Saudi Aramco Project Development

Wastewater Treatment Facilities
Jeddah Refinery And Marine Area

December 2007

Facilities Planning Dept.
OBJECTIVE:

Provide an overview of the complexities of developing a project scope for Upgrading the Industrial and Sanitary Wastewater Treatment Facilities at Jeddah Refinery attributed to:

- Difficult to treat industrial oily wastewater stream requiring multiple studies
- Multiple changes in the future operations of the Jeddah Refinery
PRESENTATION OUTLINE

- Background
- Initial Study – Conventional Biological Treatment
- Second Study – Physical Chemical Treatment
- 1st Revised Operating Scenario for Jeddah Refinery
- Third Study – Membrane Bio-Reactors
- 2nd Revised Operating Scenario for Jeddah Refinery
- Overall summary of the project development
• Environmental Master Plan (EMP) issued by Company in 2001

• EMP indicates that upgrades required for Jeddah Refinery Industrial Wastewater Treatment System and Sanitary Sewage System

• Consultant contracted in 2002 to perform field evaluation and tests and recommend upgrade requirements
Background (cont’d)

Location & Existing Facilities

- **Jeddah Refinery:**
  - Located adjacent to the Islamic Port in Jeddah
  - Commissioned in 1982
  - Currently operating at 90,000 barrel crude oil refinery producing gasoline, fuel oil, and asphalt
  - Major process units include crude distillation, vacuum, platformer unit, naphtha hydrotreating, fluid catalytic cracker (FCC)
  - Tank Farm for Crude and Product and Terminal Facilities
  - Provides feedstock/some utilities and treats wastewater from adjacent Luberef Plant
BACKGROUND (cont’d)

Location & Facilities (cont’d)

• **Existing Industrial Wastewater Treatment Facilities, Jeddah Refinery**
  - Located adjacent to the refinery in the Marine Area
  - Holding Basin for incoming wastewater flow conditions
  - API Separators for removal of oil & grease and solids
  - Media Filter for removal of total suspended solids (TSS)
  - All equipment more than 25 years old
  - Treats wastewater from the refinery, tank farm, & Luberefr
  - Design wastewater flow 2.66 million gpd (10,000 M³/d)

• **Existing Sanitary Wastewater System**
  - Sewage collected from buildings into holding tanks
  - Sewage removed via vacuum trucks and sent to Saudi Aramco’s Al-Rehab Community Center STP
  - Approximate quantity of sewage generated: 12,000 gpd (45 M³/d)
Industrial & Sanitary Wastewater Treatment
Existing Flow Scheme – Jeddah Refinery

Refinery Tank Farm, and Luberef Plant Wastewater, Stormwater

Holding Basin

API Separators

Oil & Grease Removal

Sand Filtration

Suspended Solids Removal

To Effluent Lagoons/Red Sea

Industrial Wastewater Treatment

Sanitary Wastewater Handling

Sanitary Wastewater

Septic Tanks

Vacuum Tank Trucks – To Al-Rehab STP
INITIAL STUDY (2002)

FINDINGS

• Major Deficiencies with JR Industrial Wastewater Treatment and Sewage System
  – API Separators at end of useful life
  – Separator solids difficult to remove
  – Media Filters in constant state of repair and often unavailable
  – Removal of Organic/Inorganic contaminants not possible
  – No onsite sanitary waste treatment facility
INITIAL STUDY (2002)

FINDINGS

- PME Discharge Limits are not met

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<th>JR Industrial Wastewater Discharge</th>
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INITIAL STUDY (Cont’d)

FINDINGS

• Other Physical Characteristics of Wastewater
  – Highly Variable Total Dissolved Solids, up to 16,000 ppm
  – Extreme Variability of Wastewater Parameters
  – High Temperatures 30 -50 °C
  – Highly Variable Flow Rate
• **Industrial Wastewater Treatment**
  – Conventional Biological Treatment
  – Physical Chemical Treatment (Steam Stripping)

• **Sanitary Wastewater Treatment**
  – Conventional Biological Treatment
INITIAL STUDY (Cont’d)

Recommended Industrial Wastewater Treatment Scheme – Conventional Biological Treatment

Refinery Tank Farm, and Luberef Plant Wastewater, Stormwater

- Conventional Biological Treatment
  - Dissolved/Air Flotation
  - Activated Sludge with Nitrification

- Sanitary Wastewater
  - Methanol & pH Control
  - Chiller

- Stormwater Basin
  - Skim Tanks
  - API Separators
  - Dissolved/Air Flotation

- Primary Oil & Grease Removal

- Secondary Oil & Grease Removal

- Sanitary Wastewater
  - Chiller
  - Methanol & pH Control

- Oil to Slop Oil System
  - Skim Tanks
  - API Separators
  - Dissolved/Air Flotation
  - Activated Sludge with Nitrification

- Sand Filters
  - Suspended Solids Removal
  - Chlorination
  - Removal of Organic & Inorganic Compounds; pH Adjustment
  - Biosludge Thickening & Dewatering

- Dewatered Biosludge to Disposal

- To Effluent Lagoons/Red Sea
INITIAL STUDY (Cont’d)

Issues with Recommended Biological Treatment

Advantages

- Most commonly used process for “normal” industrial oily wastewater streams
- Can be also used to treat sanitary waste

Disadvantages

- Difficult to sustain biomass due to high swings in wastewater concentrations, TDS, and temperature
- Requires complex operations (as currently experienced at Rabigh Refinery)
- Not supported by EPD
SECOND STUDY (2003)

Background Information

- EPD – Identify Simpler Treatment Process
- R&DC – Recommended resins for treatment via polymeric adsorption of contaminants
- Consultant – Contracted to perform bench testing & field pilot tests
- Physical Chemical Treatment – Proposed scheme developed
Second Study (Cont’d)

Recommended Physical Chemical Treatment – Resin Adsorption

Refinery Tank Farm, and Luberef Plant Wastewater, Stormwater

Storm Water Basin → API Separators → Skim Tanks → Dissolved/Air Flotation → Cartridge Filters → Resin Columns (Secondary Oil & Grease Removal)

- Oil to Slop Oil System
- Phenol & Organics Removal
- Steam
- pH Adjust
- GAC Columns

Sand Filters → Ammonia Removal → Air Stripper

- pH Adjust
- Chlorination

To Sanitary Wastewater Treatment Plant

To Effluent Lagoons/Red Sea

Primary Oil & Grease Removal

Suspended Solids Removal

Oil to Slop Oil System

To Sanitary Wastewater Treatment Plant

To Effluent Lagoons/Red Sea

- pH Adjust
- Chlorination

GAC Columns
Second Study (Cont’d)

Recommended Sanitary Wastewater Treatment Scheme – Membrane Bio-Reactor (MBR)

Sanitary Wastewater

Existing Septic Basins w/New Pumps & Lines

Main Collection Sump*

New MBR Treatment Plant

Treated Water

Regenerant from Industrial Wastewater Plant

Sludge To Landfill

To Effluent Lagoons

*With Grit Chamber & Screens

Irrigation
Second Study (Cont’d)
*Physical Chemical Treatment - Resin Adsorption*

- **Advantages**
  - Simple unit operations
  - High tolerance to swings in effluent conditions
  - Easy to restart after shutdown

- **Disadvantages**
  - High steam requirements
  - Frequent replacement of GAC (Regeneration possible)
  - Requires separate sanitary wastewater treatment plant

- New Rabigh Refinery/Petrochemical Complex – may affect future operation of Jeddah Refinery

- Jeddah Refinery – partial or complete shutdown of process units; study being performed by Facilities Planning Dept. (FPD)

- Industrial Wastewater Treatment Plant (IWTP) for Jeddah Refinery – capacity & treatment scheme could vary with process units remaining in operation

- Two-Phase Implementation of IWTP at Jeddah Refinery

- Phase 1 – install equipment for removal of oil & grease and total dissolve solids from the industrial wastewater to meet PME regulations

- Phase 2 – based on FPD study results and management recommendations, install remaining equipment for removal of all other contaminants from the industrial wastewater and provide onsite sanitary sewage to meet PME regulations
Phase 1 Industrial Wastewater Treatment Facilities

- Design Capacity: flexibility to allow for any changes in the operation of Jeddah Refinery
- Project Proposal Engineering: commenced on August 2004
- Detailed Engineering: commenced on December 2005
- Construction: currently under
- Plant Start Up: July 2008
1st Revised Operating Scenario for Jeddah Refinery (Cont’d)

Phase 1 Industrial Wastewater Treatment Facilities

Refinery Tank Farm, and Luberef Plant Wastewater, Stormwater

- Storm Water Tank
- API Separator
- Skim Tanks
- Walnut Shell Filters

Secondary Oil & Grease Removal and TSS

Primary Oil & Grease Removal

Oil to Slop Oil System

To Effluent Lagoons/Red Sea
1st Revised Operating Scenario for Jeddah Refinery

- **FPD Study Results for Future Operations of Jeddah Refinery Released in Early 2005**
  - Based on study recommendations and management decision in May 2005, Jeddah Refinery process units to be shutdown in 2010
  - Jeddah Refinery Tank Farm (including marine area) and Luberef to remain in operation
  - Proceed with implementation of Phase 2 Wastewater Treatment Facilities
Third Study (2005)

Phase II Industrial Wastewater Treatment Facilities

- **Shutdown of Jeddah Refinery**
  - expect lower concentrations of phenols and ammonia in wastewater
  - cooler wastewater temperatures
  - wastewater flowrate reduced by 33%

- **Membrane Bio-Reactor (MBR)**
  - EPD recommends the evaluating the use of an MBR in lieu of physical chemical treatment for industrial wastewater and sanitary sewage at Jeddah Refinery
  - Consultant contracted to perform bench testing and conducts pilot plant evaluation
  - Test Results indicate MBR viable & economical process
Third Study

Phase 2 Industrial Wastewater Treatment Facilities (Base)

Refinery Tank, Farm, and Luberef Plant Wastewater, Stormwater

Storm Water Tank
API Separators
Skim Tanks
Walnut Shell Filters

Oil to Slop Oil System

From Sanitary Waste Collection System

Granulated Activated Carbon Units

MBR Units

To Effluent Lagoons/Red Sea

Equalization Tanks

To Sludge Pit/Sludge Beds

Phase 1 Equipment
Third Study

Phase 2 Industrial Wastewater Treatment Facilities (Alternate)

Refinery Tank Farm, and Lubref Plant Wastewater, Stormwater

Phase 1 Equipment

To Effluent Lagoons/Red Sea

To Sludge Pit/Sludge Beds

From Sanitary Waste Collection System

Oil to Slop Oil System

API Separators

Skim Tanks

Walnut Shell Filters

MBR Units

Equalization Tanks

Powder Activated Carbon
2nd Revised Operating Scenario for Jeddah Refinery (2007)

- **Future Operation of Jeddah Refinery**
  - In lieu of shutting down the Jeddah Refinery process units, the JR is to continue to run as a topping refinery until 2014 for the production of fuel oil and asphalt only
  - Jeddah Refinery Tank Farm (including marine area) and Luberef to remain in operation

- **Impact on Phase 1 & 2 Wastewater Treatment Facilities**
  - Phase 1 Facilities: none, except install 2\textsuperscript{nd} API Separator in Phase 2
  - Phase 2 Facilities: re-size equipment to handle 33\% more flow & provide wastewater cooling
    - Project Proposal: commenced on September 2007
    - Plant Start-Up: March 2011
Currently Proposed Facilities

Phase 1 & 2 Industrial & Sanitary Wastewater Treatment Facilities

- Refinery Tank Farm, and Luberef Plant Wastewater, Stormwater
- Storm Water Tank
- API Separators
- Skim Tanks
- Walnut Shell Filters
- Powder Activated Carbon
- MBR Units
- Equalization Tanks
- Chiller

Design Capacity: ~ 2MM gpd (7900 M3/d)
Pre-2001: Company conducts survey of all major plants and facilities for environmental compliance

2001: Company issues Environmental Master Plan

2002: Initial Study for Jeddah Refinery with conventional biological treatment recommended

2003: EPD recommends physical chemical treatment to facilitate operations (2nd Study)

2004: Future continued operations of Jeddah Refinery under study

2004: Implementation of JR WWTP in two phases; Phase I treatment for oil & grease and TSS only; Phase I engineering commences

2005: Management decision to discontinue operation of process refining units at Jeddah Refinery (1st Operational Change)
2005: EPD recommends MBR for treatment of industrial wastewater & sanitary sewage (3rd Study)

2006: Evaluation of MBR treatment indicates viability

2007: In lieu of shutting down the Jeddah Refinery process units, the JR is to continue to run as topping refinery until 2014 (2nd Operational Change)

2007: Commence with engineering of Phase 2 wastewater treatment facilities

2008: 3rd Operational Change??????

2008: Startup of Phase 1

2011: Startup of Phase 2
Thank you