Desalination Plant
Sea Water Intake and Supply
Chlorination
MSF
Blending Plant
Potable Water
SWRO
Sea Water Intake & Supply

- Intake Pipe Line
- Stop Logs
- Stilling Basin
- Forbay basin
- Bar Screens
- Traveling Band Screen
- Trash Container
- Pumping System
Screening System

• Bar Revolving Raking Screen
  – Speed: 5/10 (m/min)

• Local Selection / Remote Manual
  – Stop – Speed (1/2) [Push Button]

• Remote Automatic
  – Timer Control
  – Differential Level Control
    • 1\textsuperscript{st} Speed (\(\Delta L = 3\) cm)
    • 2\textsuperscript{nd} Speed (\(\Delta L = 6\) cm)
    • Stop (\(\Delta L = 1\) cm)
Screening System

• Traveling Band Screen
  – Speed: 5.5/11/22 (m/min)

• Local Selection / Remote Manual
  – Stop – Speed (1/2/3) [Push Button]

• Remote Automatic
  – Timer Control
  – Differential Level Control
    • 1\textsuperscript{st} Speed (ΔL = 3 cm)
    • 2\textsuperscript{nd} Speed (ΔL = 6 cm)
    • 3\textsuperscript{rd} Speed (ΔL = 10 cm)
    • Stop (ΔL = 1 cm)
# Protection

<table>
<thead>
<tr>
<th>Rack &amp; Band Screens</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>ΔL = 25 cm</td>
<td>Alarm is initiated</td>
</tr>
<tr>
<td>Screen is blocked</td>
<td>over load safety device Operates</td>
</tr>
<tr>
<td></td>
<td>Limit switch ON</td>
</tr>
<tr>
<td></td>
<td>Driving Motor Stops</td>
</tr>
<tr>
<td></td>
<td>Screen is stopped</td>
</tr>
</tbody>
</table>
Hypo-chlorite Production Plant Process Diagram

- Sea Water
  - Gravel Filter
  - Activated Carbon filter
  - Electrolyser
  - Rectifier
  - HCl
  - Filtered SW Basin
  - Naocl Storage Tank
    - SW Intake
    - Stilling Basin
    - Blending Plant
  -Poly-electrolyte
  - Naocl
  - Nacl
  - H2O
  - H2
Hypo-chlorite Production Plant

• Sea Water Supply and Filtration System
  – Poly-electrolyte Dosing

  – Gravel Filter (Quartz sand bed)
    • $\Delta P$ 0.6 barg (app 48 W.H)
    • back wash sequence starts (app 30 min)

  – Activated Carbon Filter
    • To absorb oil Particles
    • Back wash ( 2-3 months $\Delta P$ 0.6 barg)
Sodium Hypo-chlorite Generation

- Four Series of Electrolytic Cells (Bipolar)
- Two Transformers/Rectifiers 2176 A
- Rated Generation Capacity: 95 Kg/h
- Reactions:
  - Electrochemical reaction
    \[ 2\text{Nacl} + 2 \text{H}_2\text{O} \rightarrow \text{Naocl} + \text{Nacl} + \text{H}_2\text{O} + \text{H}_2 \uparrow \]
Sodium Hypo-chlorite Storage & Dosing

• **Storage**
  - Two Storage Tanks
  - Two Fans (H₂ explosive limit 4%)
  - N₂ Purging

• **Dosing**
  - Continuous Dosing
    • Sea water intake 2 mg/l
    • Stilling basin 1.5 mg/l
    • Blending plant 1.5 ppm
  - Shock Dosing
    • Sea water intake 3 mg/l + 2 mg/l (continuous dosing) = 5 mg/l
<table>
<thead>
<tr>
<th>Level</th>
<th>Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>High High Level 3650 mm</td>
<td>Hypo production plant stops</td>
</tr>
<tr>
<td></td>
<td>Hypo production plant restarts at level 300 mm</td>
</tr>
<tr>
<td>High High High level 3700 mm</td>
<td>Alarm</td>
</tr>
<tr>
<td></td>
<td>Hypo production plant stops</td>
</tr>
<tr>
<td></td>
<td>Delay time (to flash the system)</td>
</tr>
<tr>
<td></td>
<td>Inlet valve closes</td>
</tr>
<tr>
<td>Eextreme protection 3850 mm</td>
<td>Over flow nozzle opens</td>
</tr>
<tr>
<td>Low Low Low Low level 250 mm</td>
<td>Alarm</td>
</tr>
<tr>
<td></td>
<td>All injection Pumps stops</td>
</tr>
</tbody>
</table>
Electrolyzer Cleaning

• Due to Fouling on the Cathodes (Hydroxides, Carbonates of magnesium, Calcium)

• Fouling increases
  – Low cathodic current supply
  – Low sea water flow rate

• Hydrochloric Acid Cleaning HCl
  – Concentration 5 %
MSF Process Flow Diagram

MP Steam
PRV
Brine Heater
Condensate Pump
Ejector
Feed water Pump
demister
BRP
Product Distillate Pump
Pumps

- **Sea Water pump To**
  - Evaporator
  - Vacuum system
  - Cooling water system
  - Potable water treatment
  - Acid preparation and dosing

- **SW Recirculation Pump**
  - It is a recirculation of part of the water from the heat rejection outlet to the inlet again

- **Blow down pump**
  - It discharges part of the flashing brine
  - To control the level in the last stage

- **Brine recirculation pumps**
  - Suction (last stage)
  - Discharge (heat recovery section & brine heater)

- **Condensate extraction pumps**
  - Suction (brine heater condensate steam)
  - Deaerator & feed water system

- **Product distillate pump**
  - Suction (Last stage of the disteller)
  - Discharge (Blending & DM plants)
MP Steam Supply

- Auxiliary boilers 14+23 (G station)
- Two pressure Reducing Stations
- Two de-superheating station
  - TBT control
- Components
  - Motorized Isolation Valve
  - SPRV
  - Four safety valves
Antiscale, Antifoam & Sodium Sulphite

- 2 vertical cylindrical tanks
- 2 basket filters
- 2 dosing pumps
- 2 agitators (solution’s concentration)
- Safety relief valve
- Dosing pumps
- Filling pump
On load cleaning (Taprogge)

- To retard fouling and scaling
- To clean the tubes (heat recovery + brine Heater)
- Components:
  - 2 ball recirculating pumps
  - 1 ball collector
  - 1 ball separator
    - $\Delta P = 30$ mbar back wash
Acid Cleaning

- Evaporator Performance
  - Fouling
  - Variation of cooling water
- Design Fouling limit
- Design Operating limit
# Vacuum System

- 1 hogging ejector
- holding ejectors and condensers

<table>
<thead>
<tr>
<th></th>
<th>Suction from</th>
<th>Discharge to</th>
</tr>
</thead>
<tbody>
<tr>
<td>1(^\text{st}) stage ejector</td>
<td>Vent condenser</td>
<td>1(^\text{st}) stage condenser</td>
</tr>
<tr>
<td>2(^\text{nd}) stage ejector</td>
<td>1(^\text{st}) stage condenser</td>
<td>Atmospheric condenser</td>
</tr>
<tr>
<td>Vent condenser</td>
<td>Deaerator</td>
<td>1(^\text{st}) stage ejector suction</td>
</tr>
<tr>
<td></td>
<td>Evaporator</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Pump vent lines</td>
<td></td>
</tr>
<tr>
<td>1(^\text{st}) stage condenser</td>
<td>1(^\text{st}) stage ejector discharge</td>
<td>2(^\text{nd}) stage ejector suction</td>
</tr>
<tr>
<td></td>
<td>1,2,3 evaporator stages</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Brine heater</td>
<td></td>
</tr>
<tr>
<td>Atmospheric condenser</td>
<td>2(^\text{nd}) stage ejector discharge</td>
<td>atmosphere</td>
</tr>
</tbody>
</table>
# Protection

<table>
<thead>
<tr>
<th>Protection</th>
<th>Action/Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>MP Steam valve close</td>
<td>10 min delay desal trips</td>
</tr>
<tr>
<td>HIS Level Above 75%</td>
<td>Two level switches (1 O 2) ON Steam valve trip</td>
</tr>
<tr>
<td>HIS Temp</td>
<td>125 Alarm 135 steam valve trip</td>
</tr>
<tr>
<td>TBT</td>
<td>114 Alarm 116 trip</td>
</tr>
<tr>
<td>Boiler Cascade Trip</td>
<td>Unit trips to protect MP Header</td>
</tr>
<tr>
<td>1st stage level 300 mm</td>
<td>BRP trips 5 min delay steam valve trip (both BRP) Low production rate (1 BRP trips)</td>
</tr>
<tr>
<td>Anti scale pump trip</td>
<td>10 min delay Desal trips</td>
</tr>
<tr>
<td>Control</td>
<td>Description</td>
</tr>
<tr>
<td>-------------------------------</td>
<td>-----------------------------------------------------------------------------</td>
</tr>
<tr>
<td>HIS condensate level</td>
<td>2 level transmitters (brine heater) Controls condensate CV (Pump discharge)</td>
</tr>
<tr>
<td></td>
<td>To ensure proper heat transfer &amp; to protect the pumps</td>
</tr>
<tr>
<td>Desuperheater spray</td>
<td>3 temp transmitters (Steam inlet header) Controls condensate desuperheater CV (pump discharge) TBT control</td>
</tr>
<tr>
<td>MP Steam</td>
<td>3 pressure and temperature transmitters (steam inlet header) Controls the MP/LP</td>
</tr>
<tr>
<td>Brine/ Deaerator Level</td>
<td>2 level transmitters Controls Level Control valve To pump brine to discharge pit by blow down pump</td>
</tr>
<tr>
<td>Brine flow control</td>
<td>First stage level transmitter Controls the brine flow with correction of the first stage level</td>
</tr>
<tr>
<td>Product water level</td>
<td>Controls the level of distillate in evaporator</td>
</tr>
<tr>
<td>Antiscal/ antifoam dosing</td>
<td>Makeup SW flow is measured Controls SV</td>
</tr>
<tr>
<td>SW Temp</td>
<td>Controls recirculation valve To maintain temp inside heat rejection section</td>
</tr>
<tr>
<td>Make up water</td>
<td>Make up = distillate product + Blow down</td>
</tr>
<tr>
<td>BBT Control</td>
<td>To maintain BBT</td>
</tr>
<tr>
<td>Production</td>
<td>Min</td>
</tr>
<tr>
<td>-------------------------</td>
<td>------</td>
</tr>
<tr>
<td>TBT</td>
<td>90</td>
</tr>
<tr>
<td>SW Temp</td>
<td>30</td>
</tr>
<tr>
<td>Output (t/day)</td>
<td>31280</td>
</tr>
<tr>
<td>TDS (ppm)</td>
<td>10</td>
</tr>
<tr>
<td>BBT</td>
<td>41.6</td>
</tr>
<tr>
<td>Electrical load</td>
<td></td>
</tr>
<tr>
<td>Antiscale</td>
<td>446.4 kg/day</td>
</tr>
<tr>
<td>Acid cleaning</td>
<td></td>
</tr>
<tr>
<td>Steam supply</td>
<td>0.84 bar</td>
</tr>
<tr>
<td>Steam temp</td>
<td>104</td>
</tr>
<tr>
<td>Condensate temp</td>
<td>10 &gt; LP</td>
</tr>
<tr>
<td>MP to ejectors</td>
<td>20 bar (212 C)</td>
</tr>
</tbody>
</table>
SWRO Plant

- 30 MG/day
- 9 Units (each unit 3.3 mg/day)
- TDS < 500 mg/l
- Turbidity 30 NTU or less
- SW Temp 20 to 40 C
Process Flow Diagram of SWRO
Plant Description

- **Sea water intake**
  - 3 Travelling Band screens

- **3 Sea water pumps**
  - Vertical Pumps
  - Sea water panel
    - PH/temp
    - Chlorine
    - Silt density index (manual)
    - Oil monitor

- **Hypo-chloride production Plant**
Dual Stage Media Filtration

- To reduce turbidity and suspended Solids
- Inlet valve (water flow rate in response to RO demand)
- 38 filter cells (each cell 12 filter module)
  - Air supply
  - Wash water
  - Filtrate discharge
Pre-treatment Injection

• Intake Chlorination
  – To reduce marine growth

• Coagulant feed system
  – Ferric chloride
  – To encourage the formation of large solids

• Acid feed system
  – Sulphuric acid
  – To decrease PH from 8.2 to 7.6
  – To enhance the coagulation process

• Bisulphite feed system
  – To neutralize chlorine to avoid oxidation of RO membranes

• Antifoulant Feed system
  – At the inlet of the cartridge filters
  – To minimize the potential for deposition of foulants within the membrane arrays

• Tanks Accessories
  – Ultrasonic level transmitter
  – Pump calibration tube
  – Pulsation damper
  – Pressure gage
  – Back pressure regulator
  – Pressure relief valves
  – Local control panel
• LP Pump
  – Vertical

• Cartridge Prefiltration
  – 5 micron nominal separation (2 micron during Start up)

• HP Pump
  – Horizontal

• RO Membrane
  – 140 membrane pressure vessels (each 7 element capacity)
  – Spiral wound thin film composite membranes
  – Vessels working pressure (1200 psig)

• Energy Recovery Turbine
  – To minimize the power consumption (per unit)
  – Pump section & Turbine section (single rotor)
  – Turbine (reject stream hydraulic energy to mechanical energy)
  – Pump (mechanical energy back to pressure energy into the feed stream)
Cleaning

• Flash system
  – Flashing on daily basis
  – To maintain optimal operation of the membrane system.

• CIP system
  – To allow periodic cleaning of the membrane trains.
  – 50 psi (3.4 bar) steam (heat exchanger)
<table>
<thead>
<tr>
<th>Condition</th>
<th>Action 1</th>
<th>Action 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Phase protection (phase imbalance / voltage loss)</td>
<td>Turn off the control power</td>
<td>Fault is initiated</td>
</tr>
<tr>
<td>• Motor &amp; bearing temperature (Over temperature)</td>
<td>Shutdown the motor</td>
<td>Alarm is initiated</td>
</tr>
<tr>
<td>• Pump motor overload</td>
<td></td>
<td></td>
</tr>
<tr>
<td>• Vibration (excessive vibration)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low suction pressure</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed water quality</td>
<td>Alarm is initiated</td>
<td>Shutdown the unit</td>
</tr>
<tr>
<td>Chlorine</td>
<td></td>
<td>Flush the unit</td>
</tr>
<tr>
<td>High turbidity</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Chemical tanks</td>
<td>Alarm is initiated</td>
<td>Shut down</td>
</tr>
<tr>
<td>Low level</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No flow</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Feed water</td>
<td>LP pump off</td>
<td></td>
</tr>
<tr>
<td>Level low</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Flush storage</td>
<td>Over filling protection</td>
<td>Pump running dry protection</td>
</tr>
<tr>
<td>CIP storage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Thanks for your attention

Any Questions