

Drivers for zero discharge in refineries

Wastewater treatment utilising zero-discharge techniques has reduced the impact of effluent discharges

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Recent years have seen an increasing focus on the environmental impacts of refineries and petrochemical plants, not only on reducing concentrations of contaminants in effluent discharges but also on overall pollution load and discharge volumes. Increasing demands on water consumption around the globe mean that existing facilities need to reduce water use. New facilities have to be designed to minimise water use and some to even achieve zero effluent discharge. This article looks at common drivers for reduced water usage. It reviews the technologies that are typically used and key challenges that have to be addressed if this strategy is to be successful. It will also look at two recent examples of how designs utilising zero discharge techniques have minimised the impact of effluent discharges.

Drivers

Refineries and petrochemical facilities use a considerable amount of water. Table 1 shows some typical values for a refinery and an ethylene cracker.

Typical plant water usage

Whole life costs are currently favouring evaporative cooling over seawater usage, increasing the typical demand of potable water. However, recovering water for reuse is an expensive undertaking, and this is driving the increased adoption of a range of site-specific water-recovery techniques.

The petrochemical industry is only one of many users competing for the existing water supplies.

Typical plant water usage	
Type of plant	Utility water usage (m ³)/tonne product
Refinery:	
Seawater cooling	1
Evaporative cooling	2.5
Ethylene plant:	
Seawater cooling	3.5
Evaporative cooling	25
With water recovery	16

Table 1

Many industrial developments have to rely on water supplies from remote locations, or desalination of seawater, to provide reliable supplies. The increasing level of investment required to maintain reliable supplies is promoting a serious review of water usage in an attempt to reduce the relative cost of recovery.

At the same time as water scarcity increases, best practice with regards to environmental discharges is becoming more onerous. In some instances, political rather than sound environmental science can result in consents that are difficult to achieve with conventional

treatment systems. Table 2 is a summary of various discharge consent criteria and the typical capability of a basic wastewater treatment process using a conventional activated sludge plant without tertiary treatments.

Consents and limits

It is important to understand the implication of the compliance level required. A maximum allowable concentration (MAC) needs to be met at all times. A 95 percentile basis allows one failure in every 20 samples. Often a 95 percentile basis will also have an upper tier requirement that is a MAC. In rough terms, the MAC equates to about four times the average, while a 95 percentile is about double the average. In Table 2, this means that the IFC and Saudi standards can be reasonably met by a conventional plant, while the Russian standards would need significant tertiary treatment or even zero discharge.

Uses of recovered water

Across an industrial site there are many operations and processes that require water. Good waste minimisation techniques look at elimination

Consents and limits				
Parameter	International Finance Corporation (IFC)	Russian	Saudi	Typical plant
Compliance	95%ile	MAC	30-day average	Average
pH	6-9	7-8	6-9	6-9
BOD	30	6	25	10
COD	150	35	150	60
SS	30	10	15 (MAC)	15
Total N	40	20	5 (TKN)	20
Total P	2	0.2	1	1

Table 2

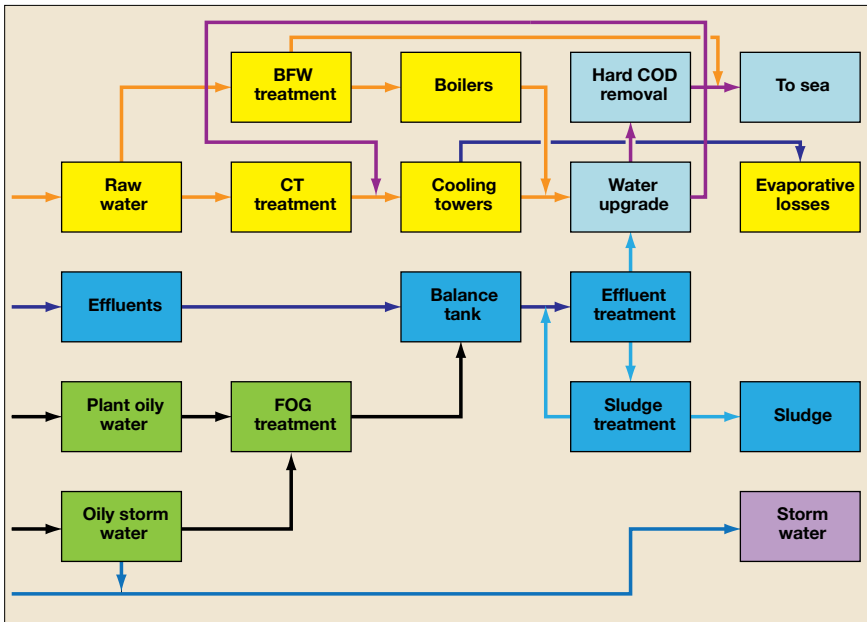


Figure 2 Refinery: Asia

index (SDI) for the same system? SDI is a typical constraint in the design and reliability of RO plants. The issue of buffering capacity has been discussed already, but if the effluent or intermediates are off-specification they need to be reprocessed and the quality of this effluent also needs to be treated, albeit at a slow or even trickle rate.

The disposal of sludge becomes increasingly problematic when undertaking zero discharge, as more contaminants end up in the sludge and will be at higher concentrations. It is critical in considering

a zero discharge system that reliable disposal of the salt-rich slurry from the crystallisers is secured.

The final challenge is how to produce a realistic map or mass balance of the water system. Any calculation or software needs to have the ability to map multiple components individually. In addition to typical wastewater system design concerns (COD, suspended solids, and so on), the salts and TDS need careful tracking. With a conventional wastewater mass balance, the flow and pollution load can be calculated from knowledge of the contaminants and how the

various processes deal with each component.

The real trick to accurate mapping for water recovery against demand is the ability to feed back flow and then recalculate the load and resulting flow to the recovery system. From extensive work with effluent systems, the ability to add a new component to any mapping is also necessary. A typical example of such problems is a licensor identifying a heavy metal in the final months of a front-end engineering design (FEED). This needs to be mapped to ensure that the sludge disposal routes are not compromised. In working with partial and full zero discharge systems, Foster Wheeler has developed a spreadsheet-based program called WM-SET (water management — system evaluation tool), which enables design engineers to provide realistic mapping.

Examples

Not all facilities are going to require a full zero-discharge system. The drivers, demands and constraints for water recovery are very site-specific. The following two examples of recent projects show that zero-discharge system methodology is now being applied at the design stage and then constructed for the installed plant.

Refinery: Asia

At the FEED stage of a new green field refinery in Asia, it was realised that some water recovery would be required. Figure 2 is a block flow diagram of the final system adopted at the engineering, procurement and construction (EPC) stage.

With this plant, the conventional AS treatment plant is expected to meet IFC and local standards. During development of the refinery, it doubled in size, but the regulator imposed the volumetric consent for the original smaller refinery. This meant that water recovery was needed to reliably reduce the normal total combined flow from the plant to less than the volumetric consent. By using RO (for water recovery), the resulting COD of the reject stream is above the IFC and local standards. In this instance, the EPC contractor elected to remove

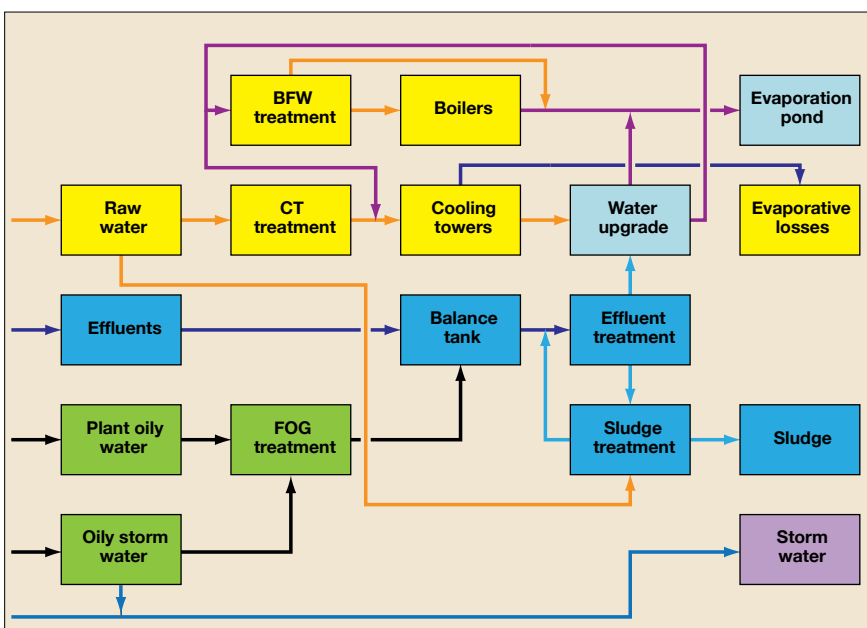


Figure 3 Petrochemical plant: Asia

the hard COD down to the required standard by using PAC, settling the carbon-rich solids in a clarifier and returning it to the AS plant. This will in turn increase the removal of COD in the AS plant.

Petrochemical plant: Asia

A company based in a remote, gas-rich area was developing a polyethylene facility. The remote location and water scarcity indicated that water recovery would be essential. Figure 3 is a block diagram of the selected process.

In this country, the discharge standards are extremely tight. The location has environmental extremes with bitter winters and scorching summers. The typical approach driven by the local regulator was to treat the effluent to IFC standards and then place it in an evaporation pond for final disposal. The resulting ponds are large, as evaporation mostly occurs in the six-month warm season.

The remote location and arid site conditions required water supply via a long pipeline. For this site, a

study was undertaken looking at the costs of no recovery, partial recovery and zero discharge. The preferred option on a net present value (NPV) basis was to recover the wastewater with RO and use it in the cooling towers. This resulted in an 80% reduction in the required size of evaporation ponds, which meant overall that the cost of buying and operating the RO plant was less than for building large evaporation ponds. The option of a zero-discharge system was more expensive in NPV terms. This means that for this site, evaporator crystallisers cost more to build and operate than the evaporation ponds.

Conclusions

There are some projects where zero discharge is the preferred option. In an increasing number of projects, there is a driver for some water recovery. Is zero discharge a good environmental solution? The extra energy expended in effectively distilling effluent to recover water increases the carbon footprint of

the manufacturing process and increases the cost of the final product. A higher production cost may drive companies to consider the countries into which new investment is best targeted. If the driver is due to the regulator attempting to reduce the environmental impact, is the increase in energy usage worth the reduction in effluent entering the aqueous phase? In future, it is anticipated, a pragmatic regulator will review the whole lifecycle impact of zero-discharge schemes.

This article is based on a presentation at the Green Refining & Petrochemicals Forum, London, October 2010 (org. Europe Petroleum Consultants).

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