CHAPTER 3

PROCESS DESCRIPTION

AND PLANT CONTROL
CHAPTER 3

PROCESS DESCRIPTION AND PLANT LOCATION

3.1 Plant Location

The WWTP is located in Kerteh industrial zone, Terengganu, West Malaysia (refer to Figure 3.1 and Figure 3.2).

Figure 3.1

Map of West Malaysia
3.2 Process Description

The Centralized Utility Facility (CUF) plant was designed for an average flow of 199.60 m$^3$/hr and the maximum hydraulic capacity of 400 m$^3$/hr. Peak flow of the plant was 317.1 m$^3$/hr. The design loading of the plant is summarized at Table 3.1.
<table>
<thead>
<tr>
<th>Parameter</th>
<th>Design loading</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$m^3$/hr</td>
</tr>
<tr>
<td>Average flow</td>
<td>199</td>
</tr>
<tr>
<td>Maximum flow</td>
<td>317</td>
</tr>
<tr>
<td>COD (Average)</td>
<td>-</td>
</tr>
<tr>
<td>COD (Maximum)</td>
<td>-</td>
</tr>
<tr>
<td>Suspended Solid (Average)</td>
<td>-</td>
</tr>
<tr>
<td>Suspended Solid (Maximum)</td>
<td>-</td>
</tr>
<tr>
<td>NH$_3$-N (Average)</td>
<td>-</td>
</tr>
<tr>
<td>NH$_3$-N (Maximum)</td>
<td>-</td>
</tr>
<tr>
<td>Oil (Average)</td>
<td>-</td>
</tr>
<tr>
<td>Oil (Maximum)</td>
<td>-</td>
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</tbody>
</table>

For an easier description, the plant flow is divided into several diagrams that consist of Splitter Box, Corrugated Plate Interceptor (CPI) Packages, Equalization Sump, Aeration Tank and Return Activated Sludge (refer to Figure 3.3). The overall schematic process flow is shown in Appendix 2.
3.2.1 Integration Of Influencts

Figure 3.4 describes the assimilation of influents from a variety of customers. It is a part of the primary treatment of the waste. Primary treatment simply screens and settles large particles and skims off floating greases and oils (Olsson, 1999).
Figure 3.4
Integration of Influenes

The backwash sump mainly received wastewater from CUF cooling water; sidestream filter backwash and boiler blow down. It also received local rainfall run-off and
sludge building floor drainage. The demin sump received wastewater from the Demin filter backwash, condensate filter backwash and the Demin run-off. Before the effluent enters the sump, the effluent flows through a bar screen located at the inlet chamber of the Backwash Sump. The bar screen provides preliminary treatment by removing large debris that might otherwise interfere with the process downstream. The bar screen was manually cleaned and with a rake occasionally. The screenings from the raking were then collected and taken out of the WWTP for solid disposal. The primary function of the Backwash Sump was as a collecting pit and a pumping station, which transfers the collected effluent to the Equalization Sump. A bar screen was also provided at the Demin Effluent Sump.

Splitter Box received waste effluent from ASGP, Backwash Sump and Demin Sump. Incoming wastewater were homogenized and split out equally to two subsequent Corrugated Plate Interceptor (CPI) units by gravity. Polymer was dosed into the Splitter Box to optimize the oil emulsion breaking, coagulation and flocculation in CPI. The Ammonia Syngas waste flows into the CPI units via the Splitter Box. Polymer addition on a routine basis was for better settleability of the sludge and to improve dewatering properties.

3.2.2 Off-Spec Flow

The nature and strength of the load entering an oxidation system such as activated sludge, will of course affect the performance of the biomass and influence the nature of the species produced. Controlling the nature of the waste stream is very difficult in some industries, particularly those where a range of products is produced in no particular regular quantity. This is the case for this integrated waste treatment plant. In the case of a facility where the discharged waste stream was quite variable in both strength and toxic content, then some form of flow or load buffering was very important. To achieve
this requires a monitoring system that can both assess the load of the incoming waste stream. Should a toxic or high load waste be detected then the waste stream should be diverted to a balancing tank whose contents can be reintroduced into the feed stream in a more dilute form.

Variables in influent characteristic make it compulsory to build an off-spec tank. The off-spec sump was provided to temporarily receive off specification flows from CUF and/or from the customers to allow time for temporary problems to be resolved at source or allow the source to be shut down in the event that the cause is likely to persist.

The off-spec sump and pump system was designed to permit the off-spec effluents to be held, mixed and corrected and then be fed to the effluent treatment plant at a controlled rate. In addition, the off-spec sump will collect storm water. It also has the provision to receive waste through the Backwash Sump, Outfall Chamber, overflow from the Equalization Sump, Acetic Acid Balancing Sump and drain from Aeration Tanks when abnormal operation occur.

Effluents from the Backwash Sump and the Effluent Monitoring Package skid enters the off-spec sump after being filtered by the bar screen to remove large debris that might be carried over from upstream. Unfiltered effluent that enters the sump might damage the Off-Spec Pumps by clogging the suction strainer of the pumps, and thus making the pumps to run dry.

On the other hand, the other effluents from the overflow of Acetic Acid Balancing Sump and Equalization Sump, drain from Aeration Tanks, and diverted flow from Outfall Chamber, enters the sump via underground and aboveground pipes without passing through the bar screen.

In the case of off-spec waste in the Off-Spec Sump, the effluent was adequately mixed before taking samples for analysis to:

- evaluate the requirements for treatment before return to the effluent treatment plant;
-evaluate the rate at which the contents of the Off-Spec Sump can be returned to the effluent treatment plant (with or without pre-treatment) without compromise of the effluent standards.

### 3.2.3 Oil and Solid Separation

The CPI is designed to separate oil and settleable solids from the effluents. Wastewater gravitates into the CPI from the Splitter Box in a laminar fashion. This wastewater contains high concentration of suspended particulate matter with some having specific gravity greater than water (e.g. settleable solids) and some less than water (e.g. grease). Settles for solids, floating grease and oil, and other solids are removed in the CPI. The resulting accumulated primary sludge is then transferred to a drum or tanker for disposal or waste to the Sludge Digester after thickening in the Sludge Thickener. Alternatively, the floating oil and grease are removed from the CPI and temporarily stored in the Oil Holding Tank (Please refer to Figure 3.5).

Normally, the CPI treated effluent, flows to the Equalization Sump by gravity for further treatment.
The primary function of the CPI is to reduce the oil and grease and floats loading in the biological treatment system downstream, and remove readily settleable solids and other floating material. The Oil Holding Tank is used to temporarily store the floats such that it can be pumped into the Oil Storage Tank, for decanting and storage or drum/tanker for disposal. Regular removal of the settled solids is essential as accumulation over a long period will cause the sludge to become septic. It can eventually aggregate into a huge solid, making it impassable through the sludge discharge nozzle. Furthermore, sludge build-up in the tank, is beyond the sludge hopper capacity, will affect the performance of the CPI, causing the clogging of the coalescing
plates with sludge. As a result, sludge and floats may be carried over with the CPI treated effluent, thereby overloading the subsequent activated sludge processes.

Floats are removed from the surface of the CPI by a surface skimmer and are deposited by gravity into the Oil Holding Tanks. Depending on the water level in the CPI, the surface skimmer height above the water level is adjustable for optimum float removal. The Oil Skimmer collects oily water, which floats on the surface of CPI. It is temporarily stored in the Oil Holding Tank, and later pumped to the Oil Storage Tank or drum for disposal.

3.2.4 **Equalization Process**

The Equalization Sump receives pre-treated CUF and Ammonia Syngas Plant effluents, pretreated waste from CPI package, balanced BPPA waste from Acetic Acid Balancing Sumps, untreated waste from VCM and cooling tower, drainage from sampling tank, untreated customer effluents, as well as return flow from the Off Spec Sump and effluents from sludge treatments. It also has provision to receive recycle waste through the Outfall Chamber. Please refer to Figure 3.6.

The flow and pollution load from the Acetic Acid Plant (BPPA) will be highly variable. The Acetic Acid Balancing Sumps will receive pH-neutralized effluent from the BPPA and will provide flow and pollution load balancing before the effluent is pumped to the Equalization Sump. Plates 3.1 and 3.2 show the Equalizing Sump and Off Spec Tank. Mixers are provided to break up stratification that might otherwise develop due to the temperature and density differences of the CUF and customer effluents. It will minimize stratification and keep light solids in suspension. The inlet chamber is equipped with a bar screen, and it only allows filtered wastewater to flow into the sump.
Figure 3.6
Equalizing Sump
Plate 3.1

Equalizing Tank And Off Spec Tank

Plate 3.2

Off Spec Tank
3.2.5 Aeration Process

Aeration Tanks are the heart of the biological treatment plant to treat all incoming waste received by the treatment plant. The design of Aeration Tanks is a tapered aeration activated sludge treatment process. It provides greater amount of dissolved oxygen at the inlet compartment, and less dissolved oxygen at the outlet compartment. Biological treatment is accomplished in the Aeration tanks by mixing microorganisms (activated sludge) with the incoming raw wastewater. The combination is commonly known as mixed liquor. A picture of the aeration pond is shown below (Plate 3.3).

Plate 3.3
Aeration Pond

The Aeration Tanks will receive WWTP waste pumped from the Equalization Tank via a Splitter Chamber (refer to Figure 3.7).
Figure 3.7
Aeration Tank
Microorganism inside the Aeration Tanks transforms organic loading to biomass (sludge). Mixed liquor flows to Clarifiers through overflow by gravity. Return Activated Sludge is pumped back into the Aeration Tanks from the bottom of Clarifiers to maintain MLSS level.

At the Splitter Chamber, the waste is divided into two equal flows and diverted to two Aeration Tanks through the opening at the bottom of the chamber. Nutrient is dosed into the Splitter Chamber to provide necessary nutrients to the microorganisms in Aeration Tanks.

Dissolved Oxygen concentration and sludge concentration are monitored to ensure a normal operating condition. Blowers in the Aeration Tanks supply oxygen for the microorganism. The blowers inject atmosphere air into the Aeration Tanks through diffusers to keep the activated sludge in suspension, provide sufficient mixing and supply the oxygen required for biological oxidation during the retention time provided. Alarms signals are provided here, to sound the alarm when the dissolve oxygen and sludge concentration in the tank exceeds or falls below any set points.

3.2.6 Discharge

The Outfall Chamber (Discharge) is the final monitoring and recording unit before the treated effluent is discharged. The Outfall Chamber will receive treated wastewater from Clarifiers as shown in Plate 3.4. The treated effluent is discharged to a common area drain. When the discharge from the Outfall Chamber does not meet the discharge standards, it will be diverted to Equalization Sump or Off Spec Sump for further treatment.
Plate 3.4

Clarifier

3.2.7 Return Activated Sludge

As requirements for high quality wastewater effluent increase, quantities of sludge generated also increase. Contaminants removed from wastewater concentrate in the sludge and can represent serious environmental insult and health effects if not properly managed. The cost of sludge handling can be estimated to constitute as much as 50% of the cost of WWTP. If properly managed, however, sludge may be considered a resource of value (Carberry, 1983).

The recycle sludge pumps are designed to withdraw activated sludge settled at the bottom of Clarifiers and transfer the sludge to Aeration Tanks. The Return Activated Sludge is pumped to Aeration Tanks continuously to maintain the biomass content inside the tanks. When some quantity of biomass needs to be wasted, the sludge is withdrawn, batch by batch to the Sludge Thickener as Waste Activated Sludge.
The Sludge Thickener receives primary sludge from CPI, scum and waste activated sludge from Clarifiers (Figure 3.8). It provides a quiescent zone for settlement of sludge. A rotating floor scraper is installed at the bottom of the tank to scrap the sludge to the center sludge pocket. The Thickened Sludge is pumped to the Sludge Digestion Tank (SDT) or tanker loading. The supernatant will flow via overflow weir by gravity to the Equalization Tank. At the SDT, there are conditions provided to supply air and residence time for the aerobic digestion of about 50% of the residual volatile matter in the sludge. The digested sludge is later pumped to the Sludge Centrifuge Decanter. The supply of air is to make sure that the oxygen demand for the microorganism is provided for. Overflows from the SDT are flowed by gravity to Equalization Tank. Digested Sludge is transferred to the SDT and later to the Sludge Centrifuge Decanter automatically. From time to time, it shall be necessary to pump the digested sludge to a tanker manually.

Whatever treatment process is chosen, the plant will inevitably produce other wastes for disposal to the environment in addition to the final liquid effluent. This can be solid waste which may be sent to landfill, such as pressed sludge, or a liquid sludge for off site disposal. Both are likely to involve haulage or tinkering, with similar restrictions on disposal to those applied to sewage sludge. Metallic or complex organic compounds can be an environmental issue and must be considered when deciding on the optimum disposal route for the sludge. This duty applies to the producer of the waste and requires that reasonable measures be taken to prevent the unauthorized or harmful deposit, treatment, or disposal of the waste and to prevent the escape of waste from the producer’s control. In addition, the producer must ensure that the transfer of waste is made only by an authorized person and with appropriate documentation (Hester, 1995).
Figure 3.8

Return Activated Sludge
3.2.8 Sludge Dewatering

Sludge dewatering is very important for the following reasons. The costs of transporting biosolids to the ultimate disposal site are greatly reduced when biosolids volume is reduced. Dewatered biosolids allows for easier handling and reduction in moisture content allows for more efficient incineration. If composting is the beneficial reuse choice, dewatered biosolids decreases the amount and therefore the cost of bulking agents. Dewatered biosolids are less offensive and when land filling is the ultimate disposal option, dewatering biosolids is required to reduce leachate production. (Spellman, 1997). Factors that govern dewatering including belt porosity, roll temperature, pressure, belt cleaning, ash content, sludge feed delivery, and sludge structure and type (Beckley, 1999).

The Dewatering process begins together with the dosing of the polymer. The Sludge Centrifuge Decanter is designed to separate water from the digested sludge prior to disposal. The Digested Sludge is pumped to the Sludge Centrifuge Decanter. The decanted sludge will fall into the Sludge Hopper by the sludge conveyer. Flushing water and decanted water are routed into the Equalization Sump for treatment. The decanted sludge will be filled into a drum.