



Chlorine Dioxide effectiveness on Microbial Corrosion-Case Study

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Agenda

- Riyadh Refinery Location & Layout
- Riyadh Refinery Water Treatment Plant (WTP)
- Background of Chlorine Vs Chlorine Dioxide
- Trial Results
- Financial Benefit

Riyadh Refinery Location & Layout

An inland refinery

Conversion refinery

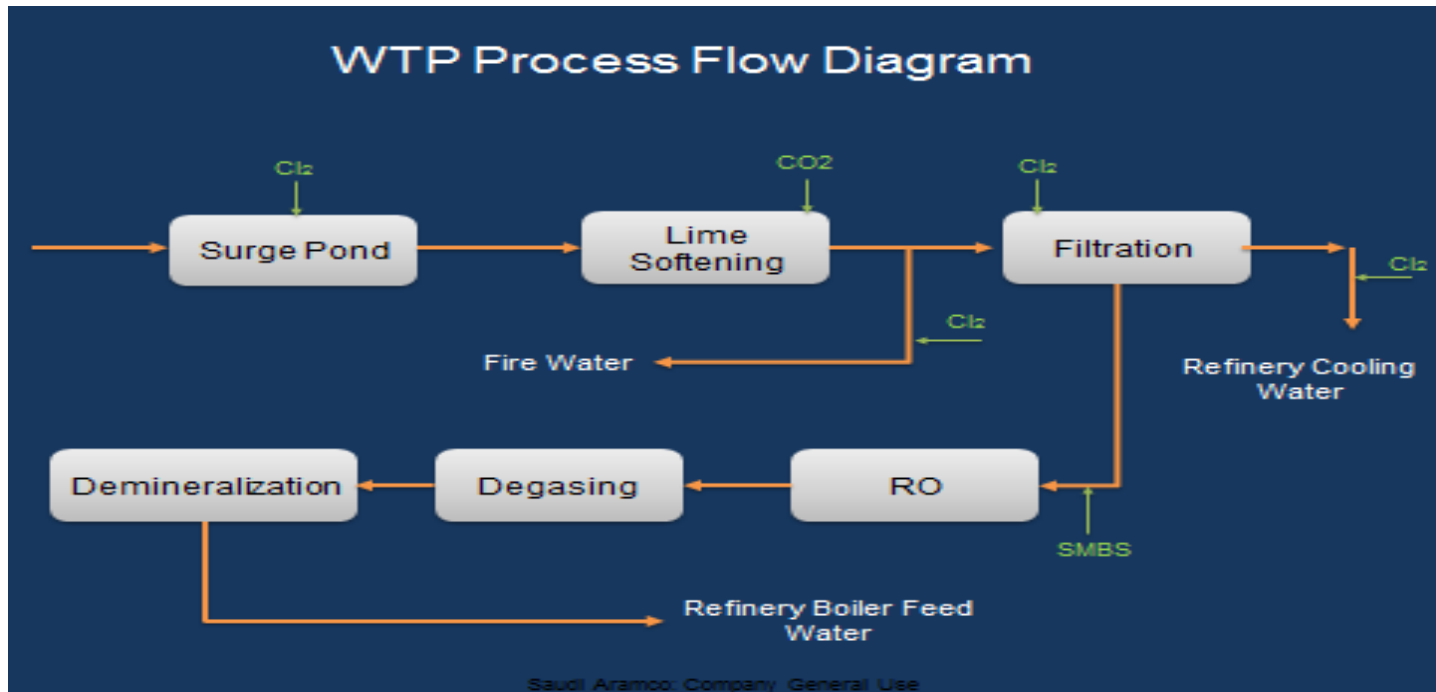
Operating capacity of 130 MBD

Provide 30% of Central Region Demand



Riyadh Refinery Water Treatment Plant (WTP)

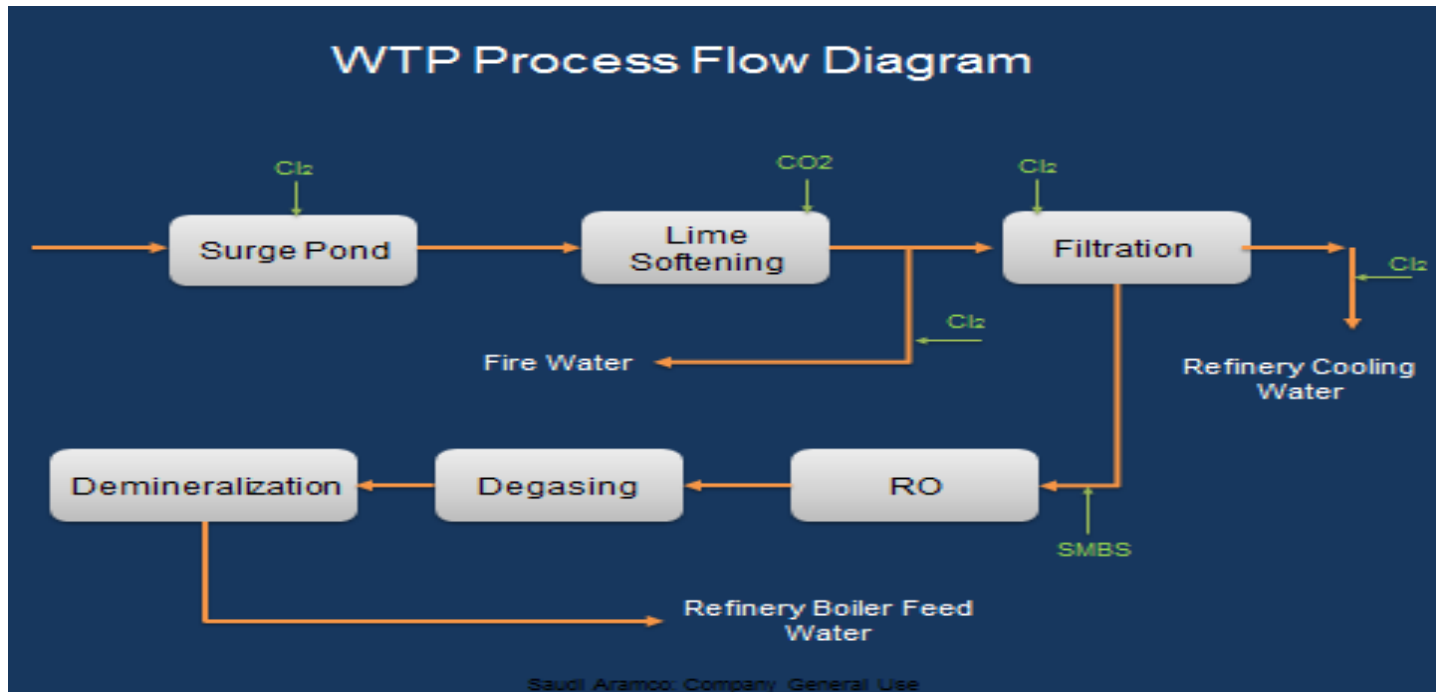
- RR utilizes treated sewage wastewater that is further treated in RR's sophisticated Water Treatment Plant (WTP).
- WTP produces 3 different kinds of industrial water:
 1. Firewater (FW)
 2. Cooling Water (CW)
 3. Boiler Feed Water (BFW)



Riyadh Refinery Water Treatment Plant (WTP)

WTP consists of several processes:

1. Pre-Treatment Units: Water is treated for suspended solids, hardness, alkalinity, pH adjustment, and microbial growth.
2. Dissolved Solids Treatment Units: Water is treated for its dissolved solids, CO₂ removal, and conductivity.



Drive for Change



1. Heavier than air
2. Toxic
3. Irritation
4. Employee Exposure
5. Chemical Handling
6. Hard to contain
7. Special Disposal

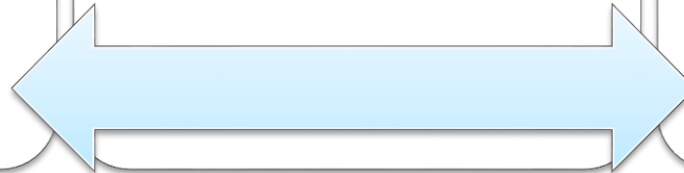


1. Very corrosive
2. Frequent rubber failure
3. Pressurized system
4. Corrosion rate



Financial Benefits

\$261 M 



Technology Selection



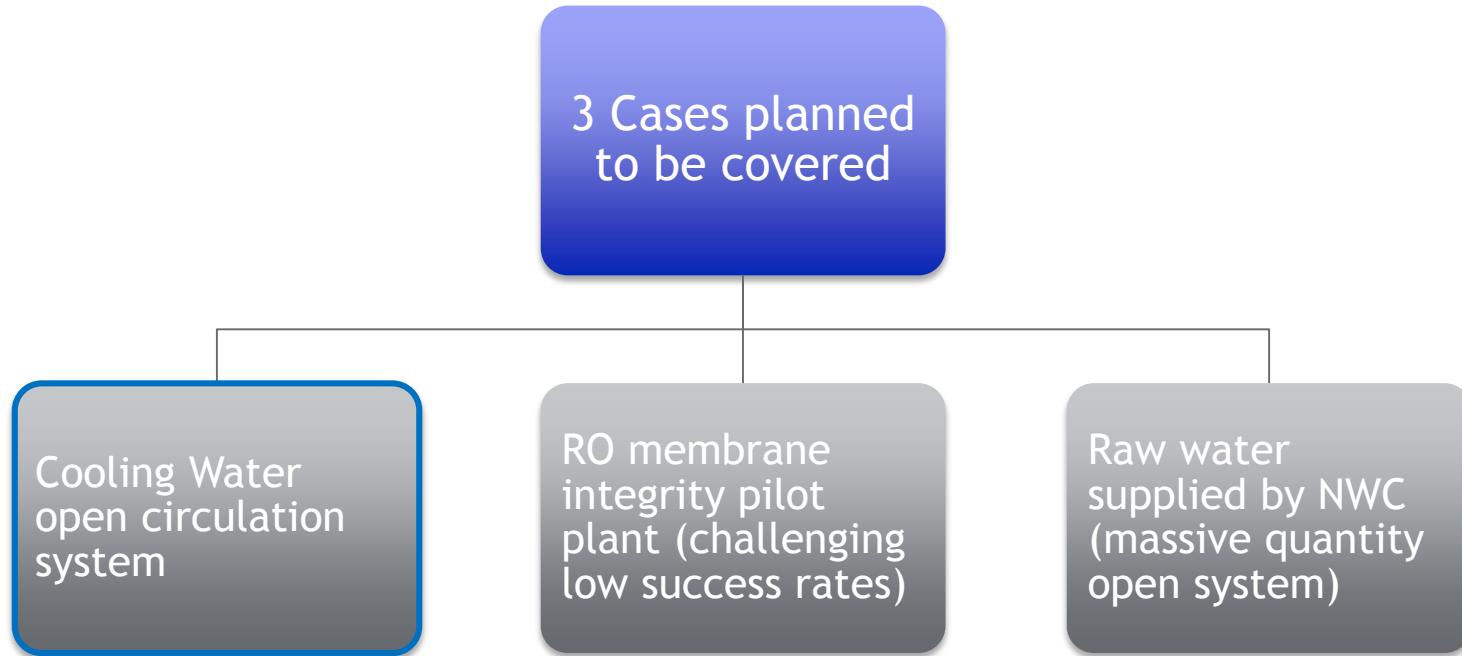
RRD & EPD
decided to fish
for new
technologies
replacing Cl₂(g)

Several
companies
were
approached

Chlorine
Dioxide was
proposed as an
alternative
disinfectant

Planned to be
trailed for one
year in a
Cooling Water
System

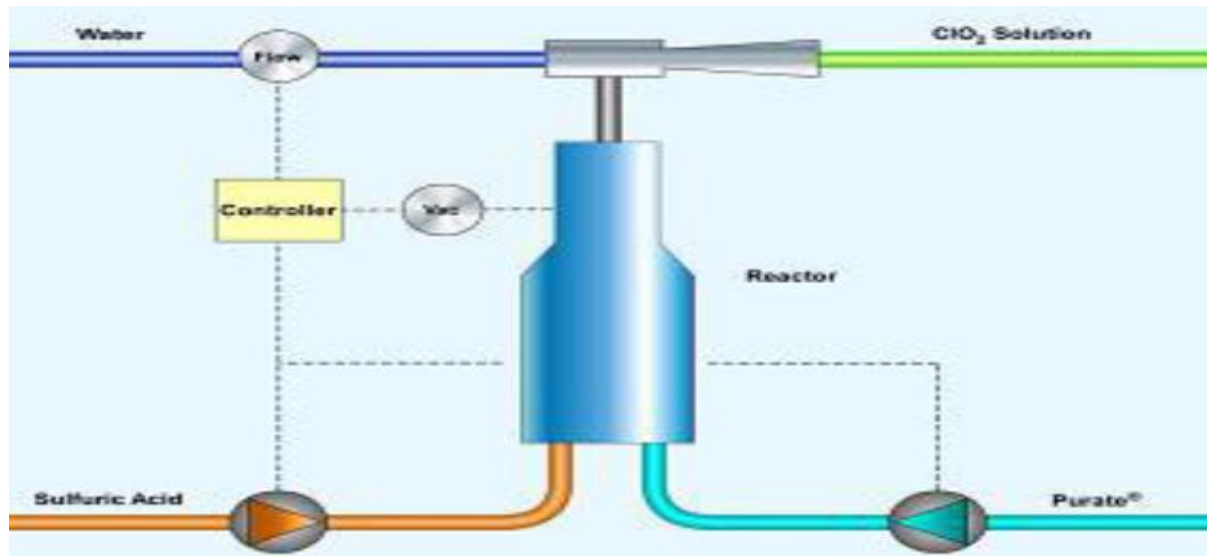
Implementation Plan



Chlorine Dioxide was first tested at the Cooling Water System



Chlorine Dioxide System

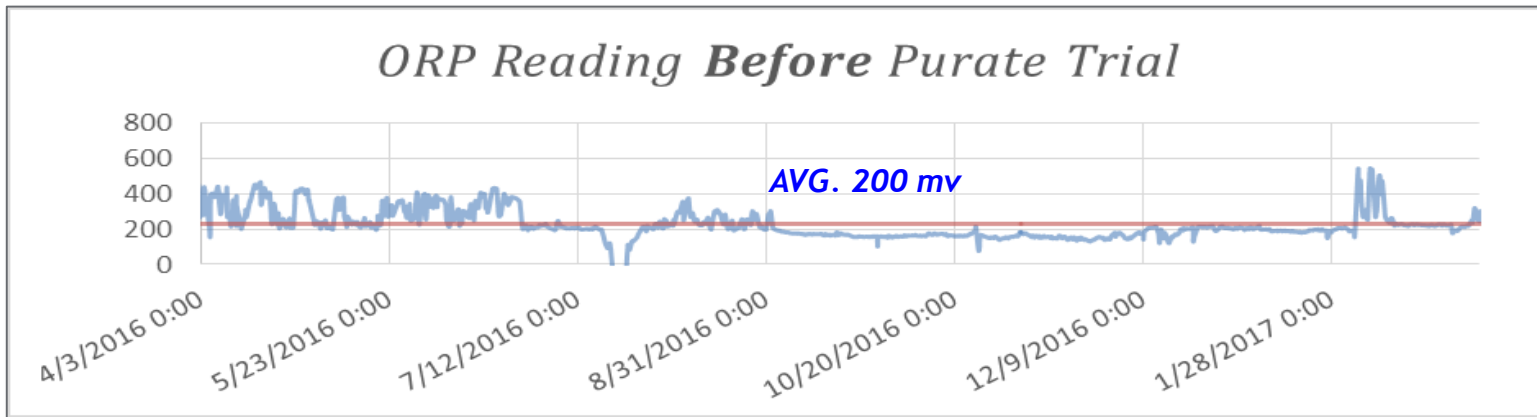
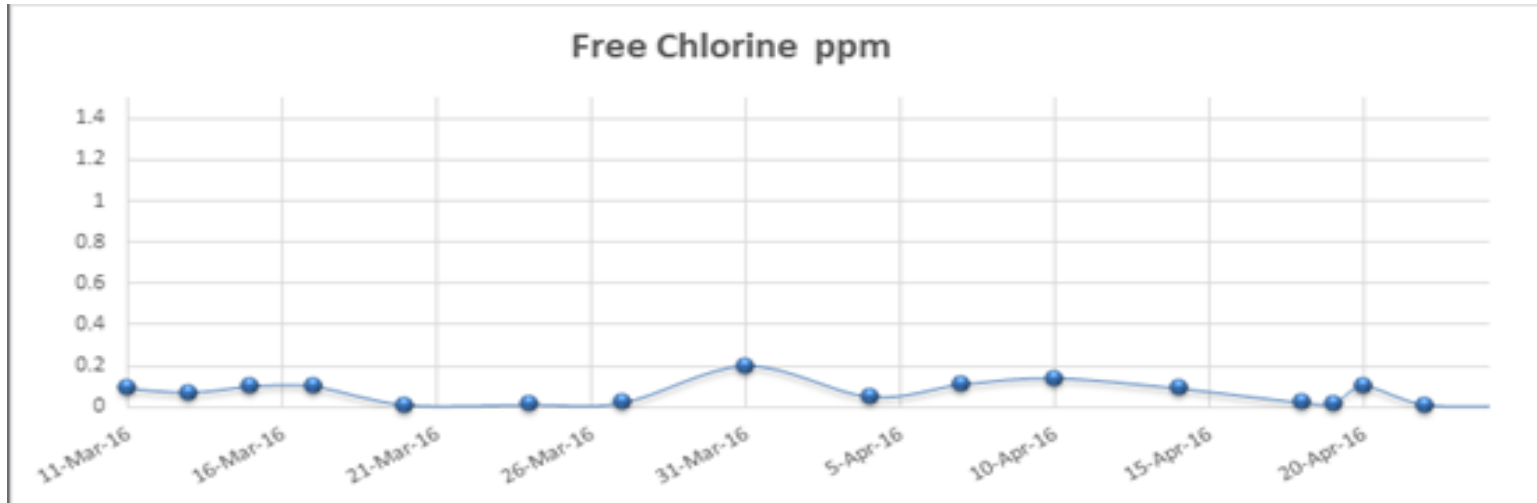


Purate®

SVP-Pure® Process

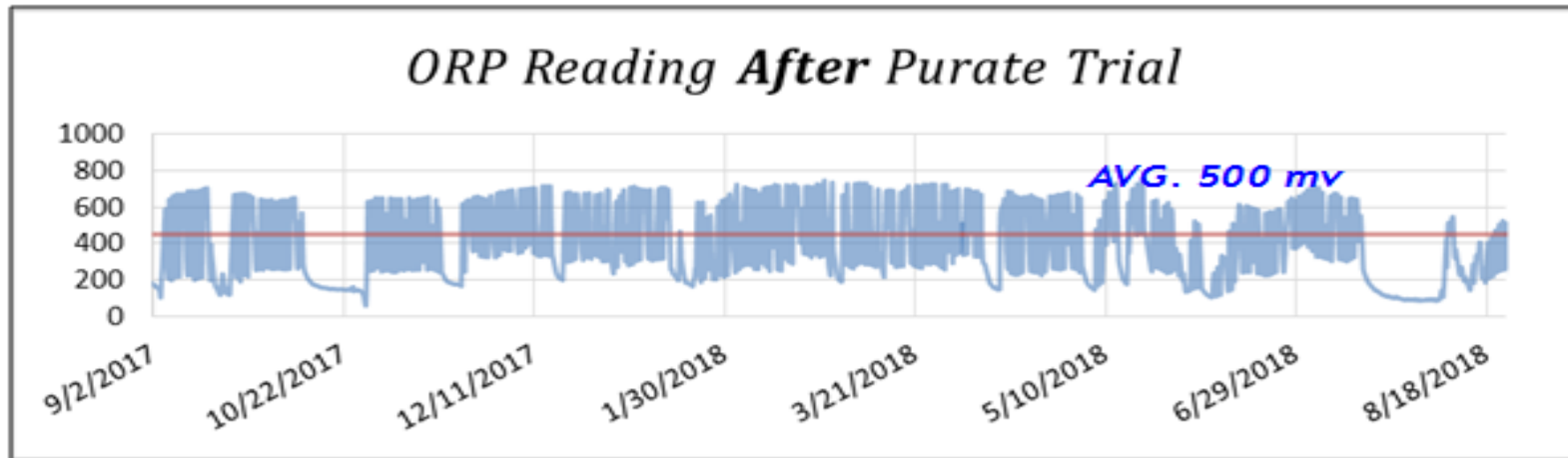
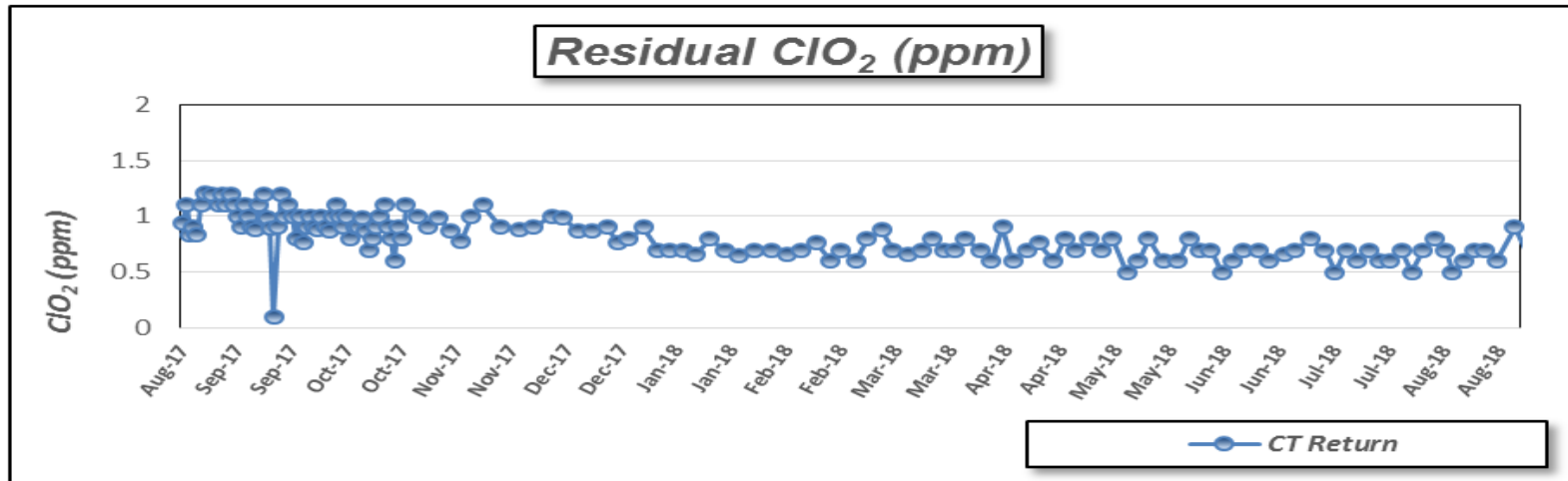
Trial Results

Chlorine Residual & ORP (Before Chlorine Dioxide Trial)



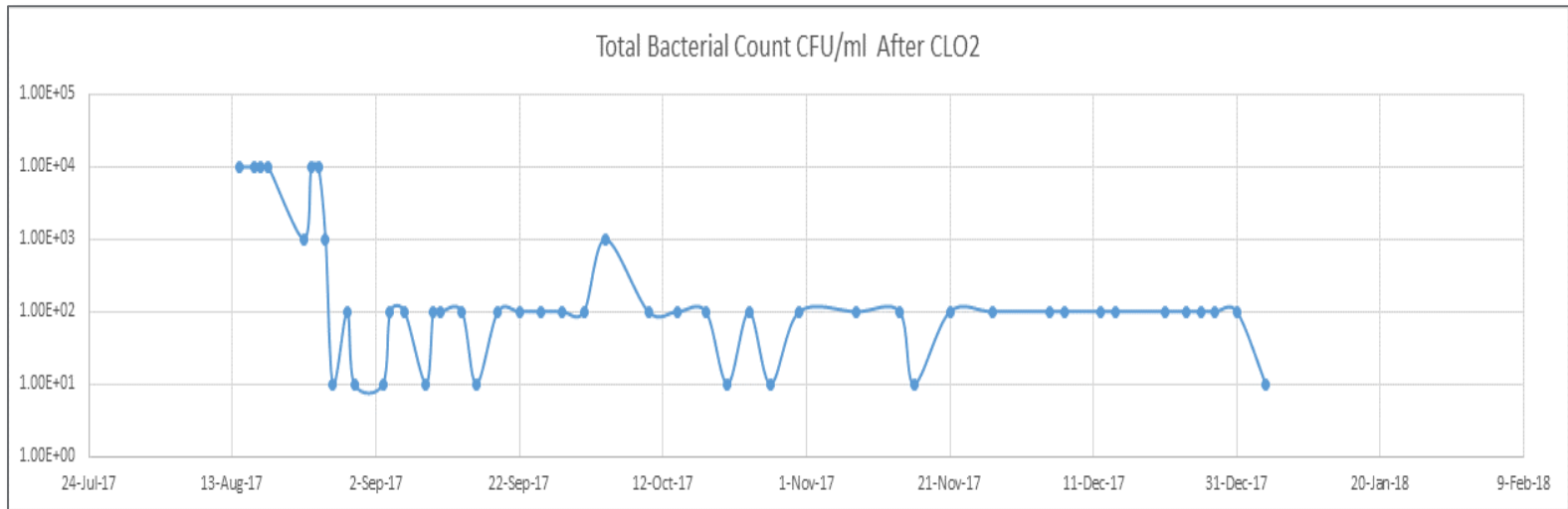
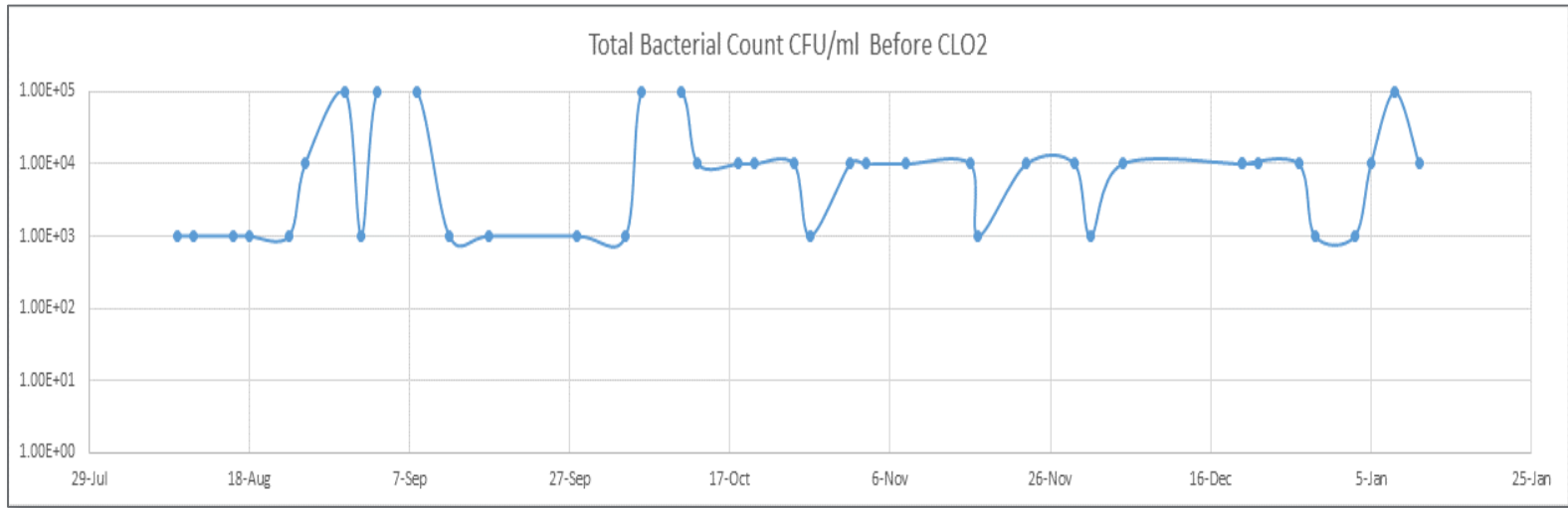
- Difficulty to reach above 200 mv ORP while injecting Gas Chlorine along with Oxidizing Biocide

Chlorine Residual & ORP (After Chlorine Dioxide Trial)



- Significant improvement in ORP reading while using Chlorine Dioxide

Microbial test analysis



Microbial Test analysis

- Before Chlorine Dioxide implementation

Analyte	Result	Test Method
AEROBIC BACTERIA		AMB2, AMB4, AMB5
Total Viable Count @ 35°C	1 500 000 CFU/mL	
Pigmented Bacteria	Not Detected	
Total Coliforms	20 est. CFU/mL	
<i>E. coli</i>	<10 CFU/mL	
<i>Pseudomonas spp</i> @ 35°C	40 000 CFU/mL	
Spores	<10 CFU/mL	
ANAEROBIC BACTERIA		AMB3, AMB6
Sulfate Reducing bacteria	200 CFU/mL	
FUNGI		AMB2
Mold	10 est. CFU/mL	
Yeast	<10 CFU/mL	

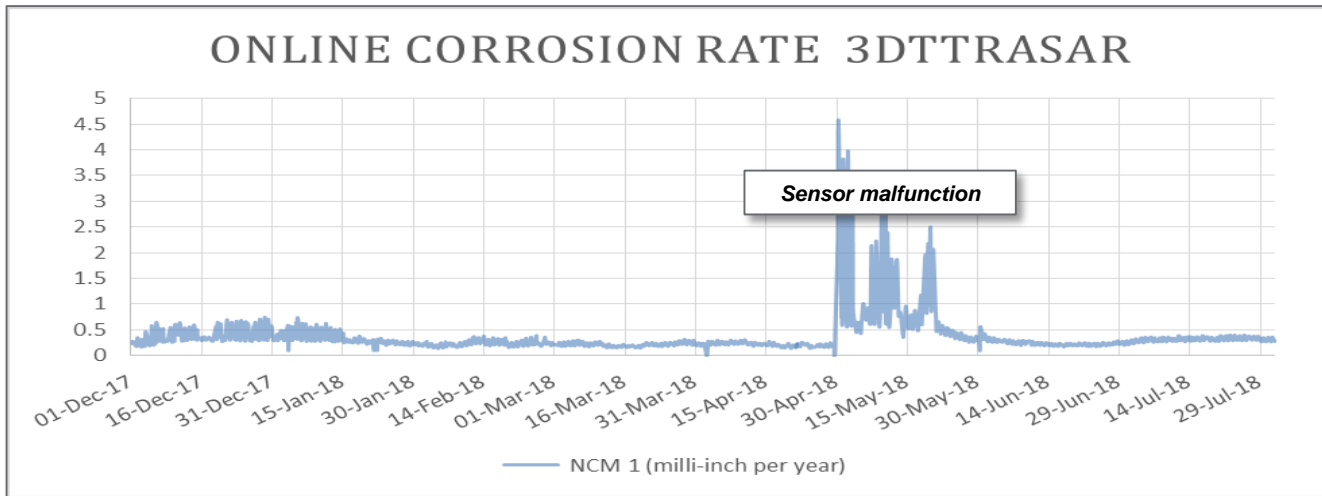
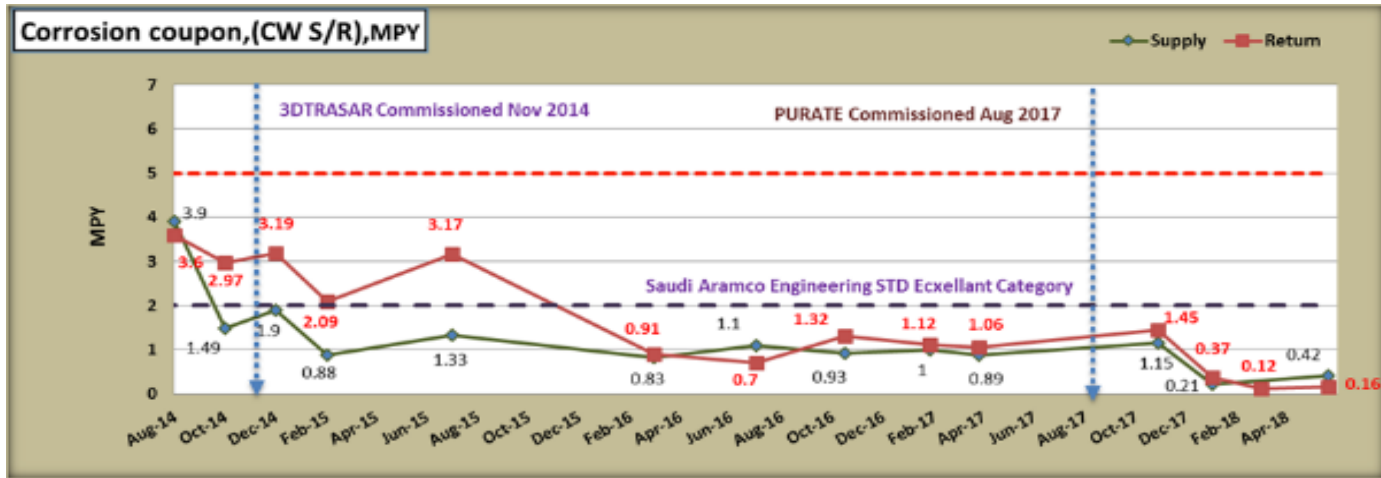
Analyte	Result	Test Method
AEROBIC BACTERIA		AMB2, AMB4, AMB5
Total Viable Count @ 35°C	610 000 CFU/mL	
Pigmented Bacteria	1 Type	
Total Coliforms	<10 CFU/mL	
<i>E. coli</i>	<10 CFU/mL	
<i>Pseudomonas spp</i> @ 35°C	320 CFU/mL	
Spores	<10 CFU/mL	
ANAEROBIC BACTERIA		AMB3, AMB6
Sulfate Reducing bacteria	14 CFU/mL	
FUNGI		AMB2
Mold	<10 CFU/mL	
Yeast	<10 CFU/mL	

Microbial Test analysis

- After Chlorine Dioxide implementation

Analyte	Result	Test Method
AEROBIC BACTERIA		AMB2, AMB4, AMB5
Total Viable Count @ 35°C	< 1 000 CFU/mL	
Pigmented Bacteria	1 Type	
Total Coliforms	<10 CFU/mL	
<i>E. coli</i>	<10 CFU/mL	
<i>Pseudomonas spp @ 35°C</i>	<10. CFU/mL	
Spores	<10 CFU/mL	
ANAEROBIC BACTERIA		AMB3, AMB6
Sulfate Reducing bacteria	<1 CFU/mL	
FUNGI		AMB2
Mold	<10 CFU/mL	
Yeast	<10 CFU/mL	

Corrosion Rate(MPY) Readings

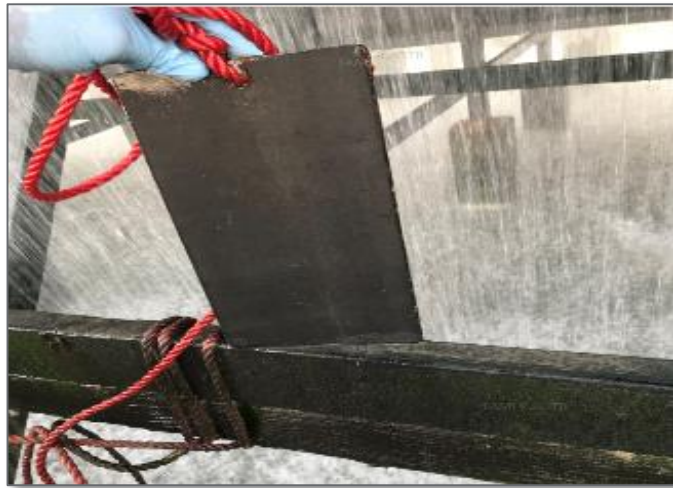


- The Cooling Water System corrosion rate decreased below 0.5 MPY
- Saudi Aramco Engineering Standard Excellent category (Below 2 MPY)

Fouling Plates Visual Condition



4 months after immersing fouling plate (Before Chlorine Dioxide Trial)



14 months after immersing fouling plate (After Chlorine Dioxide Trial)

Cooling Tower Structure & Algae Growth



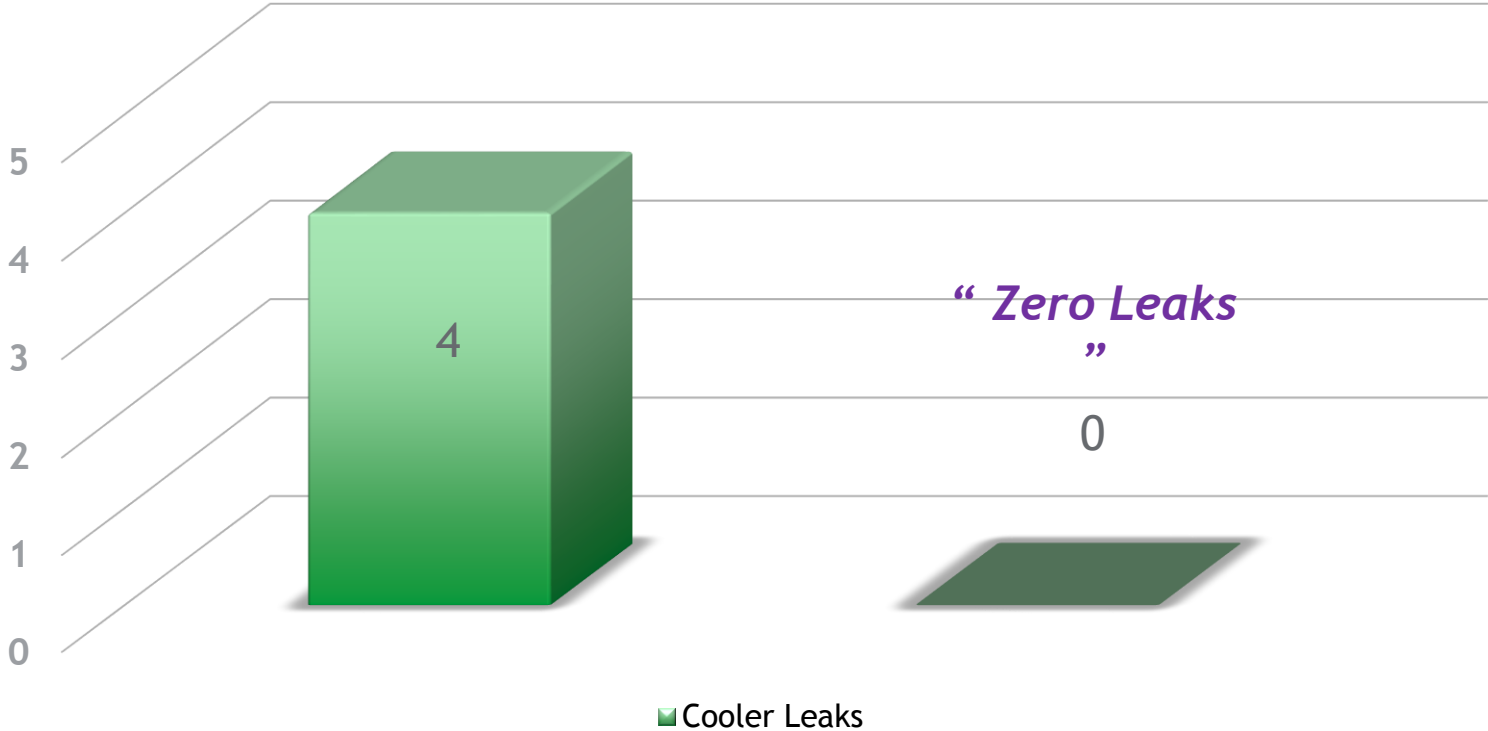
Before Chlorine Dioxide Trial



After Chlorine Dioxide Trial

Heat Exchangers leaks

Cooler Leaks



Financial Benefits

Chemical Cost (Chlorine Gas + Halogen + Non-oxidizing Biocide)

<i>Chemicals</i>	<i>Consumption in 2016 (kg / year)</i>	<i>Cost (USD)</i>
ST40 oxidizing Biocide	54,432	297,561
2894 Algae control	3,840	81,920
N 7330	3,600	7,680
8514 (Bio-Dispersant)	1,545	6,592
Chlorine Gas	17,520	12,852
Total		406,605

Chemical Cost (Chloride Dioxide)

<i>Chemicals</i>	<i>Consumption (kg / year)</i>	<i>Cost (USD)</i>
Chlorine Dioxide	54,000	94,982
Sulfuric Acid	64,800	25,920
2894 Algae Control	1,125	24,576
Total		145,478

Annual Saving of \$261 M 

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