified reject water flow rate.

6.3 Performance

6.3.1 *TDS Reduction*

6.3.1.1 The system shall reduce the TDS level of feed water to less than or equal to 500 mg/litre in the product water, as per the maximum desirable concentration specified in IS 10500, when tested as per IS 3025 (Part 16).

6.3.1.2 The influent challenge water for TDS reduction testing shall have minimum 1 500 mg/litre of TDS or the maximum operating TDS level as declared by the manufacturer, whichever is higher.

6.3.1.3 The method of testing TDS reduction is given in Annex A.

6.3.2 *Chemical Reduction*

6.3.2.1 The system shall meet the maximum allowable product water levels as given in Table 1.

6.3.2.2 The method of testing chemical reduction is given in Annex B.

6.3.3 *Microbiological Reduction*

6.3.3.1 The manufacturer shall meet the requirements of Table 1 to deliver microbiologically safe drinking water. The method of testing microbiological (bacteriological and virological) reduction is as given in Annex C.

6.3.3.2 *Optional requirements for microbiological reduction*

6.3.3.2.1 The requirements given in Table 2 shall be optional requirements which shall be tested for the RO system as per Annex D by manufacturers claiming their reduction. These requirements shall be mandatorily tested in case, the system has a TDS control mechanism employing RO-bypass blending.

6.4 Percent Recovery of Product Water and Hourly Production Rate

6.4.1 The minimum recovery rate shall be equal to or more than 40 percent.

6.4.2 Production rate shall not be less than 5 litre per hour.

6.4.3 The method for evaluating recovery rating and hourly production rate is as prescribed in Annex A.

6.4.4 The manufacture shall declare:

a) Recovery rating;

b) Maximum operatable feed water TDS;

d) Production rate, in lph; and

e) Operating pressure range, in MPa or psi.

Table 1 Chemicals and Microbiological Reduction

(*Clauses* 6.3.2.1, 6.3.3.1 *and B*-1.2)

Sl No.	Contaminant	Influent Challenge Level	Maximum Allowable Product Water Level	Method of Testing
(1)	(2)	(3)	(4)	(5)
i)	Arsenic (as As), mg/litre	0.10 ± 10 %	0.01	IS 3025 (Part 37)
ii)	Cadmium (as Cd), mg/litre	0.03 ± 10 %	0.003	IS 3025 (Part 41)
iii)	Chromium (as Cr), mg/litre	0.30 ± 10 %	0.05	IS 3025 (Part 52)
iv)	Copper (as Cu), mg/litre	3.00 ± 10 %	1.0	IS 3025 (Part 42)
v)	Fluoride (as F), mg/litre	8.00 ± 10 %	1.0	IS 3025 (Part 60)
vi)	Lead (as Pb), mg/litre	0.15 ± 10 %	0.01	IS 3025 (Part 47)
vii)	Mercury (as Hg), mg/litre	0.006 ± 10 %	0.001	IS 3025 (Part 48)
viii)	Nitrate (as NO_3), mg/litre	150.00 ± 10 %	45	IS 3025 (Part 34)
ix)	Pesticides total µg/litre	0.3 of each pesticide	0.1 (of each pesticide) 0.5 (total pesticides)	IS 10500
x)	*E. coli*	1.0×10^7 cfu/100 ml to 1.0×10^8 cfu/100 ml	99.9999 percent reduction (LRV 6)	IS 15185
xi)	MS-2 *Coliphage* (Virus)	1.0×10^4 pfu/ ml to 1.0×10^5 pfu/ ml	99.99 percent reduction (LRV 4)	Annex B of IS 10500 or the USEPA method in Manual of Method for Virology Chapter 16, June 2001

NOTES

1 Method for testing chemical reduction is given in Annex B wherein the preparation of influent challenge water is also prescribed for the test. The testing protocol given in Annex B is to be followed along with methods of test indicated in col (5) of Table 1 for specific contaminants.

2 Method for testing microbiological reduction (for *E. coli* and MS-2 *Coliphage*) is given in Annex C wherein the preparation of influent challenge water is also prescribed for the test. The testing protocol given in Annex C is to be followed along with methods of test indicated in col (5) of Table 1 for specific contaminants

3 For the estimation of contaminants given at Sl No. (i) to (viii) approved and validated international test methods from ISO/APHA/ASTM/AOAC/EPA/EN may also be followed.

Table 2 Optional Requirements for Microbiological Reduction

(*Clause* 6.3.3.2.1)

SI No.	Contaminant	Influent Challenge Level	Minimum Percent Reduction Required	Method of Testing, Ref to
(1)	(2)	(3)	(4)	(5)
i)	*Cryptosporidium parvum*	> 5×10^3/100 ml	99.9 percent (LRV 3)	Annex D
ii)	*Giardia lamblia*	> 5×10^3/100 ml	99.9 percent (LRV 3)	Annex D

NOTES

1 Claims for above microbiological reduction shall be made for the specific contaminants shown in this table. To qualify for a specific contaminant reduction claim, the system shall reduce the level of the contaminant from the influent challenge to the specified limits.

2 LRV- Log reduction value.

3 Annex D prescribes two alternative methods for evaluating the reduction of specified protozoans. The method given in **D-1** shall be the referee method in case of dispute, and either of the methods **D-1** or **D-2** shall be the routine method of testing.

6.5 Electrical Safety

6.5.1 The system shall not have excessive leakage current when tested in accordance with **13** of IS 302 (Part 1).

6.5.2 The system shall be able to withstand high voltage test when tested in accordance with **13** of IS 302 (Part 1).

6.5.3 The system shall have provision for earthing in accordance with **27.5** of IS 302 (Part 1). All parts of metallic construction shall be permanently and reliably connected to an earthing termination within the RO system and shall be free of rough or sharp edges or other hazards that may cause injury to persons adjusting, servicing, or using the system.

NOTE — Class II appliances and Class III appliances shall have no provision of earthing.

6.6 Power supply

The system shall work on electrical supply upto and including 250 V, 50 Hz for single phase & upto and including 440 V, 50 Hz for three phase supply.

6.7 Pressure Test (Hydrostatic Test) — Type Test

All the components of the RO system through which the water passes shall pass the hydrostatic test as prescribed in Annex E.

6.8 Routine Pressure Test (Pneumatic Test)

6.8.1 Minimum 5 percent of the units of RO system produced per batch shall be tested by a routine pneumatic test.

6.8.2 Full Device Leakage Testing

Compressed air (at a pressure 0.2 MPa) is fed through the inlet point of the device keeping all the outlets shut. After the pressure reaches the maximum, the airline is isolated by a manual valve and checked for a drop in pressure over a period of 3 min. If the pressure is sustained, then this is found to be free from any leak.

7 SAMPLING AND CRITERIA FOR CONFORMITY

7.1 Take samples (test systems) as per the sampling plan given in Annex F.

7.2 Test as per the sequence given in Annex F.

7.3 All tested systems should pass in all the requirements. In case of any failure, discontinue further testing.

8 MAINTENANCE OF THE PRODUCT

8.1 RO system contains a replaceable treatment component critical for effective reduction of total dissolved solids. The product water shall be tested periodically by the maintenance service provider to verify the system performance after replacement of consumables as specified by the manufacturer.

8.2 For all filtration components like sediment filter, activated carbon filter and RO membrane filter, manufacturer shall declare the maximum possible life in terms of liters of water, which can be processed through each filter. Factors affecting the performance of the filters shall be mentioned. All this information shall be provided in the user manual.

8.3 The manufacturer shall give explicit instructions in the user manual and also on the product for cleaning and disinfecting of the storage tank by halogenated solutions (usually chlorine) or any other equivalent disinfection methods. The recommended frequency shall also be mentioned in the user manual. This would help in prevention and control of biofilm formation in the storage tank.

9 PACKING

The RO system shall be suitably packed in order to avoid damage during transit and storage.

10 MARKING

10.1 The system shall be affixed with a conformance label meeting the following requirements, namely:

a) The label shall be durable and all the markings shall be legible and indelible; and
b) The label shall be affixed on a part necessary for normal operation of the product and not normally requiring replacement during the life of the product.

10.2 The label shall be marked with the following details:

a) Name and address of the manufacturer or assembler of product, as the case may be;
b) Model name or code;
c) Production serial number;
d) Date of manufacture of product;
e) Rated recovery efficiency and corresponding water reject generation;
f) Production rate in litres/h;
g) Maximum operating TDS level;
h) Supply voltage whether single or three-phase, frequency, volts and wattage; and
j) Any other requirement as given under the *Environment (Protection) Rules*, 1986.

10.3 The manufacturer shall explicitly state the following caution on the label of the RO system:

‘RO system is not recommended for arsenic level above 0.1 mg/litre, fluoride level above 8.0 mg/litre and iron level above 0.3 mg/litre’.

10.4 A user manual for the proper method of operation and use of the RO system shall be supplied along with the RO system. It shall also include the specifications and life/replacement frequency of all the filters/consumables.

10.5 The manufacturer shall provide a suitable warranty for the RO system.

10.6 BIS Certification Marking

10.6.1 The product may also be marked with the BIS Standard Mark.

10.6.2 The use of the Standard Mark is governed by the provisions of the *Bureau of Indian Standards Act*, 2016 and the Rules and Regulations framed thereunder. The details of conditions under which the licence for the use of the Standard Mark may be granted to manufacturers or producers may be obtained from the Bureau of Indian Standards.

ANNEX A

(*Clauses* 6.3.1.3 *and* 6.4.3)

EVALUATION OF TDS REDUCTION, RECOVERY RATING AND HOURLY PRODUCTION RATE

A-1 TDS REDUCTION TESTING

A-1.1 TDS reduction testing may be done prior to, or with inorganic contaminants reduction testing described in **B-1**.

A-1.2 To prepare the influent challenge water for TDS reduction testing, sodium chloride (NaCl) shall be added to chlorine-free deionized water (Turbidity ≤ 1 NTU, *p*H 7.5 ± 0.5, Conductivity ≤ 1 µS/cm, Temperature 25 °C), to achieve the required challenge concentration (± 10 %).

A-1.3 Method of Testing

Two fresh systems shall be used for TDS reduction testing.

Install and condition the new RO system as per the manufacturer's instructions. After flushing with tap water (TDS ≤ 500 mg/l, Turbidity ≤ 1 NTU, *p*H 7.5 ± 0.5, Iron < 0.3 mg/l), connect the system to the TDS influent challenge water feed at the maximum recommended inlet pressure. Before the initial sampling, allow at least 10 litres of product water to filter and drain away with the storage tank's dispensing tap open. Then close the storage tank tap and allow the tank to fill until automatic cut-off. Collect water samples in duplicate from the influent challenge water tank and the product water storage tank and analyse for TDS as per IS 3025 (Part 16).

In case of direct flow models (where no storage tank is provided), allow 10 litres of product water to flow before collecting water samples and test as per IS 3025 (Part 16).

A-1.4 If the system has a TDS control mechanism employing RO-bypass blending, TDS reduction testing will be done with the TDS control valve in full-open position (maximum flow in the bypass line).

A-2 RECOVERY RATING AND HOURLY PRODUCTION RATE

A-2.1 Recovery rating and hourly production rate may be evaluated along with TDS reduction testing.

A-2.2 Recovery Rating

Connect the system to the TDS influent challenge water feed (prepared as per **A-1.2**) at the maximum recommended inlet pressure, and allow the system to operate until the flows of product and reject water have stabilized. (If a storage tank is present, operate with the storage tank's dispensing tap open.) After the stabilization of flows, collect product water and the corresponding volume of reject water for one hour of system operation. The volume of product and reject water collected shall be recorded in litres. The recovery rating shall be calculated using the following formula:

$$\text{Recovery rating (\%)} = \frac{V_{\text{PW}}}{(V_{\text{PW}} + V_{\text{RjW}})} \times 100$$

where

V_{PW} = volume of product water generated in 1 h of operation (litres); and

V_{RjW} = corresponding volume of reject water generated (litres)

NOTE — If the system has a TDS control mechanism employing RO-bypass blending, recovery rating shall be determined with the TDS control valve in full-closed position.

A-2.3 After collecting the samples for recovery testing, allow the system to operate for 2 continuous hours and record the volume of product water collected. Hourly production rate is calculated as follows:

Hourly production rate (litres/hour) = Volume of water collected in litres/hour

ANNEX B

(*Clause* 6.3.2.2 *and Table* 1)

EVALUATION OF CHEMICAL REDUCTION

B-1 INORGANIC CONTAMINANTS

Inorganic contaminants reduction testing may be done with or subsequent to TDS reduction testing described in Annex A.

B-1.1 Two test systems shall be evaluated. Prepare 100 litres of influent challenge water for inorganic contaminant reduction testing, as follows:

Prepare TDS reduction test water as per **A-1.2**. The influent challenge levels specified in Table 1 may be achieved by adding salts in the amounts specified in Table 3. Using NaCl, adjust the final TDS of the influent challenge water to the required TDS challenge level (1 500 mg/litre or the maximum TDS claimed by the manufacturer ± 10 percent).

B-1.2 Method of Testing

The systems previously used for TDS reduction testing may be used for inorganic chemicals reduction testing. After flushing with tap water (TDS ≤ 500 mg/litre, Turbidity ≤ 1 NTU, *p*H 7.5 ± 0.5, Iron < 0.3 mg/litre), connect the system to influent challenge water feed at the maximum recommended inlet pressure and allow at least 10 litres of product water to filter and drain away with the storage tank tap open. Then close the storage tank tap and allow the storage tank to fill until automatic cut-off. Collect water samples in duplicates from the influent challenge water tank and the product water storage tank and analyse for the various chemical contaminants as per applicable parts IS 3025 as indicated in Table 1. In case of direct flow models (where no storage tank is provided), allow 10 litres of product water to flow before collecting water samples and test as per the applicable parts of IS 3025.

B-2 PESTICIDES

B-2.1 The influent challenge water for testing pesticide reduction shall be prepared by adding NaCl to deionized water, adjusting TDS in the 250 mg/litre to 300 mg/litre range. Adjust *p*H in the 7.5 ± 0.5 range by adding dilute HCl or NaOH solution as required. To this add appropriate amount of each pesticide solution (in methanol) to yield 0.3 µg/litre concentration of each pesticide.

Table 3 Composition of Inorganic Contaminants Influent Challenge Water

(*Clause* B-1.1)

Sl No.	Contaminant	Influent Challenge Level	Compound	Weight of Compound in 100 litres Solution
(1)	(2)	(3)	(4)	(5)
i)	Arsenic as As (V)	0.1 mg/litre	$Na_2HAsO_4.7H_2O$	41.7 mg
ii)	Cadmium as Cd	0.03 mg/litre	$CdCl_2$ anhydrous	4.9 mg
			or $Cd(NO_3)_2$ anhydrous	6.3 mg
iii)	Total Chromium as Cr (III) and Cr (VI)	0.3 mg/litre [0.15 mg/litre each of Cr(III) and Cr(VI)]	$CrCl_3.6H_2O$	77 mg
			and $Na_2Cr_2O_7.2H_2O$	86 mg
iv)	Copper as Cu	3 mg/litre	$CuSO_4.5H_2O$	1.18 g
v)	Fluoride as F	8 mg/litre	NaF	1.77 g
vi)	Lead as Pb	0.15 mg/litre	$PbCl_2$	20.1 mg
			or $Pb(NO_3)_2$	24.0 mg
vii)	Mercury as Hg	0.006 mg/litre	$HgCl_2$	0.81 mg
viii)	Nitrate as NO_3	150 mg/litre	$NaNO_3$	20.6 g

B-2.2 Method of Testing

To the system previously used for inorganic chemicals reduction testing, connect influent challenge water prepared in **B-2.1**, but without pesticides added, and flush until 10 litres product water is produced. Then connect the system to pesticides influent challenge water at the maximum recommended inlet pressure and allow at least 10 litres of product water to filter and drain away with the storage tank tap open. Then close the storage tank tap and allow the product water to be collected in the tank until automatic cut-off. Collect water samples in duplicate from the influent challenge water tank and the product water storage tank and analyse for the various pesticides as per IS 10500.

In case of direct flow models (where no storage tank is provided), allow 10 litres of product water to flow before collecting water samples and test as per IS 10500.

B-3 If the system has a TDS control mechanism employing RO-bypass blending, all chemical reduction testing will be done with the TDS control valve in full-open position (maximum flow in the bypass line).

ANNEX C

(*Clause* 6.3.3.1 *and Table* 1)

EVALUATION OF MICROBIOLOGICAL REDUCTION

C-1 Two fresh systems shall be used for microbiological reduction testing. Bacterial reduction testing shall be done followed by viral reduction testing in the same RO system as per the sampling plan given in Annex F.

C-2 GENERAL TEST WATER

A chlorine free general test water with the following characteristics shall be used:

a) *p*H – 7.5 ± 0.5;
b) Turbidity < 1 NTU;
c) TDS – 400 mg/litre to 500 mg/litre (adjust using NaCl);
d) Iron < 0.3 mg/litre; and
e) Temperature (25 ± 5) °C

A public tap water supply may be used. TDS may be adjusted by addition of NaCl (to raise TDS) or by diluting with RO treated/deionized water (to lower TDS). *p*H may be adjusted using dilute HCl or NaOH solution.

C-3 EQUIPMENT AND ACCESSORIES

a) Autoclave;
b) Incubator;
c) Laminar air flow;
d) Vortex mixer;
e) Vacuum pump;
f) *p*H meter;
g) UV-Vis spectrophotometer;
h) Centrifuge;
j) Refrigerator;
k) Water bath;
m) Colony counter;
n) Membrane filters of 0.45 µ;
p) Sterile polycarbonate membrane filters of 0.22 µ;
q) Sterile filtration apparatus;
r) Sterile syringes and forceps;
s) Pipettes;
t) Petri dishes;
u) Test tubes 16 mm x 150 mm; and
v) Sterile centrifuge tubes.

C-4 REAGENTS AND MEDIA

a) Sterile Coliform Chromogenic Agar /Sterile MacConkey Agar Medium/M-Endo agar/ Eosin Methylene Blue agar;

b) Tryptic Soy Agar Medium (TSA) - 1.5 percent, *p*H 7.3. Dissolve TSA by boiling, adjust to final *p*H, and autoclave at 120 °C and 15 psi for 20 min. Pour the tempered media into sterile Petri dishes. Store the agar plates at 5 °C, but allow to come to room temperature before use;

c) Phage top Agar - 1% TSA, *p*H 7.3. Dissolve TSA by boiling, adjust to final *p*H, and autoclave at 120 °C and 15 psi for 20 min. Agar shall be stored at 5 °C. On the day of testing, liquefy the TSA and place in a 45 °C water bath. The MS-2 *Coliphage* top agar shall be maintained at 45 °C to prevent agar solidification;

d) Sterile Tryptic Soy Broth Medium (TSB) Dissolve TSA by boiling and adjust to final *p*H. Dispense 8 ml aliquots of TSB into 16 mm x 150 mm test tubes. Autoclave the tubes at 120 °C at 15 psi for 20 min. Store the cooled broth at 5 °C;

e) Sterile Saline (0.85 percent);

f) Phosphate-buffered saline (PBS);

g) Ethylenediamine tetra acetic acid (EDTA); and

h) Lysozyme.

C-5 CHALLENGE ORGANISMS

C-5.1 Bacterial Challenge

Escherichia coli (ATCC # 10536 or MTCC 68).

The level of bacteria in the challenge water should be approximately ~ 5 x 10^7/100 ml, as a 7 $\log_{10}$ concentration is required for determining 6 $\log_{10}$ reduction. The quantity of bacteria in a sample is expressed as colony forming units (cfu)/100 ml.

C-5.2 Viral Challenge

MS-2 *Coliphage* (ATCC #15597-Bl)

Escherichia coli (ATCC #15597) host strain for MS-2

Coliphage presence in ground water is an indication of faecal contamination. The quantity of *Coliphage* in a sample is expressed as plaque forming units (pfu)/ml. The procedure of stock culture preparation, preparation of challenge water and quantification of MS-2 *Coliphage* plaques are given below.

The level of MS-2 *Coliphage* lysate in the viral challenge water should be about ~ 5 x 10^5 pfu/ml.

C-6 PREPARATION OF MICROBIOLOGICAL CHALLENGE WATER

C-6.1 Bacterial Influent Challenge Water

C-6.1.1 *Bacterial Stock Culture Preparation*

E. coli cultures in stationary growth phase shall be washed and suspended in phosphate-buffered saline before challenge water preparation:

a) *E. coli* is grown overnight on tryptic soy agar (TSA) slants and checked using MacConkey's agar or equivalent selective media (M-Endo agar, Eosin Methylene Blue agar) for confirmation;

b) The culture is then transferred to a TSB tube for 15 h to 18 h and incubated at 37 °C;

c) The resultant suspension is subjected to three cycles of centrifugation-resuspension in 0.85 percent sterile saline (Eppendorf 3 000 x g for 4 min at room temperature). The bacterial pellet is washed and re suspended in sterile saline (0.85 %) to get OD between 0.8 to 1.0 at λ = 600 nm. This corresponds to a viable count of about 10^9 cfu/ml; and

d) Alternatively, the culture could be recovered from the overnight plate directly in sterile saline (taking care not to scrape out agar) and the OD adjusted to 0.8 to 1.0 at λ = 600 nm.

C-6.1.2 To prepare 100 litres challenge water, add appropriate quantities of the bacterial suspension in the general test water described in **C-2**, for a final bacterial count between 10^7 ml to 10^8/100 ml. The actual cell numbers are verified by the counts of colony forming units (cfu).

C-6.2 Viral Influent Challenge Water

C-6.2.1 *Viral Stock Culture Preparation*

This section describes the propagation and harvesting methods for stock suspensions of MS-2 *Coliphage* for use as a challenge suspension. The stock preparation procedure may have to be repeated multiple times to achieve the required volume of MS-2 *Coliphage* challenge water.

a) One day prior to preparation of MS-2 *Coliphage* stock, thaw a cryogenically frozen *E. coli* host strain (ATCC #15597). Inoculate one TSB tube with 0.1 ml of the stock suspension and incubate at 37 °C for 15 h to 18 h;

b) For preparing MS-2 *Coliphage* stock, liquefy 1percent TSA and temper the media in a 45 °C water bath. Prepare 1.5 percent TSA plates, which should be at room temperature prior to use;

c) Prepare serial dilutions of MS-2 *Coliphage* suspension in sterile PBS. Plate 10^{-5} to 10^{-12} dilutions (1 ml dilution per plate) in triplicate on 1.5% TSA plates. In a sterile tube, transfer 1 ml of diluted MS-2 *Coliphage*. Then quickly add 0.1 ml of *E. coli* host to ~ 5 ml of melted 1 percent TSA. Vortex to mix inoculum and media and pour on the 1.5 percent TSA basal plates, with rocking to spread the inoculum evenly. After the 1 percent TSA layer has solidified, the plates shall be inverted and incubated at 37 °C for 15 h to 18 h;

d) Select the plates that show complete lysis of host bacterial cells by the MS-2 *Coliphage*. Flood the surface of each plate with 3 ml of TSB, and remove the 1 percent TSA layer gently using a cell scraper. Pour the contents into two sterile 50 ml centrifuge tubes and make up the total volume to 40 ml with TSB. Add 0.2 g EDTA and 0.026 g lysozyme to each tube. Incubate at room temperature for 2 h, mixing every 15 min;

e) After incubation, the tubes shall be centrifuged at 9 280 x g for 5 min, or 2 320 x g for 20 min, at 20 °C. Collect the resulting supernatant taking care to avoid the pellet. A sterile 47 mm filtration assembly with a 0.22 µm polycarbonate filter shall be aseptically constructed. Wash the filter with 10 ml of TSB broth just prior to the filtration to minimize MS-2 *Coliphage* adsorption to the filter. Filter the supernatant; and

g) The MS-2 *Coliphage* suspension is to be titrated as in **C-6.2.2**. The concentration of MS-2 *Coliphage* should be 10^{10} to 10^{12} pfu/ml.

C-6.2.2 *Enumeration of* MS-2 *Coliphage plaques*

a) Thaw a cryogenically frozen *E. coli* ATCC host strain and inoculate 0.1 ml of the stock suspension in one TSB tube. Incubate the TSB tube at 37 °C for 15 h to 18 h;

b) Liquefy 1 % TSA and temper in a 45 °C water bath. Prepare room temperature 1.5 percent TSA plates;

c) Serial dilutions of MS-2 *Coliphage* suspension shall be made using sterile PBS. 10^{-7} to 10^{-12} dilutions (1 ml dilution per plate) shall be plated in triplicate on 1.5 % TSA plates. In a sterile tube, 1 ml of diluted MS-2 *Coliphage* shall be transferred. Add 0.1 ml of *E. coli* cells quickly to ~ 5 ml of melted 1 % TSA. The inoculum and media shall be vortexed and poured on TSA plates, with rocking plates to spread inoculum evenly. After the 1percent

TSA layer has solidified, the plates shall be inverted and incubated at 37 °C for 15 h to 18 h; and

d) After incubation, plates containing 20 to 200 distinct plaque forming units (pfu) shall be enumerated using a Colony Counter. The MS-2 *Coliphage* suspension titer shall be calculated by multiplying the number of pfu obtained by the inverse of the dilution factor. The concentration of MS-2 *Coliphage* should be 10^{10} to 10^{12} pfu/ml.

C-6.2.3 To prepare 100 litres challenge water, use appropriate quantities of the viral suspension in the general test water specified in section **C-2**, for a final viral count between 10^4 to 10^5 pfu/ ml, verified by the counts of plaque forming units (pfu) in a colony counter.

C-7 METHOD OF CHALLENGING RO TEST SYSTEMS AND SAMPLE COLLECTION

C-7.1 Install and condition the new RO system as per the manufacturer's instructions. After flushing with general test water, connect the system to the microbiological influent challenge water feed at the maximum recommended inlet pressure and allow at least 10 litres of product water to filter and drain away with the product water storage tank tap open. Then close the storage tank tap and allow the tank to fill until automatic cut-off. In case of direct flow models (where no storage tank is provided), allow 10 litres of product water to flow before collecting samples.

C-7.2 Collect 500 ml of water samples from the influent challenge water tank and the product water storage tank in duplicate and analyse for the microbiological contaminants as per methods specified in **5**, Table 1.

For direct flow models, collect product water samples from the outlet faucet.

C-7.3 If the system has a TDS control mechanism employing RO-bypass blending, all microbiological reduction testing will be done with the TDS control valve in full-open position (maximum flow in the bypass line).

C-8 ANALYSIS OF WATER SAMPLES FOR MICROBIOLOGICAL REDUCTION TESTING

C-8.1 Enumeration of *E. coli* in Influent and Product Water Samples

C-8.1.1 Bacteriological water samples should be stored at (5 ± 3) °C. Analysis should be commenced on the same day as sample collection.

C-8.1.2 For enumeration, serial dilutions of the influent and product water samples (10^0 to 10^{-5}) shall be made using sterile PBS.

C-8.1.3 Method of enumeration shall be as specified in col (5) of Table 1.

C-8.1.4. The *E. coli* suspension titer shall be calculated by multiplying the number of cfu obtained by the inverse of the dilution factor. Results shall be expressed as the number of cfu/100 ml.

C-8.1.5 Use appropriate positive and negative controls to eliminate errors due to bacterial strain, diluent or culture media.

C-8.2 Enumeration of MS2 *Coliphage* Plaques in Influent and Product Water Samples

C-8.2.1 Virological water samples should be stored at (5 ± 3) °C. Analysis should be commenced on the same day as sample collection.

C-8.2.2 Serial dilutions of the influent and product water samples (10^0 to 10^{-5}) shall be made using sterile PBS. 10^0 to 10^{-5} dilutions shall be plated in duplicate on 1.5 percent TSA plates. In a sterile tube, 1 ml of diluted MS-2 *Coliphage* shall be transferred. Then quickly add 0.1 ml of *E. coli* host to ~ 5 ml of melted 1 percent TSA. Vortex the inoculum and media and pour on TSA base plates with rocking to spread the inoculum evenly. After the 1 percent TSA layer has solidified, the plates shall be inverted and incubated at 37 °C for 15 h to 18 h.

C-8.2.3 After incubation, plates containing 20 to 200 distinct plaque forming units (pfu) shall be enumerated using a Colony Counter. The MS-2 *Coliphage* suspension titer shall be calculated by multiplying the number of pfu obtained by the inverse of the dilution factor. Results shall be expressed as the number of pfu/ ml.

C-8.3 Challenge Verification

After the appropriate incubation period for MS-2 *Coliphage* and *E. coli,* the colonies shall be counted on all of the density determination plates. The mean number of microorganisms per ml for plates with 25 to 250 colonies/plaques shall be calculated. This shall verify that the challenge organism was present in the challenge test water at the optimum concentration before conducting the challenge reduction test.

C-9 DETERMINATION OF LOG_{10} REDUCTION

The bacterial or viral log reduction is calculated as follows:

Input Load = ____cfu/100 ml or pfu/ml

Log_{10} (Input) = ____

Output Load (mean) = ____cfu/100 ml or pfu/ml

Log_{10} (Output) = ____

Log_{10} Reduction = Log_{10} (Input) – Log_{10} (Output)

Percentage reduction = $\frac{(\text{Input load} - \text{Output load})}{\text{Input load}}$ X 100

C-10 SAFETY PRECAUTIONS AND HAZARDS

a) Steam sterilized samples and equipment shall be handled with protective gloves when being removed from the autoclave;
b) Cryogenic culture vials shall be handled with cryoprotective gloves; and
c) All microbiological samples and contaminated test supplies shall be steam-sterilized to 120 °C at 15 psi for a minimum of 20 min prior to being discarded.

ANNEX D

(*Clauses* 6.3.3.2.1 *and Table* 2)

EVALUATION OF MICROBIOLOGICAL REDUCTION - SPECIFIED PROTOZOANS USING INACTIVATED CYSTS AND MICROSPHERES

D-0 GENERAL

Cryptosporidium and *Giardia* are often identified during waterborne disease outbreaks. As they are less sensitive than most bacteria and viruses to conventional drinking water treatment methods, they are ideal candidates for protozoa group representation. This method, based on size exclusion principle, prescribes the use of irradiated cysts of *Cryptosporidium parvum* or fluorescent polystyrene microspheres of similar physical dimensions [> 95 percent in the (3.0 ± 0.15) µm size range] for the evaluation of removal of protozoans (*Cryptosporidium, Giardia lamblia, Entamoeba histolytica*) or their oocysts (the resistant stage in the life cycle of waterborne protozoa that may be found in surface drinking water supplies and includes oocysts of *Cryptosporidium* and *Toxoplasma* and cysts of *Giardia* and *Entamoeba*). The method given at **D-1** shall be the referee method in case of dispute and either of the methods given at **D-1** or **D-2** may be used as the routine method of test.

D-1 REDUCTION OF INACTIVATED *CRYPTOSPORIDIUM PARVUM OOCYSTS*

D-1.1 Requirements

a) Commercially available suspension of inactivated (by irradiation or formalin treatment) *Cryptosporidium parvum* oocysts containing a minimum of 400 000 oocysts/10 ml;
b) *Stock polysorbate-20* (*0.1 percent solution*) — Prepare a 0.1 percent stock solution of polysorbate-20 (tween-20 or equivalent) by dispersing 1 ml polysorbate-20 in 900 ml deionized water and make up the volume to 1 000 ml;
c) *Working solution of polysorbate-20* (*0.01 percent solution*) — Dilute the stock of polysorbate 20 with deionized water in a 1 : 10 ratio to get the working solution;
d) *Staining kit* — Fluorescent antibody staining kit containing:
   1) Stain;
   2) Wash buffer;
   3) Positive control; and
   4) Mounting medium.
e) *Membrane filters* — 25 mm, 0.4 µm/0.45 µm;
f) Filtration assembly with vacuum pump; and
g) Fluorescent microscope.

D-1.2 Preparation of Challenge Water

Prepare 50 litres of challenge water per testing unit containing 50 000 oocysts/litre (or 5×10^4/litres), as follows:

a) Based on the initial count of the cysts (as given on the vial), prepare 100 ml to 150 ml of a working stock suspension using 0.01 percent polysorbate 20 as diluent, to obtain the target number of 50 000 oocysts/litre in 50 litres challenge water. Vials containing the cysts should be washed thrice with 0.01 percent polysorbate-20 followed by rinsing thrice with distilled water; and
b) Add the working stock of cysts to 50 litres of test water (**C-2**); mix well and aliquot a 100 ml sample of challenge water for analysis from the influent (feed water) tank.

D-1.2.1 *Analysis of Challenge Water Samples*

a) Assemble the membrane holder with 25 mm membrane filter in the filtration assembly and check that there is no leakage;
b) Filter 5 ml* of the challenge water sample and wash the membrane and holder with 1 ml of 0.01 percent polysorbate 20 followed by distilled water; and
c) Proceed for staining as per the manufacturer's instructions in the staining kit.

D-1.2.2 *Collection of Product Water Samples*

a) After flushing the test unit with tap water (TDS ≤ 500 mg/litre, turbidity ≤ 1 NTU, *p*H (7.5 ± 0.5), iron (< 0.3 mg/litre), connect the system to the influent challenge water feed at the maximum recommended inlet pressure and allow at least 10 litres of product water to filter and drain away with the product water storage tank tap open. Then close the storage tank tap and allow the tank to fill until automatic cut-off. (In direct flow models without storage tanks, allow 10 litres of

* This sample size is to get 20 to 200 oocysts on the final slide.

product water to flow out before collecting samples.);

b) Collect 1 litre of product water samples in triplicates from the delivery point of the system, in sample dilution bottles containing 1 ml of 1 percent polysorbate-20; and

c) All the samples should be refrigerated until analysis.

D-1.2.3 *Product Water Sample Analysis*

a) Assemble the membrane holder with 25 mm membrane filter in the filtration assembly;

b) Conduct a leak test to check that there is no leakage from the assembly by filling the assembly completely with distilled water and wait for 10 min. Make sure that the water does not come out from the filter;

c) In separate filter assemblies, filter 200 ml each from the 3 product water samples through a 25 mm membrane filter by applying vacuum (the sample size should be such that the final slide will have 20-200 cysts). Rinse the filtration assembly funnel with 0.01 percent polysorbate 20 followed by distilled water;

d) Proceed with staining as per the kit protocol; and

e) Observe and count the stained oocysts under 20/40x objective using a fluorescent microscope.

D-1.3 Results and Computation

Record the number of oocysts on the slides of challenge and product water samples and convert them into oocysts per liter of sample as follows:

a) Oocysts/litre of challenge water sample = No. of cysts in 5 ml of sample × 200
b) Oocysts/litre of product water sample = Average no. of cysts counted in the three 200 ml samples × 5

D-1.3.1 *Expression as log_{10} Value*

Cysts $\log_{10}$ reduction = $\log_{10}$ (cysts/L of input sample) − $\log_{10}$ (cysts/L of output sample)

The water purifier must demonstrate 3 $\log_{10}$ reduction in *Cryptosporidium* oocysts, which corresponds to 99.9 percent reduction.

D-2 REDUCTION OF MICROSPHERES

D-2.1 General

For water purification systems that rely on physical filtration processes (for example, exclusion and adsorption-based technologies), testing for the required log reduction of polystyrene microspheres may be used to demonstrate the ability to remove *Cryptosporidium* oocysts, if the use of inactivated cysts is not feasible. The polystyrene microspheres shall have 95 percent of particles in the range of (3.00 ± 0.15) µm. The spheres shall have a surface charge content of less than 2 µEq/g.

The RO systems tested should demonstrate a minimum of 3 $\log_{10}$ reduction (99.9 percent reduction).

D-2.2 Requirements

a) 0.1 percent polysorbate 20;

b) Neutral charged fluoresbrite YG carboxy microspheres (3.0 ± 0.15) µm (usually available as 5 ml vial containing minimum 1×10^{11} spheres/ml), or equivalent;

c) Membrane filters, 25 mm, 0.4/0.45 µm;

d) Filtration assembly with vacuum pump; and

e) Fluorescent microscope.

D-2.2.1 *Influent Challenge Water Preparation*

a) Prepare 50 litres of spike water per device containing 50 000 microspheres/litre (or 5×10^4/litre);

b) Based on microsphere counts/litre as provided by the supplier, prepare a working stock of 100 ml to 150 ml using 0.01 percent Polysorbate as diluent, for spiking 50 litres of water to achieve a final number as 50 000 microspheres/litre;

c) Add the working stock of microspheres to 50 litres of water; mix well and aliquot 100 ml sample of *influent challenge* water for analysis from the influent (feed water) tank; and

d) All the samples should be refrigerated until analysis.

D-2.2.2 *Challenge Water Sample Analysis*

a) Assemble the membrane holder with 25 mm membrane filter in the filtration assembly and check that there is no leakage;

b) Pass 10 ml of *challenge* water sample and wash the membrane and holder with 1 ml of 0.01 percent polysorbate 20 followed with distilled water;

c) Add a drop of mounting medium on a clean slide and keep the filter membrane on the slide and add cover slip;

d) Slides should be stored in a covered container (dry box, that is, in dark condition);

e) Slides should be observed microscopically within 5 days of preparation, after which the fluorochrome dye begins to fade; and

f) Observe the slide and count the spheres under 20/40x objectives, using a fluorescent microscope.

D-2.2.3 *Product Water Sample Collection*

a) After flushing the test unit with tap water (TDS ≤ 500 mg/litre, turbidity ≤1 NTU, *p*H (7.5 ± 0.5), iron (< 0.3 mg/litre), connect the system to the influent challenge water feed at the maximum recommended inlet pressure and allow at least 10 litres of product water to filter and drain away with the product water storage tank tap open. Then close the storage tank tap and allow the tank to fill until automatic cut-off. (In direct flow models without storage tanks, allow 10 litres of product water to flow out before collecting samples.);

b) Collect 1 litre of product water samples in triplicates from the delivery point of the system, in sample dilution bottles containing 1 ml of 1 percent polysorbate-20; and

c) All the samples should be refrigerated until analysis.

D-2.2.4 *Product Water Sample Analysis*

a) Place the membrane in the filtration assembly;

b) Conduct a leak test to check that there is no leakage from the assembly by filling the assembly completely with distilled water and wait for 10 min. Make sure that the water does not come out from the filter;

c) In separate filter assemblies, filter 200 ml each from the 3 output water samples through a 25 mm membrane filter by applying vacuum. Rinse the filtration assembly funnel with 0.01 percent polysorbate-20 followed by distilled water;

d) Add a drop of mounting medium on a clean slide and keep the filter membrane on the slide and add cover slip;

e) Slides should be stored in a covered container (dry box, that is, in dark condition);

f) Slides should be observed microscopically within 5 days of preparation; and

g) Observe and count the microspheres microscopically, as in **D-2.2.2**.

D-2.3 Calculation

D-2.3.1 *Microspheres per litre of Samples*

Record the microspheres on the slides of challenge and product water samples and calculate their numbers per litre of samples as follows:

a) Microspheres/litre of challenge water sample = No. of microspheres in 10 ml of sample × 100; and

b) Microspheres/litre of product water sample = No. of microsphere in 200 ml (average of 3 counts) of sample × 5.

D-2.3.2 *Expression as log_{10} Value*

Microsphere $\log_{10}$ reduction =

$\log_{10}$ (Microspheres/litre of challenge water sample) − $\log_{10}$ (Microspheres/litre of product water sample)

The RO system should demonstrate a minimum of 3 $\log_{10}$ reduction which corresponds to 99.9 percent reduction.

ANNEX E

(*Clause* 6.7)

HYDROSTATIC PRESSURE TEST

E-1 Hydrostatic pressure test of the completely assembled RO system shall be conducted in 3 stages, with differentiation of zones for different pressurization conditions (Refer Fig. 1 for Flow path of wall-mounted/table top Reverse Osmosis System and Fig. 2 for Flow path of under-counter Reverse Osmosis System).

E-2 TESTING OF ZONE 1

The components of the RO system from the inlet port up to the booster pump comprise the low-pressure zone. This zone shall be subjected to hydrostatic pressure at 1.5 times of the maximum input water pressure recommended by the manufacturer.

Before commencing the test, attach an open/close valve followed by a non-return valve (NRV) at a point before the end of the booster pump inlet. Connect the system to a test water trough using a manual pressurization pump.

Initially, purge the system with available tap water (< 1 NTU turbidity), allowing at least 2 litres to 3 litres of permeate water to flow. Then close the open/close valve and slowly increase the pressure at a constant rate to reach 1.5 times of maximum recommended pressure in 5 min. Hold at this pressure for 15 min, and observe the components and tubing at joints.

There shall not be any leakage of water, water bubbles or hissing noise when the pressurization is held for 15 min. Release the pressure by opening the open/close valve and turn off the pressurization pump.

E-3 TESTING OF ZONE 2

Zone 2 is the high-pressure zone, from the inlet of the booster pump up to the permeate outlet of the RO membrane and flow-restrictor or any other valve in the reject water line. This zone shall be tested at a pressurization of at least 1.5 times of the pressure exerted by the booster pump.

The testing laboratory shall initially measure the transmembrane pressure when the booster pump is switched on and accordingly calculate 1.5 times the pressure. This shall be the testing pressure. For hydrostatic testing of Zone 2, the pressurization shall be increased slowly at a constant rate to reach the testing pressure in 5 min and held at that pressure for 15 min.

There shall not be any leakage of water, water bubbles or a hissing sound, when the pressurization of Zone 2 is held for 15 min. Release the pressure by opening the open/close valve and turn off the pressurization pump.

E-4 TESTING OF ZONE 3

Zone 3 covers the path of the water from the inlet of any post-RO filter to the product water discharge outlet.

For RO systems that are open to atmosphere (Fig. 1), Zone 3 is to be pressurized at a moderate pressure of 0.2 MPa (30 psi).

For RO systems that have a hydro-pneumatics (pressurized) storage tank for product water (Fig. 2), Zone 3 is to be pressurized at 1.5 times the back pressure exerted by the tank.

The pressurization shall be increased slowly at a constant rate to reach the testing pressure in 5 min and held at that pressure for 15 min.

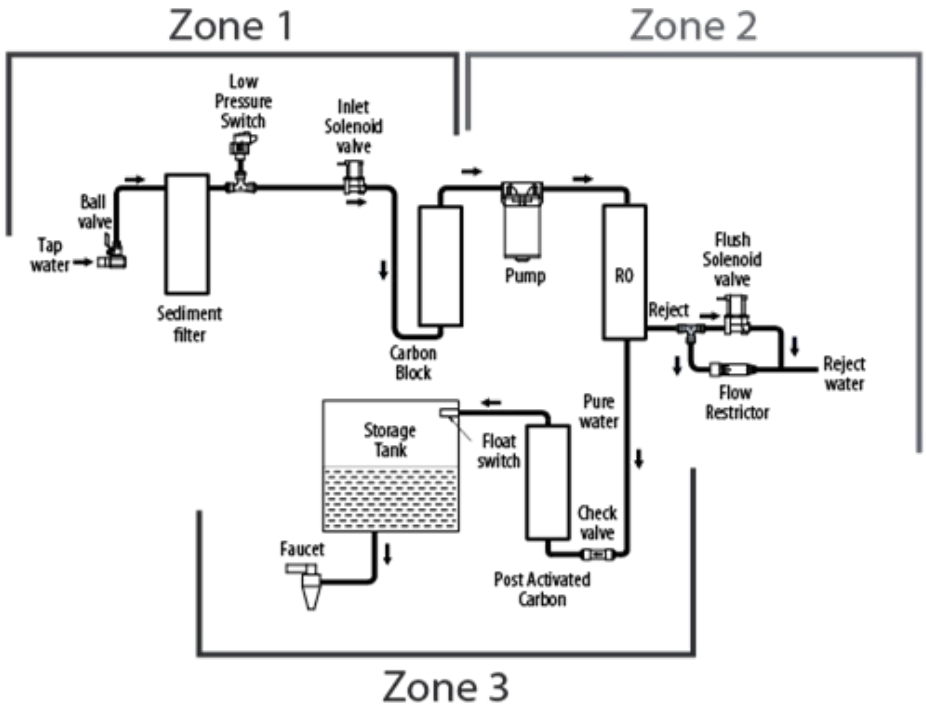
There shall not be any leakage of water, water bubbles or hissing noise, when the pressurization of Zone 3 is held for 15 min. Release the pressure by opening the open/close valve and turn off the pressurization pump.

E-5 TESTING OF HYDROPNEUMATICS STORAGE TANK

The testing requirement is 1.5 times the pressure of the tank declared by the manufacturer.

The pressurization has to be done by closing the water faucet or tap emerging from the tank. The pressurization shall be increased slowly at a constant rate to reach the testing pressure in 5 min and held at that pressure for 15 min.

There shall not be any leakage of water, water bubbles or hissing noise, from the storage tank inlet when pressurization is held for 15 min. Release the pressure by opening the open/close valve and turn off the pressurization pump.

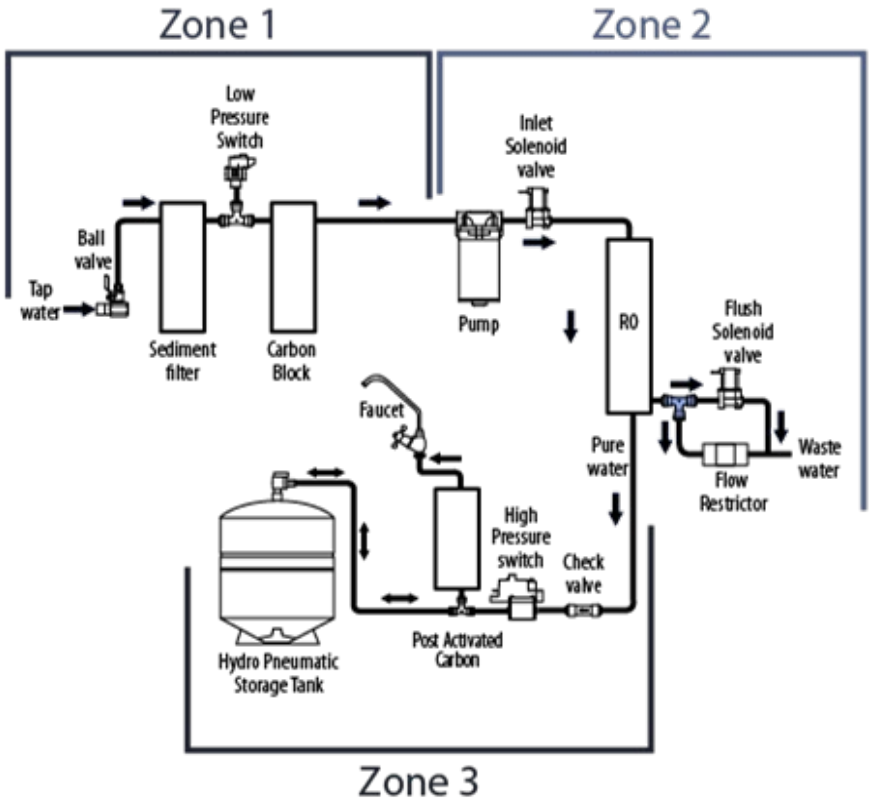


Zone 1: The test pressure up to booster pump shall be maintained at 1.5 times of the maximum input water pressure recommended by the manufacturer.

Zone 2: The test pressure is 1.5 times of the maximum pressure exerted by booster pump as per the manufacturer declaration.

Zone 3: As these systems are open to atmosphere tank designs, this zone of filters will be tested at the pressure of 0.2MPa (30psi = 2Kg/cm2).

FIG. 1 WATER FLOW PATH OF WALL MOUNT/TABLE TOP REVERSE OSMOSIS SYSTEM



Zone 1: The test pressure up to booster pump shall be maintained at 1.5 times of the maximum input water pressure recommended by the manufacturer.

Zone 2: The test pressure is 1.5 times of the maximum pressure exerted by booster pump as per the manufacturer declaration.

Zone 3: The test pressure is 1.5 times of the maximum pressure in the Hydropneumatic tank declared by the manufacturer.

FIG. 2 WATER FLOW PATH OF UNDER COUNTER REVERSE OSMOSIS SYSTEM

ANNEX F

(*Clause* 7)

SAMPLING PLAN FOR RO SYSTEM

F-1 Randomly select 4 sample units of Reverse Osmosis (RO) based Point-of-Use (PoU) water treatment system from the same batch. All RO systems of the same capacity produced under similar condition of manufacturing in a week shall constitute a batch. To ensure the randomness of selection, methods given in IS 4905 may be followed.

F-2 Use two units for microbiological reduction tests and two for chemical contaminants, TDS reduction testing, recovery rating and hourly production rate evaluation.

F-3 Conduct the testing for TDS reduction and recovery rating, chemical, and microbiological contaminants reduction, as per methods described in Annexes A, B and C respectively.

F-4 Collect influent and product water samples for analysis as per the sequence and frequency below.

F-5 Allow at least 10 litres of product water after every sequence to wash out the previous set of contaminants.

F-6 All water samples shall be collected in duplicates, although only one of which may be subjected to analysis, with the other being retained for verification if required.

Sl No.	*Parameters*	*Day 1*	*Day 2*	*Day 3*	*Day 4*	*Day 5*	*No. of Units Tested*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
i)	TDS	□	□	□	□	□	2 (new)
ii)	Recovery rating and hourly production rate	□	□	□	□	□	2
iii)	Inorganic contaminants	□	□	□	□	□	2
iv)	Pesticides	□	□	□	□	□	2
v)	Microbiological parameters						
	1) *E. coli*						2 (new)
	2) MS2 *Coliphage*	□	□	□	□	□	
		□	□	□	□	□	

ANNEX G
(*Foreword*)

COMMITTEE COMPOSITION

Water Purification Systems Sectional Committee, FAD 30

Organization	*Representative(s)*
CSIR - National Environmental Engineering Research Institute, Nagpur	DR P. K. LABHASETWAR (***Chairperson***)
Bhabha Atomic Research Centre, Mumbai	DR S. T. PANICKER SHRI T. K. DEY (*Alternate*)
Bhavan's Research Center (Microbiology), Mumbai	DR SANDHYA SHRIVASTAVA DR NISHITH DESAI (*Alternate*)
CSIR - Central Food Technological Research Institute, Mysore	DR UMESH HEBBAR SHRI KESHAVA MURTHY. P (*Alternate*)
CSIR-Central Salt and Marine Chemicals Research Institute, Bhavnagar	DR V. K. SHAHI
CSIR - Institute of Minerals and Materials Technology, Bhubaneswar	DR JAYANT KUMAR POTHAL SHRI DEBABRATA SINGH (*Alternate*)
CSIR - National Environmental Engineering Research Institute, Nagpur	DR NOOR AFSHAN KHAN DR PRANAV NAGARNAIK (*Alternate*)
Christian Medical College, Vellore	PROF VENKATA RAGHAVA MOHAN DR DILIP ABRAHAM (*Alternate*)
Confederation of Indian Industry, New Delhi	SHRI J. S. K. SRINIVASAN MS MAMTA ARORA BUDHIRAJA (*Alternate*)
Consumer Education and Research Centre, Ahmedabad	MS ANINDITA MEHTA MS KARUNA CHAUHAN (*Alternate*)
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Panel for reviewing the Indian Standard on Reverse Osmosis Based Point-of-Use Water Treatment System for Drinking Purposes, FAD 30/Panel 1

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