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Design of Reverse Osmosis System for reuse of waste water from Common Effluent Treatment Plant

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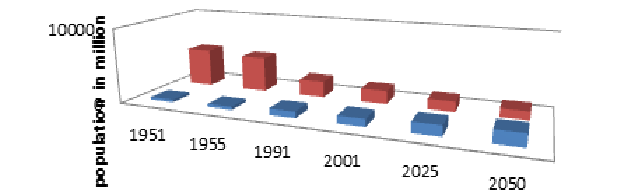
Abstract - *The case study is for analysis and design for reuse of waste water from Common Effluent Treatment Plant. It is observed that in final outlet, all parameters except Total Dissolved Solid are meeting the standards of reuse. The Treatment tried is reverse osmosis at lab scale. After number of trials, it is found that with Reverse Osmosis, the TDS is reduced to less than 2100 mg/lit, which is acceptable for reuse of waste water for agricultural purpose. It is also technically and hygienically feasible solution as farmers are drawing* waste water from ECP canal. For proposed plant, the *IMS design solution Hydranautics Design Software version 2012 is used to get detailed design. The statistical analysis is done and the mathematical model that gives the required pressure for the value of TDS.*

Key Words: Common Effluent Treatment Plant ,Total Dissolved Solids, Hydranautics design software, Reuse of Waste Water

1. INTRODUCTION

To meet with the growing water requirements, along with the waste water from municipal sewage treatment plant, it is going to be a need for thinking the reuse of waste water from the industries wherever possible. It has already been started in some of the big industries especially in metro cities and it must be implemented at all level possible industries. Examples are textile industry, pharmaceutical industry, food and beverage industry where reuse of waste water is in consideration at few places, Shiva Pharma Chem Ltd. Vadodara and Barmoli STP in Surat is a source for Pandesara users, Ultrafiltration (UF), reverse-osmosis (RO) and a membrane bioreactor (MBR) will all be part of a 32,420 m^3/d effluent treatment and recycling plant to be built in India by Chennai-based VA Tech Waba.

1.1 Per Capita Water Availability in India



	1951	1955	1991	2001	2025	2050
Population in millions	361	395	846	1027	1394	1640
Per capita water availability(m3/year)	5177	4732	2209	1820	1341	1140

Chart 1: Per Capita Water Availability In India (Source Resources (2009): Govt. Of India, Ministry of Water

From last 5 decades, the variation for increase in population and decrease in available water is noticeable. Waste water reuse is not only the requirement but it provides eco-friendly benefits like

- A dependable locally-controlled water supply
- Environmental benefits like decreasing wastewater discharges
- Reducing and preventing pollution
- To create or enhance wetlands and riparian habitats, etc.
- To decrease the diversion of water from sensitive ecosystems
- Decreases Discharge to Sensitive Water Bodies
- Reduction in Pollution
- Saving Energy

1.2 Key Objectives for Water Reuse Concepts

Scientists working [6] closely on the issues of water reuse are far from having solved all concerns related to the practice. From Decision Support Systems to the simplest analytical tools, all knowledge is valuable. As public health concerns are normally among the main constraints for reuse any scenario will need to include detailed risk assessments. Once the basic calculations were performed, after that a final decision whether the scheme can be implemented should be based on three phases of risk assessment; analysis, calculation and communication. This will allow fulfilling the key objectives of reuse of waste water: increasing the amount of water resources available, under an acceptable risk with a public full knowledge. Although wastewater reclamation and reuse has gained approval as a necessary tool to be included in sustainable integrated water resources management, there are still several key points to be developed for safe use of the resource. Among the most important items to be developed by adequate research and development (R&D), the risk approach appears to be paramount at present for several reasons

- It could finish the old controversy on restrictive or not so restrictive standards
- It can allow qualifying a reclamation treatment depending on quality of water obtained
- It is a good tool to define the acceptable risk for a given society with its particular conditions

2. A REVIEW OF WASTEWATER TREATMENT BY REVERSE OSMOSIS

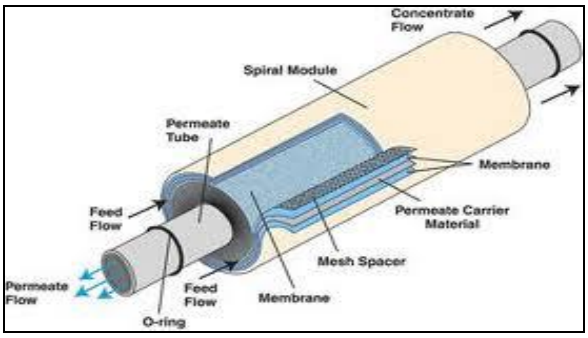


Figure 1: Reverse Osmosis Membrane

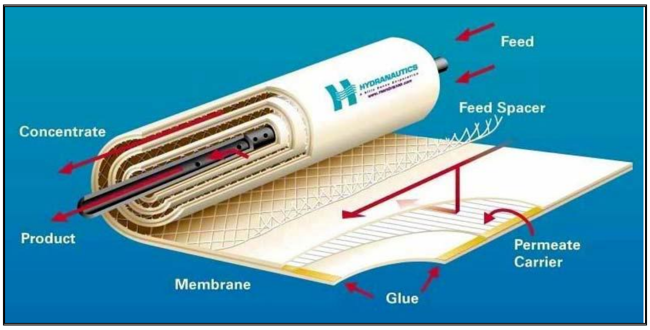


Figure 2: Process Of Treatment Inside Membrane

RO systems are simple to design and operate; they have low maintenance requirements and are modular in nature, making expansion of the systems easy both inorganic and organic pollutants can be removed simultaneously by the RO membrane processes.

- RO systems allow recovery/recycle of waste process streams with no effect on the material being recovered.
- RO membrane systems often require less energy, offer lower capital and operating costs than many conventional treatment systems.
- RO processes can considerably reduce the volume of waste streams so that these can be treated more efficiently and cost effectively by other processes such as incineration.
- RO systems can be replaced or used in conjunction with others treatment processes such as oxidation, adsorption, stripping, or biological treatment to produce high quality product water that can be reused or discharged. Applications that have been reported for RO processes include treatment of organic matter containing wastewater, wastewater from electroplating, metal finishing, pulp and paper, mining, petrochemical, textile, food processing industries, radioactive wastewater, municipal wastewater, and contaminated groundwater [6].

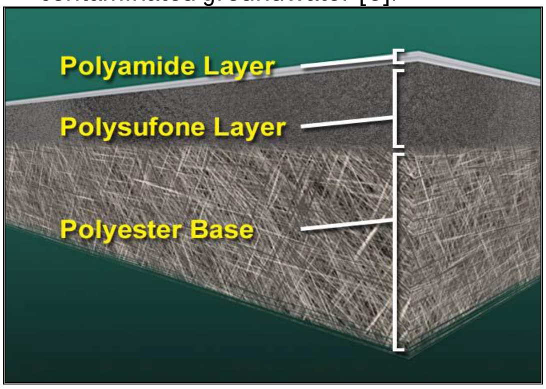


Figure 3: Layers Of Membrane
(Source: Hydranautics Design Software version 2012)

They [15] have compiled separation and flux data of cellulose acetate membranes for a large number of the organic compounds, including many organic pollutants. They found that organic separation can vary widely (from <0% to 100%) depending on the characteristics of the organic (polarity, size, charge, etc.) and operating conditions (such as feed pH, operating pressure, etc.). It was, [14] reported that some of the factors influencing separation of the several different organics (including acetone, urea, phenol, 2, 4-dichlorophenol, nitrobenzene) by cellulose acetate membranes. Rejections varied considerably for the different solutes, and rejections of ionizable organics were greatly dependent on degree of dissociation; nonionized and hydrophobic solutes were found to be strongly sorbed by the membranes and exhibited poor rejection. Duvel and Helfgott (1975) found organic separations varied with molecular size and branching; they postulated organic separation was also a function of the solute's potential to form hydrogen bonds with the membrane.

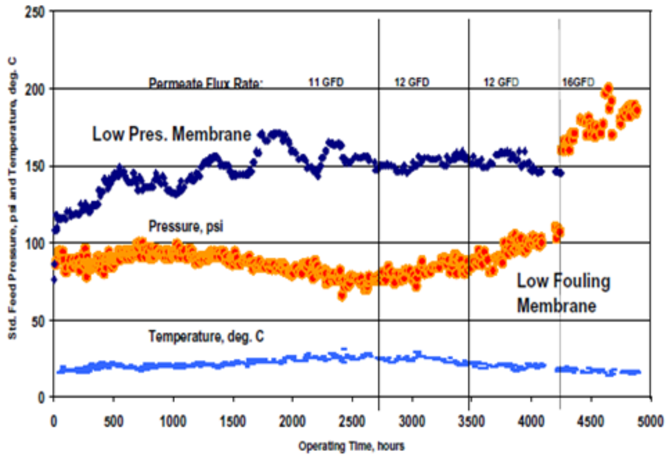


Figure 4: The Operation Of Both Membrane Types With Respect To Feed Pressure And Temperature Vs Time (Source: New Membrane Research and Development Achievements)

The specific flux of the LFC is lower than the specific flux of the low pressure RO membrane; therefore the initial feed pressure was about 90 psi, which is slightly higher than the initial pressure of the low pressure membrane at similar operating conditions. The low pressure membrane permeate flux decreased very rapidly, almost doubling, within the first 2000 hours of operation. The feed pressure had to be increased from approximately 70 psi to more than 160 psi, to maintain a constant permeate flux of 10 gfd. The LFC membrane, on the other hand, operating at an even higher permeate flux rate of 12 gfd remained very stable at a level of 90-100 psi for the duration of the opera ting period.

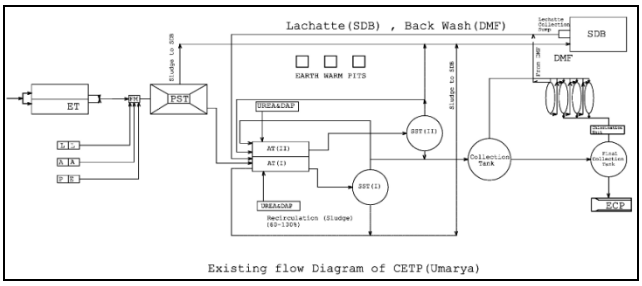


Figure - 5: Process Flow Diagram Of CETP

The effluent received from members through tanker is unloaded in the Equalization tank after checking COD. For thorough mixing & homogenization of effluent received from various industries, at bottom of Equalization tank, HDPE piping grid is installed. 25/15HP air blowers are installed at the tank for complete homogeneous mixing of the effluent received from member units. From here, the effluent is lifted to Flash Mixer. At this tank, continuous dosing of Hydrated lime and Aluminum Sulfate (Alum) slurry is done for flocculation & coagulation. A high-speed stirrer is provided to get complete mixing of dosing chemicals with effluent. After mixing the effluent is transferred to Primary Settling Tank. Sludge Pumps remove the settled sludge from the bottom of the tank. The supernatant from this tank flows by means of gravity to Aeration Tank for biological Treatment.

2.1 Reverse Osmosis Treatment

For removal of TDS the RO plant at lab scale was installed at the plant and continuous readings were taken to decide the type of treatment to be given. The lab scale RO with a small pretreatment of RO downy membrane filter was installed and the dematerialized water was allowed to pass through it. For number of days, the sample was passed through RO. Such 14 trials are done the results are as shown in table below. Figure 4.8 shows the lab scale setup of treatment. Height of storage tank was 15 ft. from the RO system. 0.5 HP motor was fitted. The specifications for lab scale RO system are:

- Maximum Flow = 6.75 GPM
- Maximum Pressure = 175 Psi
- Maximum Temperature = 100 °F
- Service Life = 1000 GAL

The sample was given to storage tank and retention time of minimum 2 hours is given, the capacity of tank was 20 lit. The filtrate was collected and the recovery was achieved up to 75 % in the treatment applied. It clearly shows that treatment is effective for the removal of TDS from the waste water and quality output is there which meets the standards for reuse of waste water.

2.2 Design Data

Design criteria for proposed plant are as follows:

Source of wastewater treated effluent of CETP = 1400 m3/day
Design flow of waste water = 58.33 m3/hr.
Total dissolved solids = 10000 mg/lit
Recovery factor = 75-85 %
PH = 6.5 – 6.8
COD= 10 mg/lit
BOD = 3 mg/lit
MPN = 2.2 /100 ml
Turbidity = 3 NTU
Design temperature = 29 °C

2.3 Basic Transport Equations in Reverse Osmosis

- Once the RO system has been installed, both membranes assembly must be tested for fluxes, salt rejection, recovery under various temperatures, pressures, and feed water salinities.

Water Flux

- The following equation defines the water flux:
- $J1 = K1 (\Delta P - \Delta \Pi)$
- $K1 = Kw \times A/\zeta$
- $\Pi = 1.21\ T\ \Sigma Mi$
- Where,
- J1 = Water flux [m3/m2/sec]
- P = Hydraulic pressure differential across the membrane [atm]
- $\Delta\Pi$ = Osmotic pressure differential across the membrane [atm]
- K1 = Pure water transport coefficient, i.e. the flux of water through the membrane per unit driving force [m3/m2/sec atm]
- Kw = Membrane permeability coefficient for water
- A = Membrane area [m]
- ζ = Membrane thickness [m]
- T = Feed water temperature [K]
- Mi = Molality of the ith ionic or nonionic materials.
- K1 is given by the membrane manufacturer or may be found by solving the equation at the standard test conditions. It depends on the membrane properties, temperature of the system and the chemical composition of the salt solution.

Salt Flux

- The salt flux is an indicator for the membrane effectiveness in removing salts from water. The salt flux is a function of the system temperature and the salt composition. Therefore, it is a property of the membrane itself and indirectly related to the feed pressure. It is proportional to the salt concentration difference across the membrane, according to the following equations;
- $J2 = K2 x\ \Delta C$
- $\Delta C = Cf - Cp$
- Where,
- J2 =Salt flux [Kg/m2/sec]
- K2 =Salt transport coefficient [m/sec]
- Cf = Salt concentration in the feed [Kg/m3]
- Cp = Salt concentration in the product [Kg/m3]
- Since the water flux through the RO membrane is higher than that of salt, there is an accumulation of salt on the membrane surface on the pressurized side of a membrane. This phenomenon is called concentration polarization.
- The increase in concentration polarization has two effects:
  - Increases the osmotic pressure, and reducing the water flux across the membrane.
  - Increases the driving force of the concentration difference across the membrane, which reduces the driving potential, increases the salt passage and gives poor product quality. All these effects increase the capital cost and the power requirements per unit of potable water produced.

Salt Rejection

Salt rejection expresses the effectiveness of a membrane to remove salts from the water. It can be calculated from the following equation;

%Salt rejection= (1- Product concentration/ Feed concentration) x 100 %
%Salt rejection = (1- Product TDS/ Feed TDS) x 100 %
%Salt rejection = 1 - %Salt passage
The salt passage depends on the feedwater temperature and composition, operating pressure, membrane type and material, and pretreatment. Salt passage and bundle pressure drop are the two indicators of membrane fouling.

Recovery

The recovery rate for an RO system is: Recovery(R) = (Qp/ Qf) x *100%
Where, Qp = Product flow [m3/day]
Qf = Feed flow [m3/day]
The recovery is specified by the feed water salinity. Increasing the recovery raises the brine concentration and the osmotic pressure, thus decreasing the permeate flux and increasing the total dissolved solid (TDS) in the product. We can increase the recovery by increasing the number of banks in the system. The above transport equation leads to the following important conclusions:

- J1 is proportional to ΔP
- J2 is proportional to ΔC and is independent of the applied pressure. The increase in the operating pressure increases the water flow without changing the salt flow.

3. Methodology - Hydranautics Membrane Solutions Design Software, v. 2012

The Hydranautics design software package offers ultrafiltration (UF), RO, and UF+RO design options. It has two inputs RO DESIGN AND DESIGN SOFTWARE 225. Primary input screen shows "calculate" button for Toray DS design program.

The menu bar allows the designer to go to the "Analysis" or "File" screens or to the help screen. The help menu opens up a long list of issues that the designer can find assistance with. Additionally, several of the program inputs allow the designer to double click on the input query and information about that issue will pop up on the screen.

The first input screen is the water analysis screen. This screen is where the designer inputs the water analysis, either as ppm ion or ppm calcium carbonate. The screen also has inputs for iron, SDI, hydrogen sulfide, and turbidity. There is a drop-down menu where the feed water source is input. The bottom of the page lists the scaling indices. Once the "analysis" page has been completed, the "RO Design" input screen can be called up by clicking on the appropriate button. "Help" contents of Hydranautics IMS Design program.

3.1 Use of Hydranautics Membrane Solutions Design Software, v. 2012

Hydranautics Membrane Solution Design software shows: Water analysis input screen of Hydranautics IMS Design program.
Primary design input screen of Hydranautics IMS Design program.
Number of stages per pass: Permeate, Backpressure, Array, Membrane selection and Run, perform the design calculations. pH and chemical feed are located at the upper right and upper left of the screen, respectively.

The designer can select sulfuric acid or caustic (or none) for chemical feed. Once the chemical feed is selected, the desired pH is entered. The chemical dosing rate required will appear in the top center of the screen. For general projections, the membrane age is of 3 years should be selected, which assumes a 3 year membrane life. This input works closely with the flux decline and salt passage increase inputs. Selecting performance at end-of-life for the membranes will yield the operating parameters necessary after years of fouling and scaling of the membrane. Flux decline per year input is located in the upper left of the screen. Recommended percentage flux decline per year is a function of feed water quality. The flux decline increases as the water quality gets worse. Salt passage increase is located in the upper left of the screen, just below the flux decline input. Recommended percentage salt passage increase per year is a function of feed water quality.

The salt passage increases as the feed water quality goes down. Clicking on the 'Recalc Array' button will change the selected array to one that is more appropriate for the conditions entered into the program. "Auto Display" allows the designer to opt for a full report rather than a summary report of the projection. The full report that comes up on the screen is what the hard copy will look like. The summary report comes up after the calculations are performed by software. The top half of the screen shows the input values, while the bottom half gives a summary of the projected performance. To change any variable and rerun, Summary report output screen of Hydranautics IMS Design program. Hydranautics' recommended salt passage increase percentages per year as a function of feed water quality.

SYSTEMDE SIGN projections, click on "Next". This brings the designer back to the screen. The hard copy output from the Hydranautics design program is two pages. The first page of the hard copy output shows the inputs and project outputs for the design, the projected water quality, and the scaling indices. The second page includes the element-by-element projection data. Here the design is done with the help for the Hydraunautics design software version 2012. The output is showing all the components. For the implementation, following is the front screen of design software.

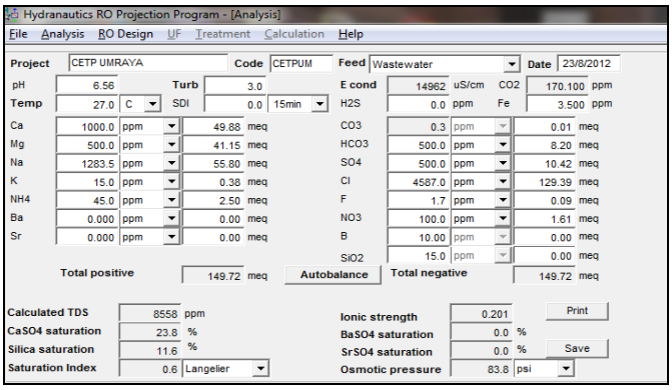


Figure 6: Screen shot for analysis

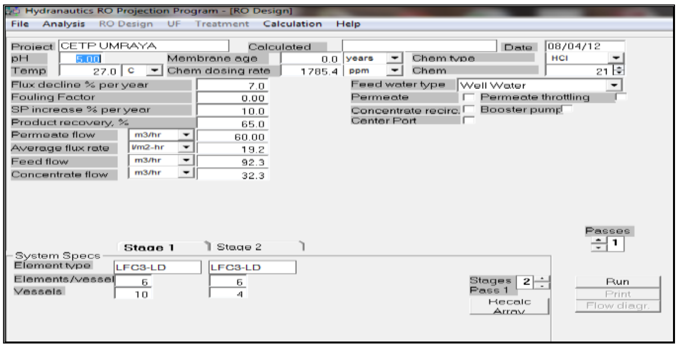


Figure 7: Second Page for anaysis

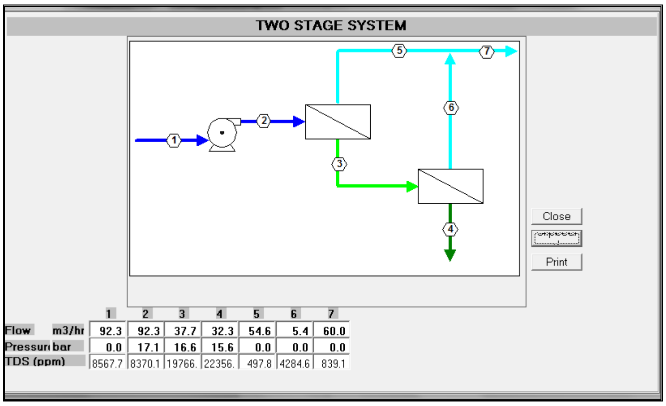


Figure 8: Two stage system

3.2 Model Membrane Element LFC3-LD

Looking to the area available with LFC3-Ld, it is selected from the available options. It has following features:

- ➢ Low Fouling Technology is selected as it can treat high TDS waste water
- ➢ Performance: Permeate Flow: 11,000 gpd (41.6 m³/d)
- ➢ Salt Rejection: 99.7 % (99.5 % minimum)

Type Configuration: Low Fouling Spiral Wound

Following are the design configurations for low fouling spiral wound.

- ➢ Membrane Polymer: Composite Polyamide
- ➢ Neutrally charged
- ➢ Membrane Active Area: 400 ft2 (37.1m2)

Feed Spacer: 34 mil (0.864 mm) with biostatic agent

3.3 Application Data* Maximum Applied Pressure: 600 psig (4.16 MPa)

Application data for maximum applied pressure is as below.

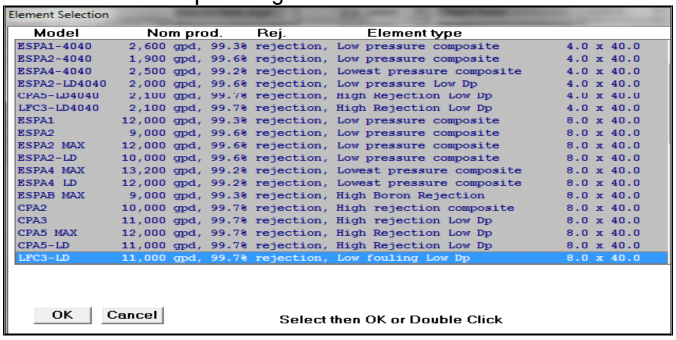
- ➢ Maximum Chlorine Concentration: < 0.1 PPM
- ➢ Maximum Operating Temperature: 113 F (45 C)
- ➢ pH Range, Continuous (Cleaning): 2-10 (1-12)*
- ➢ Maximum Feed water Turbidity: 1.0 NTU
- ➢ Maximum Feed water SDI (15 mins): 5.0
- ➢ Maximum Feed Flow: 75 GPM (17.0 m3/h)
- ➢ Minimum Ratio of Concentrate to Permeate Flow for any Element: 5:1
- ➢ Maximum Pressure Drop for Each Element: 10 psi

The limitations shown here are for general use. For specific projects, operating at more conservative values may ensure the best performance and longest life of the membrane.

Test Conditions

The specifications for test conditions are as below:

- ➢ The stated performance is initial (data taken after 30 minutes of operation), based on the following conditions:
  - ▪ 1500 PPM NaCl solution
  - ▪ 225 psi (1.55 MPa) Applied Pressure
  - ▪ 77 F (25 °C) Operating Temperature
  - ▪ 15% Permeate Recovery
  - ▪ 6.5 - 7.0 p^H Range

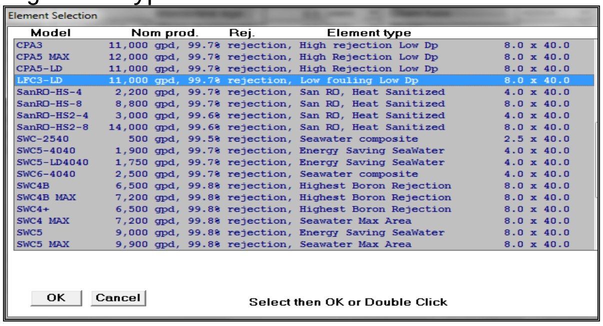


Element Selection

Model	Nom prod.	Rej.	Element type	
ESPA1-4040	2,600 gpd,	99.3% rejection,	Low pressure composite	4.0 x 40.0
ESPA2-4040	1,900 gpd,	99.6% rejection,	Low pressure composite	4.0 x 40.0
ESPA4-4040	2,500 gpd,	99.2% rejection,	Lowest pressure composite	4.0 x 40.0
ESPA2-LD4040	2,000 gpd,	99.6% rejection,	Low pressure Low Dp	4.0 x 40.0
CPA5-LD4040	2,100 gpd,	99.7% rejection,	High Rejection Low Dp	4.0 x 40.0
LFC3-LD4040	2,100 gpd,	99.7% rejection,	High Rejection Low Dp	4.0 x 40.0
ESPA1	12,000 gpd,	99.3% rejection,	Low pressure composite	8.0 x 40.0
ESPA2	9,000 gpd,	99.6% rejection,	Low pressure composite	8.0 x 40.0
ESPA2 MAX	12,000 gpd,	99.6% rejection,	Low pressure composite	8.0 x 40.0
ESPA2-LD	10,000 gpd,	99.6% rejection,	Low pressure composite	8.0 x 40.0
ESPA4 MAX	13,200 gpd,	99.2% rejection,	Lowest pressure composite	8.0 x 40.0
ESPA4 LD	12,000 gpd,	99.2% rejection,	Lowest pressure composite	8.0 x 40.0
ESPAB MAX	9,000 gpd,	99.3% rejection,	High Boron Rejection	8.0 x 40.0
CPA2	10,000 gpd,	99.7% rejection,	High rejection composite	8.0 x 40.0
CPA3	11,000 gpd,	99.7% rejection,	High rejection Low Dp	8.0 x 40.0
CPA5 MAX	12,000 gpd,	99.7% rejection,	High Rejection Low Dp	8.0 x 40.0
CPA5-LD	11,000 gpd,	99.7% rejection,	High Rejection Low Dp	8.0 x 40.0
LFC3-LD	11,000 gpd,	99.7% rejection,	Low fouling Low Dp	8.0 x 40.0

OK Cancel Select then OK or Double Click

Figure 9: Type Of Membranes Available For Selection



Element Selection

Model	Nom prod.	Rej.	Element type	
CPA3	11,000 gpd,	99.7% rejection,	High rejection Low Dp	8.0 x 40.0
CPA5 MAX	12,000 gpd,	99.7% rejection,	High Rejection Low Dp	8.0 x 40.0
CPA5-LD	11,000 gpd,	99.7% rejection,	High Rejection Low Dp	8.0 x 40.0
LFC3-LD	11,000 gpd,	99.7% rejection,	Low fouling Low Dp	8.0 x 40.0
SanRO-HS-4	2,200 gpd,	99.7% rejection,	San RO, Heat Sanitized	4.0 x 40.0
SanRO-HS-8	8,800 gpd,	99.7% rejection,	San RO, Heat Sanitized	8.0 x 40.0
SanRO-HS2-4	3,000 gpd,	99.6% rejection,	San RO, Heat Sanitized	4.0 x 40.0
SanRO-HS2-8	14,000 gpd,	99.6% rejection,	San RO, Heat Sanitized	8.0 x 40.0
SWC-2540	500 gpd,	99.5% rejection,	Seawater composite	2.5 x 40.0
SWC5-4040	1,900 gpd,	99.7% rejection,	Energy Saving SeaWater	4.0 x 40.0
SWC5-LD4040	1,750 gpd,	99.7% rejection,	Energy Saving SeaWater	4.0 x 40.0
SWC6-4040	2,500 gpd,	99.7% rejection,	Seawater composite	4.0 x 40.0
SWC4B	6,500 gpd,	99.8% rejection,	Highest Boron Rejection	8.0 x 40.0
SWC4B MAX	7,200 gpd,	99.8% rejection,	Highest Boron Rejection	8.0 x 40.0
SWC4+	6,500 gpd,	99.8% rejection,	Highest Boron Rejection	8.0 x 40.0
SWC4 MAX	7,200 gpd,	99.8% rejection,	Seawater Max Area	8.0 x 40.0
SWC5	9,000 gpd,	99.8% rejection,	Energy Saving SeaWater	8.0 x 40.0
SWC5 MAX	9,900 gpd,	99.8% rejection,	Seawater Max Area	8.0 x 40.0

OK Cancel Select then OK or Double Click

Figure 10: selection Of Membrane Module

3.4 LFCD-F3 Membrane

Following figure shows the details and working of LFC3-LD

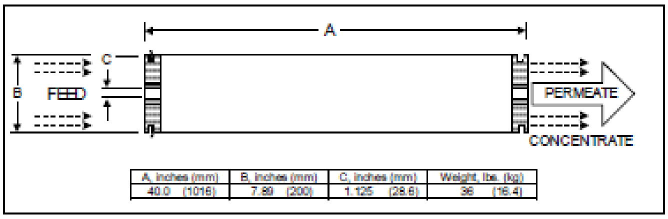


Figure 11: Membrane LFC3-LD
(Source: Hydraunautics Design Software version 2012)

3.4.1 Design by Hydranautics software

Input parameters are added in software and the detail design generated, as end result.

Hydranautics Membrane Solutions Design Software, v. 2012 8/26/2012

BASIC DESIGN

RO program licensed to:				
Calculation created by:				
Project name:	CETP UMRAYA		Permeate flow:	60.00 m3/hr
HP Pump flow:	92.3 m3/hr		Raw water flow:	92.3 m3/hr
Feed pressure:	17.1 bar		Permeate recovery:	65.0 %
Feedwater Temperature:	27.0 C(81F)			
Feed water pH:	5.00		Element age:	0.0 years
Chem dose, ppm (21%):	1321.2 HCl		Flux decline % per year:	7.0
			Fouling Factor	0.20
			Salt passage increase, %/yr:	10.0
Average flux rate:	19.2 lm2hr		Feed type: Wastewater	

Stage	Perm. Flow m3/hr	Flow/Vessel Feed m3/hr	Flow/Vessel Conc m3/hr	Flux l/m2-hr	Beta	Conc.&Throt. Pressures bar	Conc.&Throt. Pressures bar	Element Type	Elem. No.	Array
1-1	54.6	9.2	3.8	24.5	1.11	16.6	0.0	LFC3-LD	60	10x6
1-2	5.4	9.4	8.1	6.1	1.01	15.6	0.0	LFC3-LD	24	4x6

	Raw water		Feed water		Permeate		Concentrate	
Ion	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l	mg/l	meq/l
Ca	1000.0	49.9	1000.0	49.9	38.539	1.9	2785.6	138.9
Mg	500.0	41.2	500.0	41.2	19.270	1.6	1392.8	114.6
Na	1283.5	55.8	1283.5	55.8	227.450	9.9	3244.7	141.1
K	15.0	0.4	15.0	0.4	3.278	0.1	36.8	0.9
NH4	45.0	2.5	45.0	2.5	9.835	0.5	110.3	6.1
Ba	0.000	0.0	0.000	0.0	0.000	0.0	0.0	0.0
Sr	0.000	0.0	0.000	0.0	0.000	0.0	0.0	0.0
CO3	0.3	0.0	0.0	0.0	0.000	0.0	0.0	0.0
HCO3	500.0	8.2	33.6	0.6	5.402	0.1	86.0	1.4
SO4	500.0	10.4	500.0	10.4	11.868	0.2	1406.5	29.3
Cl	4573.2	129.0	4842.3	136.6	446.277	12.6	13006.4	366.9
F	1.7	0.1	1.7	0.1	0.301	0.0	4.3	0.2
NO3	124.0	2.0	124.0	2.0	67.401	1.1	229.1	3.7
B	10.00		10.00		8.679		12.45	
SiO2	15.0		15.0		0.76		41.45	
CO2	170.10		570.01		570.01		570.01	
TDS	8567.7		8370.1		839.1		22356.4	
pH	6.56		5.00		4.29		5.23	

	Raw water	Feed water	Concentrate
CaSO4 / Ksp * 100:	24%	24%	88%
SrSO4 / Ksp * 100:	0%	0%	0%
BaSO4 / Ksp * 100:	0%	0%	0%
SiO2 saturation:	12%	9%	27%
Langelier Saturation Index	0.63	-2.11	-1.06
Stiff & Davis Saturation Index	0.15	-2.58	-1.96
Ionic strength	0.20	0.20	0.54
Osmotic pressure	5.8 bar	5.7 bar	15.2 bar

Product performance calculations are based on nominal element performance when operated on a feed water of acceptable quality. The results shown on the printouts produced by this program are estimates of product performance. No guarantee of product or system performance is expressed or implied unless provided in a separate warranty statement signed by an authorized Hydranautics representative. Calculations for chemical consumption are provided for convenience and are based on various assumptions concerning water quality and composition. As the actual amount of chemical needed for pH adjustment is feedwater dependent and not membrane dependent, Hydranautics does not warrant chemical consumption. If a product or system warranty is required, please contact your Hydranautics representative. Non-standard or extended warranties may result in different pricing than previously quoted.
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Hydranautics Membrane Solutions Design Software, v. 2012 8/26/2012

BASIC DESIGN

RO program licensed to:				
Calculation created by:				
Project name:	CETP UMRAYA		Permeate flow:	60.00 m3/hr
HP Pump flow:	92.3 m3/hr		Raw water flow:	92.3 m3/hr
Feed pressure:	17.1 bar		Permeate recovery:	65.0 %
Feedwater Temperature:	27.0 C(81F)			
Feed water pH:	5.00		Element age:	0.0 years
Chem dose, ppm (21%):	1321.2 HCl		Flux decline % per year:	7.0
			Fouling Factor	0.20
			Salt passage increase, %/yr:	10.0
Average flux rate:	19.2 lm2hr		Feed type: Wastewater	

Stage	Perm. Flow m3/hr	Flow/Vessel Feed m3/hr	Flow/Vessel Conc m3/hr	Flux l/m2-hr	Beta	Conc.&Throt. Pressures bar	Conc.&Throt. Pressures bar	Element Type	Elem. No.	Array
1-1	54.6	9.2	3.8	24.5	1.11	16.6	0.0	LFC3-LD	60	10x6
1-2	5.4	9.4	8.1	6.1	1.01	15.6	0.0	LFC3-LD	24	4x6

Stg	Elem no.	Feed pres bar	Pres drop bar	Perm flow m3/hr	Perm Flux lm2hr	Beta	Perm sal TDS	Conc osm pres	Ca	Cumulative Perm Ion levels Mg	Cl	B	SiO2
1-1	1	17.1	0.1	1.3	35.4	1.15	168.6	6.6	5.18	2.59	100	5.43	0.13
1-1	2	16.9	0.1	1.2	31.6	1.10	199.2	7.8	6.34	3.17	122	5.96	0.16
1-1	3	16.8	0.1	1.0	27.1	1.10	245.3	9.1	7.92	3.96	152	6.59	0.20
1-1	4	16.7	0.1	0.8	22.1	1.10	309.4	10.510. 12	5.06	194	7.34	0.26	
1-1	5	16.7	0.1	0.6	17.1	1.13	394.5	12.013. 05	6.53	249	7.98	0.34	
1-1	6	16.6	0.0	0.5	12.6	1.11	503.1	13.316. 84	8.42	321	8.36	0.43	
1-2	1	16.4	0.2	0.3	9.4	1.03	550.1	14.313. 35	6.68	254	6.09	0.34	
1-2	2	16.2	0.1	0.2	6.4	1.02	611.6	14.615. 34	7.67	294	6.51	0.39	
1-2	3	16.1	0.1	0.2	5.3	1.02	673.5	14.817. 70	8.85	339	7.06	0.45	
1-2	4	15.9	0.1	0.2	4.4	1.02	736.3	15.020. 74	10.37	397	7.74	0.53	
1-2	5	15.8	0.1	0.1	3.7	1.01	799.7	15.224. 60	12.30	471	8.33	0.63	
1-2	6	15.7	0.1	0.1	3.1	1.01	863.6	15.329. 41	14.71	562	8.68	0.75	

Stage	NDP bar
1-1	7.9
1-2	2.6

Product performance calculations are based on nominal element performance when operated on a feed water of acceptable quality. The results shown on the printouts produced by this program are estimates of product performance. No guarantee of product or system performance is expressed or implied unless provided in a separate warranty statement signed by an authorized Hydranautics representative. Calculations for chemical consumption are provided for convenience and are based on various assumptions concerning water quality and composition. As the actual amount of chemical needed for pH adjustment is feedwater dependent and not membrane dependent, Hydranautics does not warrant chemical consumption. If a product or system warranty is required, please contact your Hydranautics representative. Non-standard or extended warranties may result in different pricing than previously quoted.
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Figure 12: Desing output by software

At the initial stage of CETP: the primary. secondary and tertiary treatments were tried and reduction was good in parameters, but not up to the mark as per standards of disposal.

It also concluded that if efficiency of filtration system by filter press, it can remove further turbidity in a range at 3-5 NTU. The COD will be in the range of 150-250 mg/lit & BOD range of 20-30 mg/lit.

4. CONCLUSIONS

- If the units are expanded, then according to the quality to be treated, the experiments are to be carried out.
- If the member industries are not following the criteria for giving waste water to CETP, then it can be challenging to maintain quality of waste water in CETP.
- If the number of industries, tankers for giving waste water is not maintained, according to quality and quantity design criteria then quality output for disposal to ECP is difficult.
- RO reject has to be handled carefully. Evaporator can be designed instead of disposal to ECP channel or to put in equalization tank. Many industries are mixing reject at equalization tank. If evaporator is to be designed, then solar evaporator is a better option.
- At present 1000-1500 KL water is disposed in ECP canal and it ultimately reaches to sea, instead member industries should use this RO treated water and cooperate with many count by that be recirculation in cost of fresh water and saving through water quantity.
- Proper maintenance of plant and continuous monitoring is required for quality output.
- Replacement of membrane as per requirement has to be done time to time carefully for successful operation of plant.

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