

DESALTER WASTE WATER TREATMENT

Technology Introduction & OPEX Calculations



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1. Introduction

This document describes the technology and approaches used by Esmil during this project to treat the desalter waste water produced at Antipinsky Refinery whilst achieving the reuse/discharge limits set.

As a reference, operating costs for individual units and potential schemes for desalter waste water treatment are included. However, these are based on conditions within this particular project and are subject to change with varying parameters. Including feed water quality and source, required treated water quality, technological scheme etc.

1.1 Antipinsky Refinery Project Overview

Antipinsky Refinery and Subcontractors Petrofac LLC requested the design and construction of a desalter waste water treatment plant.

The Waste Water Treatment Plant was designed to remove oil and dissolved salts from the refineries desalter unit. The treated water will be suitable for process reuse or discharge to sewer system.

The general treatment philosophy employed is based on using proven technologies combined to achieve the purification required for this application.

The complete system consists 2 x 100% duty identical streams each rated for 110 m³/day over a 20 hour period.

1.1.1 Process Overview

Each stream is comprised of:

- A tilted plate separator for gross oil/ water/ solids separation;
- An Ultrafiltration membrane stage for removal of residual oil. Also acts as pre-treatment for the downstream Reverse Osmosis unit;
- A Reverse Osmosis (RO) plant to dramatically reduce the concentration of dissolved salts and enable reuse of the recovered water.

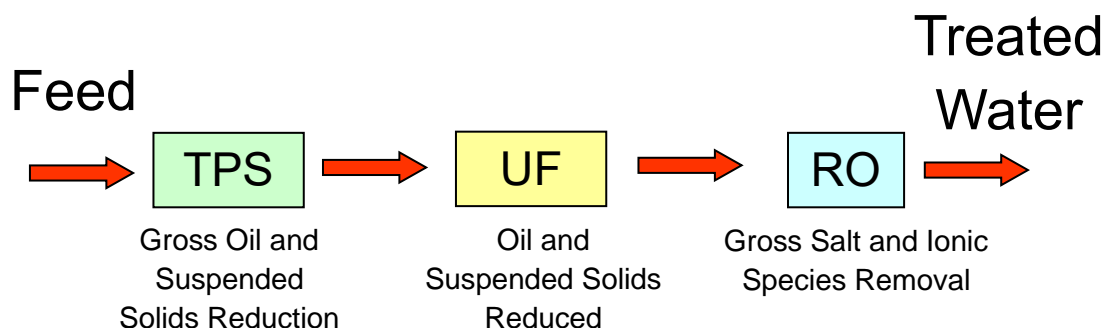


Figure 1. Desalter WWTP Block Flow Diagram

1.1.2 Design Basis

The design is based on an influent of 1500 mg/l TDS (Total Dissolved Solids), free oil at 500 mg/l and 1.0 kg/m³ density at 20°C.

The capacity of the plant is 110 m³/day over a 20 hour period (5.5 m³/hr).

2. Desalter Waste Water Treatment Units

The following sub-sections give an explanation of the different technologies used in each Plant and the part they play in achieving the treatment required of the feed waste water.

2.1 Process Description

2.1.1 Tilted Plate Separator (TPS)

Waste water fed to the TPI Separator enters the inlet compartment. Any heavy solids will settle here and are collected in a hopper. A double slotted baffle induces the incoming water to flow evenly and uniformly to the entrance of the corrugated plate pack.

In the plate pack the oil droplets are intercepted and coalesce into large droplets. These leave the pack, rapidly counter-current and then move upwards against the liquid flow to the surface.

The separated oil is skimmed by a rotatable skim pipe and discharged to the oil collection equipment (by others).

The water that flow through the plate pack finally enters the outlet compartment.

The output from the CPI unit will approximate as follows:-

- Oil < 30 mg/l
- TDS No change
- Temperature Only marginal change
- Separated oil will be approximately 50:50 oil/water.

Clarified water is collected in TPI outlet chamber and fed by gravity to the clarified water tanks. Each tank is provided with a transfer pump rated at 5.5 m³/hr at 2 bar for feeding the ultrafiltration system.

2.1.2 Ultra-Filtration

Downstream of the clarified water transfer pumps and upstream of UF feed pumps, 20 micron Cartridge filters are installed for protection of the UF system.

Ultrafiltration is a process that reduces colloidal matter and oil by passing the liquor across a membrane surface. This liquor divides into two streams, namely:

Permeate – This passes through the membrane with substantial reduction of suspended solids and oil, but retains the bulk of the dissolved salts.

Concentrate – This continues to flow over the membrane surface accumulating the ever increasing suspended solids and oil; until finally exiting the membrane element as a highly concentrated fluid.

Each UF system is in two stages each with its own recirculation pump of 15 m³/hr at 2.5 bar. This recycles a portion of the concentrate back to the feed side of the elements to increase overall system recovery.

2 x 100% duty UF streams produce 5 m³/hr of permeate when fed with 5.5 m³/hr of clarified water.

The permeate is collected for further treatment by RO. The concentrate may be returned to the TPI Separator or disposed of.

The output from the UF plant will approximate as follows:-

- A UF membrane does not remove any dissolved salts
- Oil (permeate) < 1 mg/l
- UF concentrate 0.5 -1% oil

2.1.3 Reverse Osmosis

Each RO system is in two stages in series fed by a single High Pressure Pump of 9 m³/hr at 17 bar. A portion of the concentrated is recycled back to the feed side of the membranes to increase system recovery.

As with UF, the feed divides into streams, namely:

Permeate – This passes through the membrane with substantial reduction (rejection) of dissolved salts.

Concentrate – This continues to flow over the membrane surface accumulating the ever increasing dissolved salts; until finally exiting the membrane element as a highly concentrated fluid.

Salt rejection of the membrane can be as high as 95-98%, whilst the permeate: concentrate ratio (hydraulic recovery) will be in the range of 10:1.

Therefore, 2 x100% duty RO streams each provide 4.5 m³/hr of permeate when fed with 5 m³/hr of UF permeate.

The permeate is of a high quality suitable for process reuse or discharge directly to sewer; it will likely have the following characteristics depending on the feed constituents:

Constituents	Treated Water mg/l	Concentrate mg/l
Calcium, Ca	1.0	299
Magnesium, Mg	2.8	850
Sodium, Na	23.0	6970
Potassium, K	1.7	236
Chloride, Cl	44.0	12570
Sulphate, SO ₄	3.5	1760
Bicarbonate, HCO ₃	0.5	151
Silica	0.1	2.6
Free CO ₂	0.1	0.1
Conductivity	76	22860
pH	6.7	8.9
Oil	nil	Trace

2.1.4 Cleaning System (CIP)

The nature of the wastewater to be treated by the reverse osmosis unit is as such that routine cleaning of the membranes is necessary.

A cleaning station with heated mixing and recycling system, together with chemical mixing facilities is provided to allow maximum flexibility in the preparation of acidic, neutral or alkaline cleaning solution to be prepared to combat a range of foulants.

The cleaning operation is typically a manual sequence controlled by an operator.

Various chemicals may be used singularly or in combinations from time to time for a more rigorous membrane cleaning. The permeate water can be used as dilution water and cleaning solutions are to be discharged to waste.

3. Treatment Schemes & OPEX Costs.

Depending on the required treated water quality of the desalter waste water; the selected treatment scheme may be adjusted accordingly with the addition of units as necessary.

The following OPEX costs are based on the previously described desalter waste water treatment system as 2 x 100% trains of 5.5 m³/hr TPI, UF & RO units.

3.1 Tilted Plate Interceptor

TPI is the simplest form of Oily Water treatment. Will reduce the free-oil and suspended solids concentration of the feed as follows:

- Oil Concentration <30 mg/l
- Suspended Solids Concentration <30 mg/l

Table 1. TPI OPEX Breakdown

TPI OPEX	Description	Value	Cost /day	Cost /m ³
Power	Pumps, air blowers, Instruments	12.6 kWh/day	£1.39 ¹	£0.01
Water	Service Water	-	-	-
Chemicals	Dosing	-	-	-
	Cleaning	-	-	-
Replacements	Plate packs	5 years ²	£6.50	£0.05
TOTALS			£6.92	£0.05

¹ Energy cost based on £0.11/kWh

² Minimum lifetime, likely last much longer

3.2 Ultra-Filtration

Requires an upstream TPI unit to reduce gross oil concentration; for effect treatment of the Desalter Waste Water. Will further reduce the oil and solids concentration of the effluent:

- Suspended Solids concentration – nil
- Oil concentration < 5 mg/l

Table 2. Ultra-Filtration OPEX Breakdown

UF OPEX	Description	Value	Cost /day	Cost /m ³
Power	Feed Pumps, Recirculation Pumps, Instruments	161 kWh/day	£17.69 ¹	£0.16
Water	Service Water, CIP (once a day)	1.05 m ³ /day	£0.84	£0.01
Chemicals	Dosing	-	-	-
	Cleaning (Daily)	11.8 kg/d as 100%	£55.46	£0.50
Replacements	Membranes	2 years	£19.73	£0.18
	Cartridge Filter (UF)	15 days – 30 days ²	£1.00	£0.01
	Cartridge Filter (CIP)	30 days	£0.02	£0.00
TOTALS			£94.73	£0.86

¹ Energy cost based on £0.11/kWh

² Vary Greatly depending on feed suspended solids content

3.3 Reverse Osmosis

Requires pre-treatment (e.g. TPI + UF) to prevent excessive fouling of the RO membranes. Able to remove the majority of the dissolved salts and other contaminants

- Salt removal 95-98%
- Suspended solids and Oil concentration – nil.

Table 3. Reverse Osmosis OPEX Breakdown

RO OPEX	Description	Value	Cost /day	Cost /m ³
Power	Feed Pumps, Recirculation Pumps, Instruments	424.9 kWh/day	£46.74 ¹	£0.32
Water	Service Water, CIP (once per 2 weeks)	0.53 m ³ /day	£0.30	£0.00
Chemicals	Acid	As applicable ²	-	-
	Antiscalent	1.2 kg/d as 100%	£2.88	£0.03
	Cleaning (2 weeks)	0.51 kg/d as 100%	£2.42	£0.02
Replacements	Membranes	2 years	£4.93	£0.04
	Cartridge Filter (CIP)	30 days	Included in UF OPEX	Included in UF OPEX
TOTALS			£57.27	£0.52

¹ Energy cost based on £0.11/kWh

² Acid dosing only applicable to reduce pH of permeate if required.