Desalination MSF Unit
Jiddah Refinery

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About the presenter

Professional Chemical Engineer (PEC & SCE)
MBA & CEM® Certified (AEE)
15 years of Engineering experience
Present Assignment:
Engineering Division, Jiddah Refinery, Saudi Aramco.
About
Desalination MSF Unit Presentation

What’s expected
The audience will be able to know about:
• Jiddah Refinery MSF Unit
• Operational Challenges
• Best Practices adopted
• Sharing experience
Outline

• Introduction
• Process Overview
• Major Equipment
• Common Problems
• MSF Unit Problems & Challenges
• Performance & Troubleshooting
• Benefits Realized
• Best Practices & Lesson Learned
Introduction

Process Overview
Introduction

Purpose of Desalination

To convert seawater into freshwater.

Principle of MSF (Multistage-Flash Unit)

Evaporation at a temperature higher than the saturation temperature is referred to as *Flash Evaporation*.
Introduction

Jeddah Refinery Desalination
- Own seawater pump house supply
- Two units (MSF & MED)
- Used for Boilers, Process, Potable, Domestic Users

MSF Unit Design
- Capacity = 5040 m$^3$/day
- Steam Consumption = 26 T/h (1.1 bar saturated steam)
- Water Quality < 10 μS/cm
Process Overview
Process Overview

Simple Process Diagram
Major Equipment
Major Equipment

- Evaporator (22 Flash stages)
  - 1 - 19 Heat Recovery Section
  - 20 - 22 Heat ejection Stages
- Brine Heater
  - Shell & Tube Heat Exchanger
- Venting Unit
  - Steam Ejector & Condensers
- Make-up Water system
  - Deaerator
  - Anti-scale chemical Injection
  - Anti-foam Injection
- Ball Cleaning System
- Chemical Injection
Common Problems
Common Problems

• Poor Vacuum
  - Air leaks in Evaporator Shell, deaerator, vent/ejecter condenser
  - Low steam pressure
  - Plugging of ejector nozzles
  - Low cooling water flow

• Low Distillate Production
  - Low brine recirculating flow
  - Poor Vacuum in stages
  - Scaling in brine heater and Evaporator tubes

• Impure Distillate
  - Brine level
  - Foaming in stages
  - Demister improper setting
  - Impure condensate return
MSF Unit Problems & Challenges
Jiddah Refinery
MSF Unit Problems & Challenges

Major Issues

• Low Brine Circulation
• Low Distillate Production
• Poor Brine Heater Performance
• Higher Distillate conductivity
• Leaks in Evaporator tubes
• Vacuum issues
MSF Unit Problems & Challenges

Main Challenges

• Major Source of Distillated water
• Quality of water <10 µS/cm
• Aging of the equipment
• Pumps performance
• Leakage during operation
• Steam Balance
Challenges of MSF Unit
Some Examples
Performance & Troubleshooting
## Performance & Troubleshooting
### MSF Unit Performance

<table>
<thead>
<tr>
<th>Process Parameter, Units</th>
<th>2/16/2017 10:36</th>
<th>2/16/2017 8:30</th>
<th>2/16/2017 13:27</th>
<th>2/16/2017 15:21</th>
<th>2/19/2017 1:30</th>
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<tbody>
<tr>
<td>Brine recirculation pumps G-001 A/B, flow, m³/hr</td>
<td>1770</td>
<td>1600</td>
<td>1510</td>
<td>1314</td>
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<td>SW supply pressure, Kg/cm²</td>
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<td>SW discharge m³/hr</td>
<td>1490</td>
<td>1488</td>
<td>1487</td>
<td>1490</td>
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<td>Make up flow, m³/hr</td>
<td>325</td>
<td>320</td>
<td>322</td>
<td>326</td>
<td>300</td>
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<tr>
<td>Brine heater E-002 Inlet temp °C</td>
<td>91.4</td>
<td>87.8</td>
<td>85</td>
<td>79.7</td>
<td>80</td>
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<td>Brine Heater Outlet temp. °C</td>
<td>100.8</td>
<td>96.3</td>
<td>93</td>
<td>86.5</td>
<td>86.5</td>
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<td>Brine blowdown flow G-002 A/B</td>
<td>237</td>
<td>352</td>
<td>315</td>
<td>324</td>
<td>347.5</td>
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<td>Vent Condensate temp. °C</td>
<td>26</td>
<td>-</td>
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<td>-</td>
<td>25.6</td>
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<td>Distilled pumps G-003 A/B, m³/hr</td>
<td>200</td>
<td>179</td>
<td>160</td>
<td>127.5</td>
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<tr>
<td>Condensate flow G-004 A/B, m³/hr</td>
<td>23.5</td>
<td>19.4</td>
<td>17.9</td>
<td>12</td>
<td>11.3</td>
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<td>Last stage vapor pressure, mmHg</td>
<td>-789</td>
<td>793</td>
<td>-795.5</td>
<td>-797</td>
<td>-797.9</td>
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<td>Brine Level, %</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td>49</td>
<td>52</td>
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<td>Anti-foam Flow &amp; Strokes %</td>
<td>60</td>
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<tr>
<td>Anti-scale (BELGARD) Flow &amp; Strokes %</td>
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<td>Distillate conductivity, µS/cm</td>
<td>14</td>
<td>11.9</td>
<td>7.13</td>
<td>6.25</td>
<td>5.5</td>
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<td>Evaporators Tray Level, %</td>
<td>45.4</td>
<td>41.6</td>
<td>51.2</td>
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<td>5.2</td>
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<td>Brine to Recovery pH</td>
<td>8.8</td>
<td>8.79</td>
<td>8.96</td>
<td>8.8</td>
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<td>High Pressure Steam valve Pressure &amp; Opening, %</td>
<td>0.817</td>
<td>0.863</td>
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<td>1.149</td>
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<td>Brine heater E-002 temp °C</td>
<td>115</td>
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<td>103.5</td>
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Performance & Troubleshooting

Successful Troubleshooting

- Blowdown & Brine Circulation
  - Improved with pumps performance
- Cleaning and Fixing Leaks in Evaporator tube
  - Stages 1-4 tubes hydro-jetting (90/10 Cu/Ni)
  - Stage 7 & 8 total re-tubing
- Suitable Chemicals Injection
- Brine Heater Efficiency Improvement
  - Leaks repair
  - Scale removal with special techniques
- Improved Vacuum (After Mar 2017 T&I)
  - Ejectors performance
  - Vent & Ejector condenser performance
Performance & Troubleshooting Example
Benefits Realized
Benefits Realized

• Distillate Production increased
  - 140 to 200 Tons/hr
• Brine Heater Efficiency Improved
  - Heater outlet temperature 104 → 91°C
• Better Quality distillate
  - Conductivity improved from 15 → 3 µS/cm
• Vacuum improved
  - From condenser repair 560 → 740 mmHg
Best Practices & Lesson Learned
Lesson Learned
Best Practices adopted

- Ball Cleaning System
  - Run after every 72 hrs.
- Avoid acid with better chemical replacement
  - To avoid tube leaks
  - HSE concern (Handling issues)
- Monitoring of the Unit
  - Key parameters
  - Maintain Brine circulation Ratio
- Good plan for Turnaround and Inspection
- Special techniques used to remove scaling *(Aqua milling)* at Brine Heater tubes
- Tubes leaks and repair should be done properly
“Science is simply common sense at its best”
-Thomas Huxley