

# CASE STUDY

## OPERATING AND DESIGN PROBLEMS: HIGH PURITY WATER SYSTEM ON POTW EFFLUENT

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# INTRODUCTION

- PROJECT LOCATION: MEXICO
- TYPE OF POWER PLANT: COGEN
- IN OPERATION SINCE 2002
- MAKEUP WATER SOURCE: TREATED POTW PLANT EFFLUENT (GRAY WATER), OPERATED BY AMERICAN FIRM. PRETREATMENT PROCESS INCLUDES BIOLOGICAL TREATMENT, CLARIFICATION
- TOTAL MAKEUP WATER FLOW: 5500 GPM (8 MGD)
- PRIMARY USE: COOLING TOWERS MAKEUP, BOILER MAKEUP, PLANT AUXILIARY SYSTEMS
- CYCLING MODE (START/STOP BASED ON DEMAND)

# INCOMING GRAY WATER ANALYSIS

- Hardness: 525 ppm as  $\text{CaCO}_3$
  - Alkalinity: 224 ppm as  $\text{CaCO}_3$
  - Silica: 19
  - TDS: 1400 ppm
  - Conductivity: 1850 mmho
  - Turbidity: 2-5 NTU
  - Other contaminants: Organics, oil, grease
- (Note: This is a partial water analysis)

# PRETREATMENT PROCESSES AT COGEN PLANT

## PRIMARY TREATMENT-COOLING TOWER MAKEUP LOOP

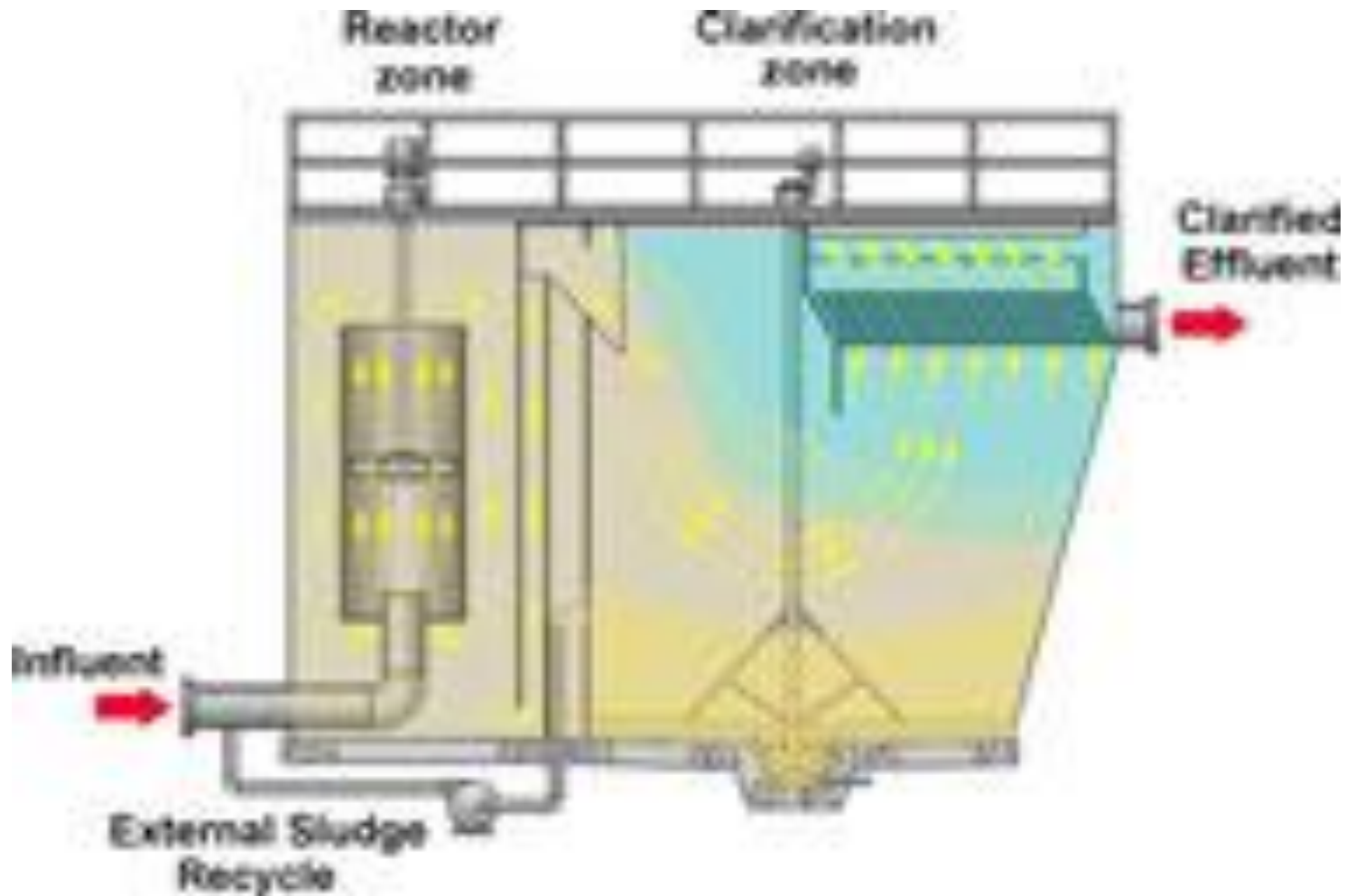
- Gray water receiver sump
- Rapid mix tank (Caustic feed, feed water pH adjustment)
- Lime softening/Slow mix/Solids settling with inclined plate clarifier (Lime feed, polymer feed) with sludge recirculation pumps
- Clearwell (Hypochlorite feed, acid feed, treated water pH adjustment)
- Sludge processing by belt press, and disposal

# HIGH PURITY WATER TREATMENT PROCESSES

- MULTI MEDIA FILTERS
- ULTRAFILTRATION-HOLLOW FIBER TYPE MEMBRANE ELEMENTS (85% PRODUCT RECOVERY). FEED/BLEED CONCEPT
- SODIUM BISULFITE FEED, SCALE INHIBITOR FEED
- TWO-PASS REVERSE OSMOSIS (TFC MEMBRANE ELEMENTS) WITH INTER-STAGE FORCED DRAFT DEGASIFIER. FIRST PASS RECOVERY-60%, SECOND PASS RECOVERY-85%
- MIXED BED ION EXCHANGE, ON SITE-REGENERATION CHEMICAL FEED SYSTEMS
- MEMBRANE CLEANING SYSTEM

# Typical Clarifier With Inclined Plate Settler

(Courtesy: Infilco Degremont)



# TYPICAL 4", 6" AND 8" DIA KOCH UF MEMBRANE ELEMENTS



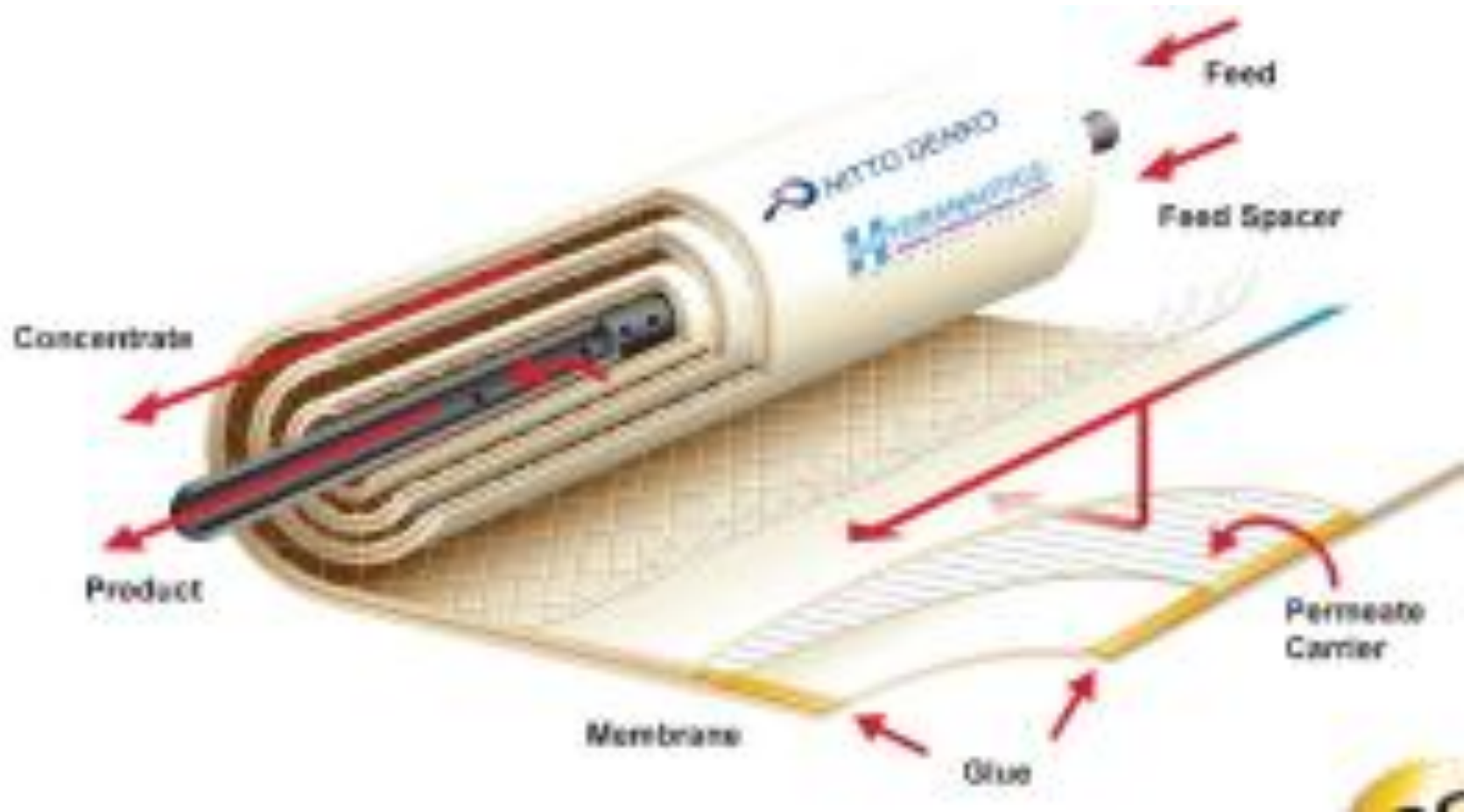
# TYPICAL UF MEMBRANE SKID

(Courtesy: Koch Membrane Systems)





# Typical Hydranautics RO membrane Element



# Typical Hydranautics 4" and 8" RO membrane Elements



# OPERATIONAL PROBLEMS

- FLUCTUATIONS IN THE INCOMING WATER QUALITY
- LACK OF STANDBY CLARIFIER/SOFTENING SYSTEM
- PLUGGING/FOULING OF INCLINED PLATES IN CLARIFIER SECTION
- WIDE SWINGS IN LIME SOFTENING EFFLUENT HARDNESS.
- TSS LOAD/TURBIDITY SPIKES IN THE CLARIFIER EFFLUENT
- PLUGGING/FOULING OF UF MEMBRANE
- POTENTIAL MECHANICAL DAMAGE OF UF MEMBRANE
- PLUGGING/FOULING OF RO MEMBRANE (HIGH DELTA P ACROSS MEMBRANE)
- SHORT RUN LENGTHS OF ION EXCHANGE UNIT

# POTENTIAL PROBLEMS WITH MAJOR EQUIPMENT (1)

- SOFTENING/INCLINED PLATE CLARIFIER
  - DIFFICULT TO CONTROL PROCESS PARAMETERS DURING FREQUENT START/STOP OPERATION. FLOC CARRYOVER, HARDNESS EXCURSIONS, TURBIDITY EXCURSIONS
  - NO STANDBY CLARIFIER (DIFFICULT TO MAINTAIN SYSTEM DURING NORMAL OPERATION)
  - LACK OF SLUDGE COLLECTION TANK (NO DECANT CAPABILITY, DILUTE SLUDGE TO BELT PRESS)
  - PLUGGING OF INCLINED PLATES, LEADING TO SHORT CIRCUITING, CHANNELING. PLASTIC FILL BECOMES BRITTLE UPON EXPOSURE TO SUNLIGHT, CHLORINE ENVIRONMENT

# POTENTIAL PROBLEMS WITH MAJOR EQUIPMENT (2)

- MULTI MEDIA FILTERS
  - MIGRATION OF SAND INTO ANTHRACITE LAYER (PROBABLE CAUSE: AIR FLOW IMBALANCE)
  - EFFLUENT TURBIDITY SPIKES UP TO 10 NTU (PROBABLE CAUSE: IMPROPER SELECTION OF FILTER MEDIA, LACK OF POLY ELECTROLYTE FEED, FLOW DISTRIBUTION PROBLEMS, CHANNELING)
  - LACK OF RINSE VALVES (SEND HIGH TSS WATER TO UF- IMMEDIATELY AFTER BACKWASH CYCLE)
  - COARSE MEDIA ON TOP- INABILITY TO REMOVE FINE SUSPENDED SOLIDS

# POTENTIAL PROBLEMS WITH MAJOR EQUIPMENT (3)

- UF MEMBRANE TRAINS
  - FREQUENT START/STOP OPERATION (CYCLING)
  - UF PERMEATE SDI VALUES EXTREMELY HIGH (FILTER PAPER PLUGS QUICKLY, CANT MEASURE SDI VALUES)
  - LACK OF INSTRUMENTS/MEASURES TO VERIFY INTEGRITY OF UF MEMBRANE ELEMENTS ON LINE
  - LACK OF UF PERMEATE STORAGE TANK
  - LACK OF O&M TRAINING/APPARATUS TO TEST UF MEMBRANES OFF LINE
  - ALMOST NO COMMUNICATION WITH MEMBRANE SUPPLIER DURING NORMAL OPERATION
  - THREE UF TRAINS ARE PROVIDED, ONLY TWO IN SERVICE DURING NORMAL OPERATION. SEVERE GROWTH OF BACTERIA POSSIBLE DURING LONG STANDBY MODE.
  - 50% HIGHER FLUX THAN RECOMMENDED DESIGN FLUX

# POTENTIAL PROBLEMS WITH MAJOR EQUIPMENT (4)

- RO TRAINS
  - FIRST PASS RO TRAINS OPERATING UNDER EXTREMELY HIGH DP (70 PSIG)
  - FIRST PASS RO MEMBRANES OPERATING UNDER VERY HIGH PERMEATE FLUX CONDITIONS (15-19 GFD).
  - ALTHOUGH TWO RO TRAINS ARE PROVIDED, ONLY ONE IS IN SERVICE WHILE THE SECOND TRAIN IS ON STANDBY (ORIGINAL DESIGN)
  - FREQUENT START/STOP OF RO TRAINS, LEADING TO HYDRAULIC HAMMERING OF RO MEMBRANE ELEMENTS, MECHANICAL DAMAGE

# POTENTIAL PROBLEMS WITH MAJOR EQUIPMENT (4)

- MIXED BED DEMINERALIZERS
  - EFFLUENT CONDUCTIVITY IN THE RANGE OF 0.2-2 MMHO (5-0.5 MEGA-OHM)
  - SHORT RUNS (SHORT THROUGHPUT BETWEEN EACH REGENERATION), POSSIBLY DUE TO HIGH CO<sub>2</sub> LOAD FROM FORCED DRAFT DEGASIFIER.



# PROCESS IMPROVEMENT IDEAS (1)

- PRETREATMENT
  - INSTALL RECIRCULATION LOOP TO MAINTAIN RELATIVELY CONSTANT FLOW ACROSS THE SYSTEM
  - CONSIDER STANDBY CLARIFIER TO ALLOW MAINTENANCE OF ONE UNIT WHILE THE OTHER UNIT IS BEING WORKED ON
  - SCHEDULE MAINTENANCE TO CLEAN INCLINED PLATES, CLARIFIER BOTTOMS
  - CONSIDER SODA ASH ADDITION IN LIEU OF CAUSTIC ADDITION (LIME/SODA ASH SOFTENING PROCESS), KNOCK DOWN HARDNESS TO 35 PPM ON A CONSISTENT BASIS.

# PROCESS IMPROVEMENT IDEAS (2)

- MEDIA FILTERS
  - CHANGE MEDIA TO IMPROVE REMOVAL OF FINER SUSPENDED SOLIDS
  - PROVIDE FAST RINSE CAPABILITY
  - INVESTIGATE ADDITION OF POLYELECTROLYTE TO IMPROVE COAGULATION OF SUSPENDED SOLIDS
  - EVALUATE INTERNAL DISTRIBUTORS TO MINIMIZE CHANNELING, IMPROVE FLOW DISTRIBUTION

# PROCESS IMPROVEMENT IDEAS (2)

- UF SYSTEM
  - PROVIDE UF PERMEATE STORAGE TANK TO MINIMIZE START/STOP OF RO TRAINS
  - INSPECT ALL UF MODULES, PLUG LEAKY FIBERS
  - DISINFECT UF TO KILL BACTERIA, INJECT BISULFITE BEFORE RO
  - OPERATE ALL UF TRAINS CONTINUOUSLY. INSTALL RECIRC LOOP TO MAINTAIN FLOW ACROSS MEMBRANE. THIS WILL LOWER PERMEATE FLUX RATE (GFD VALUES), MINIMIZE PRESSURE DROP, MINIMIZE BACTERIAL GROWTH
  - MONITOR UF PERMEATE SDI VALUES REGULARLY
  - PERFORM CIP OPERATIONS UNDER SUPERVISION
  - TRAIN OPERATORS AND MAINTENANCE PERSONNEL TO FIND LEAKY MEMBRANES, PERFORM SIMPLE REPAIRS

# PROCESS IMPROVEMENT IDEAS (3)

- RO SYSTEM

- OPERATE ALL RO TRAINS (MINIMIZE STANDBY PHILOSOPHY). THIS WILL REDUCE PERMEATE FLUX RATE (GFD), REDUCE PRESSURE DROP, MINIMIZE BACTERIAL GROWTH
- PERFORM CIP OPERATION UNDER PROPER SUPERVISION
- CONSIDER INSTALLING VFD FOR THE RO HIGH PRESSURE PUMPS
- INSTALL RECIRCULATION LOOP TO RECYCLE RO PERMEATE

# PROCESS IMPROVEMENT IDEAS (4)

- MIXED BED UNITS
  - REDUCE CO<sub>2</sub> LOAD BEFORE MIXED BED  
(REDUCE ANION LOAD, INCREASE RUN LENGTH,  
MINIMIZE CAUSTIC CONSUMPTION)
  - ALTERNATE OPERATION OF MIXED BED UNITS  
(MINIMIZE BACTERIAL GROWTH, ORGANICS  
BUILDUP, IMPROVE PRODUCT WATER QUALITY)
  - CHEMICAL CLEANING OF RESIN (IF RESIN  
ANALYSIS INDICATES METAL OR ORGANIC  
FOULING)
  - INSTALL RECIRCULATION LOOP

# SUMMARY (1)

- UTILIZATION OF SECONDARY TREATED GRAY WATER FROM MUNICIPAL EFFLUENT, IS BECOMING ATTRACTIVE OPTION FOR POWER PLANT MAKEUP, PARTICULARLY IN THE ARID PARTS OF THE WORLD
- MOST COMMON PROBLEMS INCLUDE EXCURSIONS IN INCOMING WATER QUALITY, CA/MG HARDNESS, ORGANICS, SUSPENDED SOLIDS AND COLLOIDAL PARTICLES
- IT IS BEST NOT TO PUSH THE TECHNOLOGY BEYOND ITS CAPABILITY. THAT INCLUDES CONVENTIONAL SOFTENING EQUIPMENT, MEDIA FILTERS, UF AND RO MEMBRANE SYSTEMS
- ON-AGAIN, OFF-AGAIN (CYCLING) OPERATION MUST BE AVOIDED IF POSSIBLE. CONSIDER INSTALLING RECIRCULATION LOOPS AROUND CLARIFIERS, UF, RO AND MIXED BED EQUIPMENT TO KEEP WATER MOVING CONTINUOUSLY.

# SUMMARY (2)

- IT IS GOOD IDEA TO HAVE BREAK TANKS BETWEEN MAJOR PROCESS COMPONENTS.
- OWNERS MUST TRAIN OPERATORS TO ANALYZE, LOG AND INTERPRET CRITICAL PARAMETERS SUCH AS SDI, TURBIDITY, MEMBRANE FLUX RATES
- IT IS POSSIBLE TO PERFORM SIMPLE REPAIRS TO SOME UF MEMBRANE MODULES. THESE REPAIRS CAN PREVENT SERIOUS DAMAGE TO THE EQUIPMENT DOWNSTREAM
- IT IS GOOD IDEA TO EVALUATE THE SYSTEM DESIGN PARAMETERS PERIODICALLY.

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