Case Study – Power Plant Water Recycle

Project Background

Plant Type/Location: Gas-Fired Power Plant in Southern California, U.S.A.

Project Objective: 100% recycle of cooling tower blowdown (CTBD)

Year Installed: 2004

Average CTBD Flow: 300 GPM (68 m^3/hr)

Treatment Concept: The process starts with chemical softening and Duraflow Membrane Filtration (DMF) followed by Reverse Osmosis (RO). The RO permeate is returned to the cooling tower, and the reject stream is fed to a two-stage thermal system that evaporates the RO reject into crystalline solids. The solids are disposed of as landfills, the distillate is used as makeup water for the heat recovery steam generators (HRSG), and the balance is returned to the cooling tower with an evaporation rate of over 3,000 GPM.

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Major Contaminants: Hardness (Calcium and Magnesium), Silica, Organic (Anti-scalant & Dispersants) and Total Suspended Solids (TSS)

Membrane Softening Process

Chemical Softening:	Reaction I –	Ferric salt	(Organic coagulation)
		Na_2CO_3 to pH 8.5	(pH adjustment)
		NaOCl	(Bio-growth control)
		Magnesium salt	(Silica adsorption)
	Reaction II -	Na_2CO_3 & Lime to pH 10.5	(Hardness precipitation)

Duraflow Filtration: The DF membranes are manufactured in a tubular configuration designed to handle high solid concentration as illustrated in Figure 1. The membranes, made of PVDF, are cast on the surface of porous polymeric tubes to produce a nominal pore size of 0.1 micron. Bleach and/or hydrochloric acid are typically used for membrane cleaning.

Figure 1 – DF Membrane Module

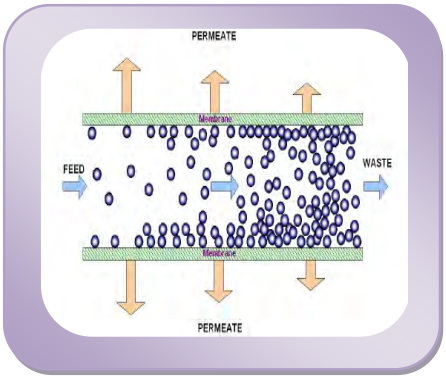

Figure 2 – DF Crossflow Filtration

The chemically pre-treated wastewater is processed through the DF membrane modules designed for separation of the precipitates from water. The wastewater is pumped at a velocity of 12 – 15 ft/sec through the membrane modules (Figure 2) connected in series. The turbulent flow, parallel to the membrane surface, produces a high-shear scrubbing action which minimizes deposition of solids on the membrane surface. During operation, filtrate permeates through the membrane, while the suspended solids retained in the re-circulation loop are periodically purged for further de-watering. An automatic back-pulse mechanism is an integral part of the operation design to provide physical surface cleaning by periodically reversing the filtrate flow direction. The DF has been operated with an average flux of >300 GFD. The entire treatment process is schematically depicted in Figure 5.

DF Membrane Module Specifications

DF Membrane Module Specifications	
Flow configuration	Cross-flow
No. of tubes per module	10
Dimensions	6” (15 cm) dia. x 72” (183 cm) long
Tube diameter	1” (2.5 cm)
Membrane area per module	15 ft^2 (1.40 M^2)
Shell construction	Schedule 40 PVC
Membrane material	PVDF
Nominal pore size	0.1 micron
Module weight	40 lbs (18.2 kg)

DF Membrane Equipment Configuration

See Figure 3 and 4 for physical equipment arrangement.

DF Membrane System Configuration	
No. of DF modules (total)	216
No. of skids (total)	6
No. of DF modules / skid	36
No. of Trains / skid	3
No. of DF modules / Train	12
No. of skids in service mode	3 - 4
No. of skids in standby mode	2 - 3

Key DF System Operation Data

DF System Operating Data	
No. of modules per train	Up to 12
Operating inlet pressure	50 PSI (3.5 Kg/CM^2)
Operating temperature	<105°F (41^{0}C)
Operating TSS in Conc. Tank	2 to 3 % (wt.)
Feed flow velocity	15 Ft/Sec (4.5 M/Sec)
Feed flow per train	350 GPM (80 M^3/Hr)
Membrane flux (average)	300 GFD (510 LMH)
Back-pulse frequency/duration	20 Min / 10 Sec
Back-pulse volume/module	1.5 – 3.0 GPH (6 – 12 LPH)
DF module cleaning frequency	1 – 1.5 Weeks
DF modules replacement	5 - 6 Years
RO module cleaning frequency	5 - 6 Months
RO modules replacement	4 – 5 Years

Key Performance Data

The removal efficiency for the contaminants of concern is presented as follow:

Contaminants	Influent (CTB) (mg/L as ion)	DF Filtrate (mg/L as ion)	RO Permeate (mg/L as ion)
Ca	260	<20.0	<1.0
Mg	130	<10.0	<0.5
SiO_2	120	<10.0	<1.0
COD	400	<120	<5.0
TSS	250	<1.0	ND
pH	8.5 S.U.	10.5 S.U.	6.8 S.U.
SDI	>Max. SDI Test Value	<3.0	----
NTU	Very High	<1.0	<0.5

DF Membrane System Pictures

Figure 3 – DF Membrane System Installation

Figure 4 – DF Membrane Skid Assembly

Figure 5

Cooling Tower Blowdown (CTB) Recycle

ZLD Process Flow Diagram