GOVERNMENT OF INDIA

भारत सरकार

MINISTRY OF RAILWAYS

रेल मंत्रालय

Guidelines

on

Water Purification

By

Reverse Osmosis(RO)

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Works Directorate

कार्य निदेशालय

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1.0 Introduction:

Water is essential for life. The amount of fresh water on earth is limited, and with the rapid industrialization, its quality is under constant pressure. Preserving the quality of raw water is important not only for the drinking-water supply, but also for food production and other water uses. Water quality can be compromised by the presence of infectious agents, toxic chemicals, and radiological hazards.

Water quality deterioration in distribution systems is mainly caused by inappropriate planning, design and construction or inadequate operation and maintenance and water quality control. This has been linked to a significant proportion of the burden of waterborne and water-related illness. Stresses on these systems caused by rapid urbanization, population growth and aging infrastructure further exacerbates the problems.

The integrity of well managed distribution systems is one of the most important barriers that protect drinking-water from contamination. However, management of distribution systems often receives little attention. Distribution systems can incorrectly be viewed as passive systems with the only requirement being to transport drinking-water from the outlets of treatment plants to consumers.

Hence it is the prime responsibility of Civil Engineering Department to arrange adequate and safe supply of water of acceptable quality to Railway premises as well Railway stations for the passengers.

2.0 Selection of water purification system :

In Indian Railway, normally underground water is drawn through deep tubewell to provide the safe drinking water to Railway premises. But where the extraction of underground water is not feasible and other sources of water not readily available, the treated water is been taken through municipal corporation of that area. Although Standards on the quality of drinking water has been laid down by organizations like BIS, ISO, Ministry of Drinking water & sanitation/Govt. of India etc., no standards has been laid regarding selection of appropriate/adequate purification system of water. Standards of quality of drinking water as per IRWM Annexure 5.2 Para 531 (physical and chemical standards) and Indian Standard - Drinking water - Specification (First Revision) IS: 10500 - 2012 is as under:

S.No.	Characteristics	Requirement (Desirable limit)	Permissible limit in the absence of alternate source
1	Turbidity (NTU scale)	1	5
2	Colour Hazen units	5	15
3	Taste and odour	agreeable	agreeable
4	Ph value	6.5 to 8.5	No relaxation
5	Total dissolved solids (mg/l) max.	500	2000
6	Total hardness as CaCo3(mg/l) max	200	600
7	Chlorides as Cl2(mg/l)	250	1000
8	Sulphates as SO4 (mg/l) max.	200	400**
9	Fluorides as F (mg/l)max.	1.0	1.5
10	Nitrates as NO3 (mg/l)max.	45	No relaxation
11	Calcium as Ca (mg/l) max.	75	200
12	Iron as Fe (mg/l) max.	0.3	No relaxation
13	Zinc as Zn (mg/l) max.	5.0	15.0
14	Mineral Oil (mg/l)max	0.5	No relaxation
15	Copper as Cu (mg/l) max.	0.05	1.5
16	Residual free Chlorine (mg/l) max	0.2*	1.0
	Toxic materials		
17	Arsenic as As (mg/l) max.	0.01	0.05
18	Cadmium as Cd (mg/l) max.	0.003	No relaxation
19	Lead as Pb (mg/l) max.	0.01	No relaxation

*When protection against viral infection is required, it should be min. 0.5 mg/l.

** Provided Magnesium (as Mg) does not exceed 30 mg/l.

Centre for Disease Control & Prevention, Atlanta (http://www.cdc.gov/healthywater) has issued a Guide to Drinking Water Treatment Technologies for Household, which is as under:

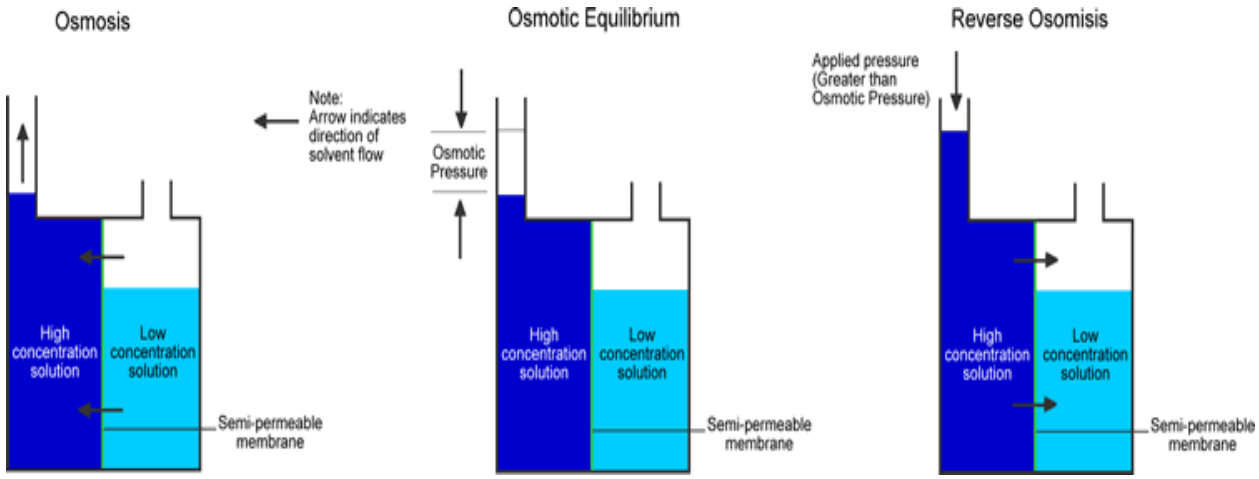
S.No.	Point of Use technologies that may remove small/ all contaminants	Water Contaminants			
		Protozoa	**Bacteria**	**Viruses**	**Chemicals**
1.	**Filtration**				
a)	Microfiltration (approx. 0.1micron)	Very high effective	Moderate effective	Not effective	Not effective
b)	Ultra-filtration (approx. 0.01micron)	Very high effective	Very high effective	Moderate effective	Low effective
c)	Nano-filtration (approx. 0.001micron)	Very high effective	Very high effective	Very high effective	Moderate effective
2.	**Reverse Osmosis (RO) Systems**	Very high effective	Very high effective	Very high effective	***Will remove common contaminants*** (metal ion, aqueous salts), including sodium chloride , copper, chromium , and lead; ***also reduce*** arsenic, fluoride, radium, sulfate, calcium , magnesium, potassium, nitrate, fluoride and phosphorus.
3.	**Distillation Systems**	Very high effective	Very high effective	Very high effective	Will reduce most common chemical contaminants , including arsenic, barium, chromium, lead, nitrate, sodium, sulfate and many organic chemicals
4.	**Ultraviolet Treatment Systems**	Very high effective	Very high effective	high effective	Not effective
5.	**Water Softeners**	Ion exchange technology for chemical or ion removal to reduce the amount of hardness (calcium, magnesium) in the water , can also be designed to remove iron and manganese, heavy metals, some radioactivity, nitrates, arsenic, chromium, selenium and sulfates; does not protects against protozoa, bacteria and viruses.			

3.0 Reverse Osmosis (**RO**) is a water purification technology that uses a semi-permeable membrane. This membrane technology is not exactly a filtration method. In reverse osmosis, an applied pressure is used to overcome osmotic pressure, a colligative property that is driven by chemical potential which is a thermodynamic parameter. Reverse osmosis through a semi-permeable membrane can remove many types of molecules and ions from solutions, and is used in both industrial processes and the production of potable water.

Reverse osmosis is most commonly known for its use in drinking water purification from seawater and those areas where water contamination includes viruses and chemicals like metal ions, lead, arsenic, fluoride, radium, sulfate, magnesium, potassium, nitrate, fluoride and phosphorus.

4.0 Working of RO (Reverse Osmosis) :

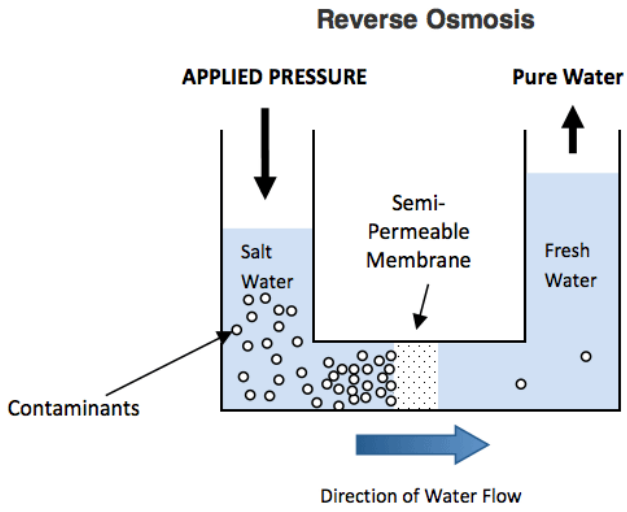
Reverse Osmosis works by using a high pressure pump to increase the pressure on the salt side of the RO and force the water across the semi-permeable RO membrane, leaving almost all (around 95% to 99%) of dissolved salts behind in the reject stream. The amount of required pressure depends on the salt concentration of the feed water. The more concentrated the feed water, the more pressure is required to overcome the osmotic pressure.



The desalinated water that is de-mineralized or de-ionized, is called permeate (or product) water. The water stream that carries the concentrated contaminants that did not pass through the RO membrane is called the reject (or concentrate) stream. *From the data collected from Reverse Osmosis System manufacturers, normally 40-60% water is rejected during the Reverse Osmosis process.*

Reverse Osmosis membrane has a tight pore structure (less than 0.0001 micron) that effectively removes up to 99% of all contaminants and impurities such as total dissolved solids, chemicals, bacteria and viruses from drinking water. Anti-microbial filters used in Reverse Osmosis also help to remove unwanted odors, colors and tastes from water.

Reverse Osmosis Systems have a very high effectiveness in removing protozoa, bacteria and viruses in comparison to other systems. Reverse Osmosis Systems can also remove common chemical contaminants (metal ions, aqueous salts), including sodium, chloride, copper, chromium, lead and can reduce arsenic, fluoride, radium, sulfate, calcium, magnesium, potassium, nitrate, and phosphorous.



Reverse Osmosis is capable of removing up to 99%+ of the dissolved salts (ions), particles, colloids, organics, bacteria and pyrogens/pathogens from the feed water (although an RO system should not be relied upon to remove 100% of bacteria and viruses). Reverse osmosis removes impurities by two distinct mechanisms. One is based on resistance to passage of ions, due to their electrical charge. This mechanism is responsible for removal of ionic impurities. Even the smallest molecules are rejected if they have ionic charge. The efficiency of removal by this mechanism is in the range of 96-99%, but this depends on the particular membrane and the ionic charge. The other mechanism of impurity removal is based on the ultrafiltration effect, in which the small pores of the reverse osmosis membranes act like molecular filters. The cut-off molecular size is approximately 14-20 nanometers. Any impurity whose molecular size is above the cut-off point will be rejected almost completely. Any impurity whose molecular size is below the cut-off point will pass through almost totally. Few organics have molecular size below 14-20 nanometers. Examples are: methanol, formaldehyde, formic acid, and ethanol.

Since RO membrane rejects contaminants based on their size and charge, many gases like carbon dioxide, hydrogen sulfide, methane, and ethane that are not ionized (charged) also have very low molecular weight will pass through reverse osmosis. Any contaminant that has a molecular weight greater than 200 is likely rejected by a properly running RO system. Because an RO system does not

remove gases, the permeate water can have a slightly lower pH level depending on CO2 levels in the feed water as the CO2 is converted to carbonic acid. Some pesticides, solvents and volatile organic chemicals (VOCs) are also not removed by RO.

5.0 Types of RO Membranes:

Two materials make up the bulk of commercial RO membranes, cellulose acetate and an aromatic polyamide. Aromatic polyamide is also commercially called **thin film composite membranes.**

CTA (Cellulose Triacetate) membrane is a paper by-product membrane bonded to a synthetic layer and these require a small amount of chlorine in the water source to prevent bacteria from forming on it.

TFC (Thin Film Composite) membrane is made of a synthetic material, and requires chlorine to be removed before the water enters the membrane as chlorine causes irreversible damage to a thin film membrane element. These membranes are stronger and can be used at a higher temperature (45°C) than cellulose acetate (35°C).

The general characteristics of reverse osmosis membranes available in the market are described below:

	Limitations of various parameters	**Cellulose acetate membranes**	**Cellulose triacetate membranes**	**Thin film composite membranes**
1.	pH	pH 2 - 8	pH 4 - 9	pH 2 - 11
2.	Temperature	5°C - 30°C	5°C - 35°C	5°C - 45°C
3.	Resistance to bacterial attack	poor	fair/good	excellent
4.	Resistance to damage by chlorine	fair (0 - 1 ppm)	good (0 - 3 ppm)	poor (0 - 0.1 ppm)
5.	Typical rejection of salts at 60 psi	85% - 92%	92% - 96%	94% - 98%
6.	Typical rejection of nitrate at 60 psi	30% - 50%	40% - 60%	70% - 90%
7.	Typical treated water production at 60 psi	40 liter/m^2 of membrane/day	40 liter/m^2 of membrane/day	80 liter/m^2 of membrane/day
8.	Turbidity allowed in feed water	none	none	none
9.	Iron allowed in feed water	1ppm	1ppm	0.1ppm
10.	Relative cost	low	medium	high

6.0 Main Components of Reverse Osmosis System :

6.1 Dual Media Filter: This removes the total suspended solids, dirt, iron and reduce silt. The raw water from the source is taken to Dual Media Filter (DMF) where all the suspended solids are removed with the help of filter bed. The filter require backwash when differential pressure goes above 0.5Kg/cm^2 or when it stops giving desired output or after pre-decided time interval.

6.2 Activated Carbon Filter: Filtered water from dual media filter is fed to activated carbon filter in order to remove free chlorine, organic compounds, colour and smells. The filter require backwash when differential pressure goes above 0.5Kg/cm^2 or when it stops giving desired output or after pre-decided time interval.

6.3 Anti-scalant Dosing System: The commonly used reverse osmosis (RO) membranes consist of a polyamide salt-rejecting film on a poly-sulphone base. The very thin surface layer of polyamide (up to 3 µ m) provides the semi-permeable and salt-rejecting properties to the membrane. RO systems create salt concentrated water streams on rejection sides that could produce scale or fouling on the membrane. This may lead to blocking of the flow channels in the membrane. The anti-scalant chemical is added online to protect the membrane from scaling/ fouling formation.

6.4 Reverse Osmosis Membrane: Reverse Osmosis is the tightest possible membrane process in liquid/ liquid separation. In principle, water should be the only material passing through the membrane and essentially all dissolved and suspended material is rejected. The Reverse Osmosis Membrane is the heart of the system. The most commonly used is a spiral wound of which there are two options: the CTA (cellulose tri-acetate), which is chlorine tolerant but of lower service life, and the TFC (thin film composite/material), which is not chlorine tolerant but higher service life.

Advanced reverse osmosis technology uses "cross flow" that allows a partially permeable membrane to clean itself continuously. As some of the fluid passes through the membrane, the rest continues downstream, sweeping the rejected species away from it. The process requires a pump to push the fluid through the membrane. The higher the pressure, the larger the driving forces.

As concentration of the fluid being rejected increases, so does the driving force. Reverse osmosis is used to reject bacteria, salts, sugars, proteins, particles, dyes, and other constituents. Separation of ions with reverse osmosis is aided by charged particles. This means that dissolved ions that carry a

charge, such as salts, are more likely to be rejected by the membrane .The larger the charge and the particle; the more likely it will be rejected.

6.5 Ultraviolet System: Sunlight has long since been known to kill micro-organisms. The rays from the sun contain the UV spectrum which is being used in Ultraviolet Water Treatment Systems – although at much lower intensities. It is also referred to as the Germicidal Spectrum/frequency. The frequency used in killing micro-organisms is 254 nanometers (nm). The UV lamps used for this purpose are designed specifically to have the highest amount of UV energy at this frequency.

7.0 Specification of Reverse Osmosis (RO) Plant: The technical specification of Reverse Osmosis (RO) Plant can generally be as under or as decided by tendering authority.

7.1 ***General features***:

i) The system shall be completely assembled, pre-piped, pre-wired and preferably skid mounted.

ii) The system shall have microprocessor based control panel for ease of operation and inbuilt process logic.

iii) The system shall have auto start/ stop based on water level in the supply tank.

iv) The system shall be equipped with Electrical panel/ MCB for plant protection and shall have integrated raw water pump with the unit.

v) The system shall have integrated pretreatment modules for removal of suspended solids along with pressure gauge.

vi) The system shall have inbuilt protection to high pressure pump by way of low/high pressure switch.

vii) The system shall have the membrane of General Electric (GE) or Hydranutics make. Glycerin filled Stainless Steel pressure gauge shall be provided for durability. Online rotameter shall be provided for measuring flow. Blending cartridge shall be provided to adjust taste/TDS and followed by UV disinfection for total safety. System should have automatic backwashing of filters.

viii) The system shall be capable of working 24hrs.x365 days by using the semi treated water provided through Borewell / Municipal water supply.

ix) Recovery of water (i.e. component of treated water) shall be in range of **40%-60%.** If desired, the waste/ rejected water may be separately stored by using suitable pump. This water may be used for cleaning, gardening or toilet purpose.

7.2 ***Technical features***:

S. No.	Description		RO Plant Specifications depending upon capacity			
			250 LPH Capacity	**500 LPH Capacity**	**1000 LPH Capacity**	**2000 LPH Capacity**
1.	**RAW WATER FEED PUMP**	Type	Centrifugal	Centrifugal	Centrifugal	Centrifugal
		Flow rate	1500 Litres/Hour	1500 Litres/Hour	2000 Litres/Hour	3300 Litres/Hour
		Discharge Capacity	2.5 kg/cm^2 (min.)	2.5 kg/cm^2 (min.)	2.5 kg/cm^2 (min.)	2.5 kg/cm^2 (min.)
		Motor Rating	0.5 HP (min.)	1.0 HP (min.)	1.0 HP (min.)	2.0 HP (min.)
		Electricity	220 V, Single phase	220 V, Single phase	220 V, Single phase	415 V, Three phase
		Quantity	1	1	1	1
		Make	KBL, KSB, Shakti or equivalent	KBL, KSB, Shakti or equivalent	KBL, KSB, Shakti or equivalent	KBL, KSB, Shakti or equivalent
2.	**Pressure Sand Filter (PSF) {For capacity below 500LPH}**	Capacity	1500 Litres/Hour	1500 Litres/Hour	Not applicable	Not applicable
		Min. Operating Pressure	1.5 kg/cm2	1.5 kg/cm2	Not applicable	Not applicable
		Media	Support bed + Carbon	Support bed + Carbon	Not applicable	Not applicable
		Quantity	1	1	Not applicable	Not applicable
2A.	**DUAL MEDIA FILTER (DMF) {For capacity above 500LPH}**	Capacity (min.)	Not applicable	Not applicable	2000 Litres/Hour	3300 Litres/Hour
		Operating Pressure(Min)	Not applicable	Not applicable	3.5 kg/cm^2	3.5 kg/cm^2
		Type of Valve	Not applicable	Not applicable	Single-multiport	Single-Multiport
		Media	Not applicable	Not applicable	Anthracite* + Support Bed.	Anthracite + Support Bed.
		Bed depth (min.)	Not applicable	Not applicable	800mm	800mm
		Quantity	Not applicable	Not applicable	1	1
		Vessel Make	Pentair, wave or Equivalent	Pentair, wave or Equivalent	Pentair, wave or Equivalent	Pentair, wave or Equivalent

* Anthracite coating on sand particles improve the dirt holding capacity of filter media.

3.	**ACTIVATED CARBON FILTER (ACF)**	Capacity	1000 Litres/Hour	1200 Litres/Hour	2000 Litres/Hour	3500 Litres/Hour
		Min. Operating Pressure	1.5 kg/cm^2	1.5 kg/cm^2	1.5 kg/cm^2	1.5 kg/cm^2
		Media	Activated Carbon + sand	Activated Carbon + sand	Activated Carbon + sand	Activated Carbon + sand
		Quantity	1	1	1	1
		Vessel Make	Pentair, wave Ion Exchange or Equivalent	Pentair, wave Ion Exchange or Equivalent	Pentair, wave Ion Exchange or Equivalent	Pentair, wave Ion Exchange or Equivalent
4.	**Antiscalant Dosing System**	**Dosing Pump**				
		Type	Electro-magnetic	Electro-magnetic	Electro-magnetic	Electro-magnetic
		Capacity	1.5 Litres/Hour	1.5 Litres/Hour	1.5 Litres/Hour	1.5 Litres/Hour
		Discharge Pressure	4 kg/cm^2	4 kg/cm^2	4 kg/cm^2	4 kg/cm^2
		Quantity	1	1	1	1
		Make	E dose, hydra-cell, Sandur or Equivalent	E dose, hydra-cell, Sandur or Equivalent	E dose, hydra-cell, Sandur or Equivalent	E dose, hydra-cell, Sandur or Equivalent
		Dosing Tank				
		Capacity	100 Litres	100 Litres	100 Litres	100 Litres
		Material of Const.	HDPE	HDPE	HDPE	HDPE
		Quantity	1	1	1	1
		Make	Sintex, WimPlast or Equivalent	Sintex, WimPlast or Equivalent	Sintex, WimPlast or Equivalent	Sintex, WimPlast or Equivalent
5.	**Micron Cartridge Filter (For removing suspended particles >5 micron)**	Capacity	1000 Litres/Hour	1200 Litres/Hour	2000 Litres/Hour	3300 Litres/Hour
		Material of Cartridge	Polypropylen	Polypropylen	Polypropylen	Polypropylen
		Filter Rating	5 micron	5 micron	5 micron	5 micron
		Length	10”	20”	20”	20”
		Quantity	1	1	1	1
		Make	Pratham, Aquapuro or Equivalent	Pratham, Aquapuro or Equivalent	Pratham, Aquapuro or Equivalent	Pratham, Aquapuro or Equivalent

6.	**High Pressure Pump**	Type of Pump	Vertical Multistage centrifugal	Vertical Multistage centrifugal	Vertical Multistage centrifugal	Vertical Multistage centrifugal
		Capacity	1000 Litres/Hour	1200 Litres/Hour	2000 Litres/Hour	3300 Litres/Hour
		Discharge Pressure (Max.)	11 kg/cm^2	13 kg/cm^2	13 kg/cm^2	13 kg/cm^2
		Material of Construction	SS 304	SS 304	SS 304	SS 304
		Electricity	220 V, Single phase	220 V, Single phase	220 V, Single phase	415 V, Three phase
		Quantity	1	1	1	1
		Make	Nanfang, CRI, Yuken or Equivalent	Nanfang, CRI, Yuken or Equivalent	Nanfang, CRI, Yuken or Equivalent	Nanfang, CRI, Yuken or Equivalent
7.	**Reverse Osmosis Membrane**	Permeate capacity	250 Litres/Hour	500 Litres/Hour	1000 Litres/Hour	2000 Litres/Hour
		Membrane Type	Spiral wound TFC-polyamide	Spiral wound TFC-polyamide	Spiral wound TFC-polyamide	Spiral wound TFC-polyamide
		Size	Dia. 4" X 40" long	Dia. 4" X 40" long	Dia. 4" X 40" long	Dia. 4" X 40" long
		No. of Membrane	1	2	5	9
		No. of Membrane Housing	1	2	2	3
		Skid Material of Construction	Mild Steel – Powder Coated	Mild Steel – Powder Coated	Mild Steel – Powder Coated	Mild Steel – Powder Coated
		Make of Membrane	Gen. Electric, Hydronautics or Equivalent	Gen. Electric, Hydronautics or Equivalent	Gen. Electric, Hydronautics or Equivalent	Gen. Electric, Hydronautics or Equivalent
8.	**UV system**	Capacity	250 Litres/Hour	500 Litres/Hour	1000 Litres/Hour	2000 Litres/Hour
		Quantity	1	1	1	1
		Make	Sukrut or Equivalent	Sukrut or Equivalent	Sukrut or Equivalent	Sukrut or Equivalent
9.	**Instrument List**	**A) Pressure gauges**	3 Nos.	3 Nos.	5 Nos.	5 Nos.
		Range	0 – 21 bar	0 – 21 bar	0 – 21 bar	0 – 21 bar
		Dail Size	4 inches	4 inches	4 inches	4 inches
		Type	Bourdon	Bourdon	Bourdon	Bourdon

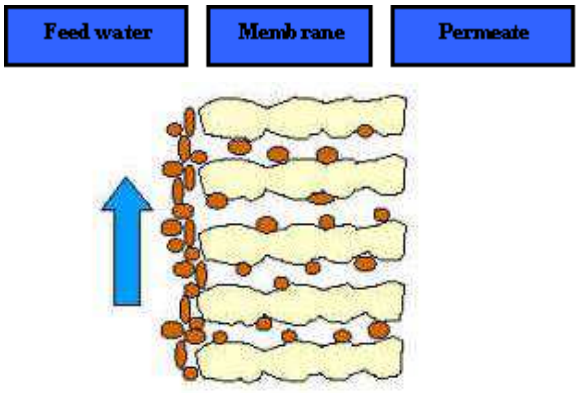
		B)Pressure switches	2 Nos.	2 Nos.	2 Nos.	2 Nos.
		Range	0-450 psi	0-450 psi	0-450 psi	0-450 psi
		C)Conductivity meter	1 (Panel Mounted)	1 (Panel Mounted)	1 (Panel Mounted)	1 (Panel Mounted)
		D) Rotameter	2	2	2	2
		E)Level switch	2	2	2	2
		F) Digital TDS Meter	1	1	1	1
10.	**Electrical Control Panel**	A)Starters, overload relays, single/three phase controller for pump	Should be provided of adequate capacity Havells/Anchor/ Equivalent	Should be provided of adequate capacity Havells/Anchor/ Equivalent	Should be provided of adequate capacity Havells/Anchor/ Equivalent	Should be provided of adequate capacity Havells/Anchor/ Equivalent
		B)Voltmeter, Ammeter, MCB's	Should be provided of adequate capacity	Should be provided of adequate capacity	Should be provided of adequate capacity	Should be provided of adequate capacity
		C)PLC & Touch Panel	Should be provided	Should be provided	Should be provided	Should be provided
		D) Feed/ Product water conductivity meter	Should be provided	Should be provided	Should be provided	Should be provided
11.	**pH Correction Dosing Tank** (Optional, as per requirement)	**Dosing Pump**				
		Quantity	1	1	1	1
		Type	Electro-magnetic	Electro-magnetic	Electro-magnetic	Electro-magnetic
		Capacity	0-1.5 LPH	0-1.5 LPH	0-1.5 LPH	0-1.5 LPH
		Discharge Pressure	2 kg/cm^2	2 kg/cm^2	2 kg/cm^2	2 kg/cm^2
		Make	E dose, hydra-cell, Sandur or Equivalent	E dose, hydra-cell, Sandur or Equivalent	E dose, hydra-cell, Sandur or Equivalent	E dose, hydra-cell, Sandur or Equivalent
		Dosing Tank				
		Capacity	50 Litres	50 Litres	50 Litres	50 Litres
		Material	HDPE	HDPE	HDPE	HDPE
		Make	Sintex, wimplast or Equivalent	Sintex, wimplast or Equivalent	Sintex, wimplast or Equivalent	Sintex, wimplast or Equivalent

8.0 RO Membrane Cleaning:

RO membranes will inevitably require periodic cleaning, anywhere from 1 to 3 times a year depending on the feed water quality. As a general rule, if the normalized permeate flow has decreased by 15% then it is time to clean the RO membranes. There are several different membrane cleaning methods, such as forward flush, backward flush and air flush. Chemicals may also be added in order to aid flushing.

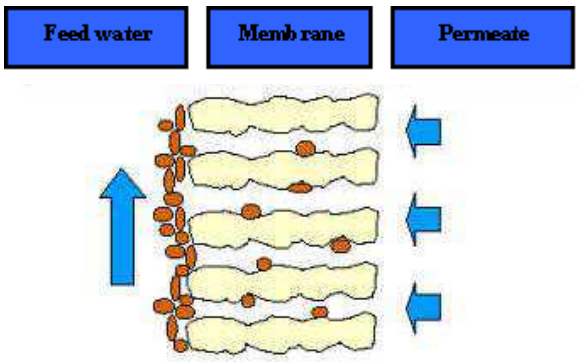
Forward flush

When forward flush is applied, membranes are flushed with feed water in forward direction. The feed water or permeate flows through the system more rapidly than during the production phase. Because of the more rapid flow and the resulting turbulence, particles that are absorbed to the membrane are released and discharged. The particles that are absorbed to membrane pores are however not released. These particles can only be removed through backward flushing.



Backward Flush

Backward Flush is a reversed filtration process. Permeate is flushed through the feed water side of the system under pressure. When backward flush is applied the pores of a membrane are flushed inside out. The pressure on the permeate side of the membrane is higher than the pressure within the membranes, causing the pores to be cleaned.



Air Flush or Air/Water Flush

A newer cleaning method is the so-called air flush or air/ water flush. This is a forward flush during which air is injected in the supplier pipe. Because air is used, causing air bubbles to form, which cause a higher turbulence. Because of this turbulence the fouling is removed from the membrane surface.

Chemical Cleaning

During a chemical cleaning process, membranes are soaked with a solution of chlorine bleach, hydrochloric acid or hydrogen peroxide. First the solution soaks into the membranes for few minutes and after that a forward flush or backward flush is applied, causing the contaminants to be rinsed out. RO membrane cleaning involves low and high pH cleaners to remove contaminants from the membrane. Scaling is addressed with low pH cleaners and organics, colloidal and bio-fouling are treated with a high pH cleaner. Cleaning RO membranes is not only about using the appropriate chemicals. There are many other factors involved such as flows, water temperature and quality. Hence properly designed cleaning skids and an experienced service group must be ensured for proper cleaning of RO membranes.

9.0 Maintenance of Reverse Osmosis (RO) Plant : Besides periodical cleaning of RO membrane, the maintenance and servicing of the Reverse Osmosis (RO) Plant shall consisting of following:

1. Micron Filter should be replaced during every servicing.
2. Cleaning of Sand filter.
3. Cleaning of Activated Carbon Filter
4. Anti scaling dosing chemical (As per requirement)
5. Raw water pump (Checking/servicing, if required)
6. R.O. Membrane (Checking/ Replacement, if required)
7. High pressure pump (Checking/servicing, if required)
8. Checking of flow rate of membrane & TDS on site

Following items/parts may require replacement during the service period of Reverse Osmosis (RO) Plant:

S.No.	Description of item	Present market cost	Frequency of replacement
1.	Membrane	Rs. 22,170/- per candle	1 Year (normally)
2.	Micron Filter	Rs. 260/- per candle	During every servicing i.e. 6 times annually
3.	Anti-scalant Chemical	Rs. 6,620/- per pack	1 Year (normally)

10.0 Cost of RO system & Annual Maintenance (AMC) Charges: The cost of RO system & Annual Maintenance Charges collected from some manufacturers are as under:

S. No.	Description of Item	Manufacturer	250 LPH Capacity	500 LPH Capacity	1000 LPH Capacity	2000 LPH Capacity
1.	**Supply & Installation Cost (Rs.)**	Western region based	1,89,000/-	2,70,000/-	3,60,000/-	-
		Northern region based	1,78,000/-	2,12,000/-	2,98,000/-	4,13,000/-
		Pan India Presence	2,35,000/-	2,75,000/-	5,80,000/-	7,05,000/-
2.	**AMC (Labour) charges (Rs.)**	Western region based	37,800/-	54,000/-	72,000/-	-
		Northern region based	20,000/-	30,000/-	37,500/-	48,600/-
		Pan India Presence	9,110/-	9,110/-	9,700/-	10,000/-
3.	**Consumables (Annual in normal working condition)**	Membrane	1 no. 22,170/-	2 nos. 22170x2= 44,340/-	5 nos. 22170x5= 1,10,850/-	9 nos. 22170x9= 1,99,530/-
		Micron Filter	1 no. in each servicing 260x6= 1,560/-	2 no. in each servicing 260x6x2= 3,120/-	2 no. in each servicing 260x6x2= 3,120/-	2 no. in each servicing 260x6x2= 3,120/-
		Anti-scalant Chemical	1 packet 6,620	2 packet 6,620x2= 13,240/-	2 packet 6,620x2= 13,240/-	2 packet 6,620x2= 13,240/-
		Total Consumables Cost (Annually)	Rs. 30,350/-	Rs.60,700/-	Rs. 1,27,210/-	Rs. 2,15,890/-

11.0 Cost Analysis for per litre of treated water:

Cost per litre of RO treated water is assessed as under. **Since normal drinking water acts as feed water for RO system, water extraction cost is excluded in this calculation.**

A - For 2000 LPH supply RO system

i) Cost of unit- Rs. 7,05,000/-

ii) Electricity Requirement - 6.25KW = 6.25x16 = 100KW (Assuming 16Hrs. working daily. Power consumption by the equipment is taken as provided by manufacturer)

iii) Electricity charges @ Rs.8.36/- per KW for 365 days = 100x365x8.36 = Rs.3,05,140/-

iv) Labour AMC cost for year - 10,000/-

v) Consumables (Assuming normal service requirement) – Rs. 2,15,890/-

Assuming life of RO system as 5 Years, Annual cost of one unit - Rs.1,41,000.00

Total cost involved for a year= Rs. 1,41,000.00 + Rs. 3,05,140.00+ Rs. 10,000.00 + Rs. 2,15,890.00
= Rs. 6,72,030.00

Cost of per liter RO treated water = Rs. $\frac{6,72,030.00}{2000x16x365}$ = **Rs. 0.06 per liter**

B - For 1000 LPH supply RO system :

i) Cost of unit- Rs. 5,80,000/-

ii) Electricity Requirement - 4.25KW = 4.25x16 = 68KW (Assuming 16Hrs. working daily. Power consumption by the equipment is taken as provided by manufacturer)

iii) Electricity charges @ Rs.8.36/- per KW for 365 days = 68x365x8.36 = Rs.2,07,495/-

iv) Labour AMC cost for year - 9,700/-

v) Consumables (Assuming normal service requirement) – Rs.127210/-

Assuming life of RO system as 5Years, annual cost of one unit - Rs.1,16,000.00

Total cost involved for a year= Rs. 1,16,000.00 + Rs. 2,07,495.00+ Rs. 9,7000.00 + Rs.127210.00
= Rs. 4,60,405.00

Cost of per liter RO treated water = Rs. $\frac{4,60,405.00}{1000x16x365}$ = **Rs. 0.08 per liter**

C - For 500 LPH supply RO system :

i) Cost of unit- Rs. 2,75,000/-

ii) Electricity Requirement - 3.25KW = 3.25x16 = 52KW (Assuming 16Hrs. working daily. Power consumption by the equipment is taken as provided by manufacturer)

iii) Electricity charges @ Rs.8.36/- per KW for 365 days = 52x365x8.36 = Rs.1,58,673/-

iv) Labour AMC cost for year - 9,110/-

v) Consumables (Assuming normal service requirement) – Rs.60,340/-

Assuming life of RO system as 5Years, annual cost of one unit - Rs.55,000.00

Total cost involved for a year= Rs. 55,000.00 + Rs. 1,58,673.00+ Rs. 9,110.00 + Rs. 60,340.00
= Rs. 2,83,123.00

Cost of per liter RO treated water = Rs. $\frac{2,83,123.00}{500x16x365}$ = **Rs. 0.10 per liter**

D - For 250 LPH supply RO system :

i) Cost of unit- Rs. 2,35,000/-

ii) Electricity Requirement - 1.25KW = 3.25x16 = 20KW (Assuming 16Hrs. working daily. Power consumption by the equipment is taken as provided by manufacturer)

iii) Electricity charges @ Rs.8.36/- per KW for 365 days = 20x365x8.36 = Rs.61,028/-

iv) Labour AMC cost for year - 9,110/-

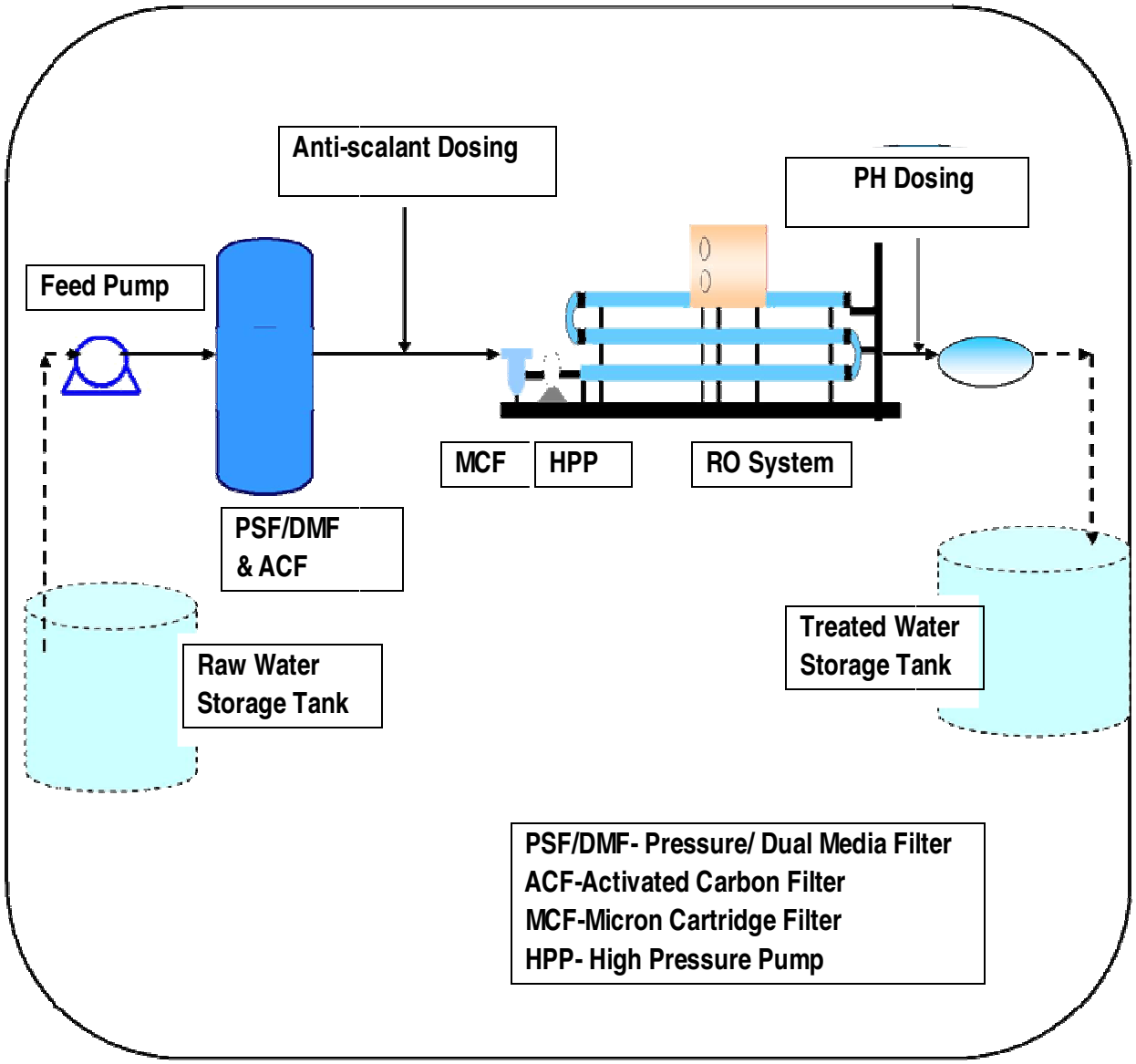
v) Consumables (Assuming normal service requirement) – Rs.30,350/-

Assuming life of RO system as 5Years, annual cost of one unit - Rs.47,000.00

Total cost involved for a year= Rs. 47,000.00 + Rs. 61,028.00+ Rs. 9,110.00 + Rs. 30,350.00
= Rs. 1,47,488.00

Cost of per liter RO treated water = Rs. $\frac{1,47,488.00}{250x16x365}$ = **Rs. 0.10 per liter**

12.0 SCHEMATIC DIAGRAM OF RO PLANT :



ANNEXURE

List of reputed manufacturer of RO Plant

1- **Eureka Forbes Limited** (Pan India Presence)
NASEOH, 3RD Floor, Postal Colony Road, Mumbai 400071(India)
Website: www.eurekaforbes.com
Euro Helpline : 3988 3333

2- **SHREYANS WATER ENGINEERS**
153, Shukan Mall, Science City Road, Sola,
Ahmedabad 380060, Gujarat, India
Mob: +91 90999 89280
www. Sreyanswater.com

3- **Aqua Royal Engineering**
21 Veer Savarkar block Shakar pur, Delhi 110092
Tel.: +91-9313967292, 011-22452578.
E-mail:-aquaroyal2011@gmail.com, info@aquaroyalengg.com
Web site:-www.aquaroyalengg.com

4- **Saffire Spring RO System**
Plot No. 30, Bardoli-Palsana Road, Nandida Chowkdi, Bardoli
Surat - 394601, Gujarat, India
Call: 08373902529
Tel: +(91)-(2622)-223104
Website: http://www.rosystemmanufacturer.com/

5- **Megha Home Appliences**
42/101, Dum Dum Road, Kolkata - 700074.
Phone: 91 - 33 - 65198318
Mobile: 09831024793
Email: info@meghawatertreatment.com
meghahomeappliances@gmail.com

6- **GREEN ENVIRO SOLUTIONS (RO SPARES & TREATMENT CHEMICALS)**
Mr. D.Thiyagarajan.
1/1267, Avinashi Nagar, P.N.Road,
Poyampalayam Extn., Pooluvapatti - Post., Tirupur - 641 602
Mobile : +91-90036 73443
+91-73058 73443
E-Mail: info@greenenvirosolutions.in, gesolutions.08@gmail.com

7- Daksha Greenenviro Systems Pvt. Ltd.

Mr. Shivaram N Hegde,
Pranav Complex, No 14, 2nd Floor,
11th Main Road, Gokula 1st Stage, 1st Phase,
Mathikere Main Road, Bengaluru - 560054, Karnataka, India
Mob: +91-09601852973

8- AQUACARE

ISHAN MARKETING
Above Bhadra Post Office, Opp. City Civil Court
Bhadra, Ahmedabad-380001, Gujarat, India
Office Contact: +91 079 2550 4100, 2550 5752
Mr. Kiran Jethwa (+91 9879367736/ +91 9825022376)
Mr. Asitbhai (+91 9377774105)
www.aquacareindia.net

9- Cosmos Water Solutions Pvt. Ltd.

Mr. Sandip Mehta (Director)
207, Aashirvad Paras, Corporate Road,
Above Planet Health, Prahladnagar
Ahmedabad - 380015, Gujarat, India
Call : **09953353130,** +(91)-(79)-40308678

10- Aquashakti Water Solution

Mr. Vijay Patel (Owner)
70-71, Panchratna Estate, Behind Zaveri Estate, Singarva Kathwada Road, Kathwada
Ahmedabad - 382430, Gujarat, India
Call: 08447557314, (+91)-(79)-32504022

11- MICRO AQUA TECH

18/17 Quide Milath Street
Aminjikarai, Chennai – 29
Ph : 044 23611413
Mob : 0944444 3000
Email : mail@kudineer.com

12- Sai Aquafresh

X-10, 2nd Floor, Main Market, West Patel Nagar
New Delhi - 110 008, Delhi, India
Call : **08447499373**
Telephone: +(91)-(11)-25881093 , +(91)-(11)-25889739

13- ELECTROTECH INDUSTRIS

Mr. R. K. Goyal
98/9, 1st Floor, Mangolpur Kalan (Near Jain Sweets),
Sector-2, Rohini, Delhi - 110085, India
Mobile : +919868063431, +919810156099, +919953720410, +918588809501
Phone : 91-11-27514578