OIL & GREASE RECOVERY IN REFINERY
WITH
"PLATE INTERCEPTORS"

By

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College of Engineering
University of Petroleum & Energy Studies
Dehradun
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"PLATE INTERCEPTORS"

A thesis submitted in partial fulfillment of the requirements for the Degree of
Master of Technology
(Health, Safety& Environmental Engineering)

By
(MAYANK KUMAR SHARMA)

Under the guidance of

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Approved

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Dean

College of Engineering
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This is to certify that the work contained in this thesis titled **"OIL AND GREASE RECOVERY IN REFINERY WITH PLATE INTERCEPTORS"** has been carried out by MAYANK KUMAR SHARMA under my supervision and has not been submitted elsewhere for a degree.

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Abstract/ Synopsis

The main objective of this study is to recover oil and grease with more efficiency with the help of tilted plate interceptor **(TPI)** than API oil separators and doing the design calculations of the API AND TPI SEPERATORS with respect to the waste water flow rate in the refinery.

Oil and grease cause surface films and shoreline deposits leading to environmental degradation. If present in excessive amounts, they may interfere with aerobic and anaerobic biological processes and lead to decreased wastewater treatment efficiency. AS oil and grease both have detrimental effect on the life of all organisms. Along with the oil and grease there are other environmental water pollution concerns affecting the quality of water. Along with the oil and grease there are other environmental water pollution concerns affecting the quality of water. There are some main water pollutants in refinery waste water –

1. **Oil & grease**

Presence of Oil & Grease in water contributes to BOD/ COD. It is detrimental to all organisms. Further, it imparts odor to the water and not desirable from aesthetic point of view.

Toxic and Other Undesirable Effects of Oil & grease on Life

Undesirable effects of hydrocarbons in water include taste and odor contamination in addition to toxicity. Petroleum hydrocarbons in concentrations as low as 0.5 mg/L can impart a perceptible unpleasant taste whereas concentrations as low as 10 to 100 µg/L can adversely affect aquatic organisms. Naphthenic acid from refineries can have a toxic effect on plant and animal life at concentrations as low as 0.5 mg/L.

Hydrocarbons, especially aromatic hydrocarbons, are toxic and/or carcinogenic to humans and animals as well as to aquatic life where feeding or reproductive behavior may be altered. Cattle drinking water containing oil & grease are often affected by diseases of the alimentary tract.

Gasoline is particularly high in aromatic content because aromatic compounds such as benzene and toluene are high octane blending components. Most of the components of gasoline are very volatile and tend to evaporate from roadways and parking lots and are therefore not present in storm water runoff. However, some of these components may still be present in refinery wastewater streams.

2. **BOD (Biochemical Oxygen Demand)**

BOD is not a pollutant in itself. It is expressed as oxygen required for decomposition of organic chemicals biologically and indicates biologically ox disable organic matter in the water. Presence of BOD is not desirable as it consumes Dissolved Oxygen required for aquatic life.

3. COD (Chemical Oxygen Demand)

COD is expressed as oxygen required for decomposition of organic chemicals chemically (oxidants like Potassium Dichromate) and indicates total oxdizable organic matter. As more organic matter is decomposed chemically, COD is always more than BOD. It indicates presence of toxic chemicals/ bio refractory chemicals in the water.

4. TSS (Total Suspended Solids)

TSS is important to be controlled as its presence creates problems for aquatic animals which respirate through gills.

5. Phenol

Phenolic compounds are basically hydroxy derivatives of Benzene. They contribute to BOD/ COD. Chlorination of the water containing phenols produces odorous & objectionable tasting Chlorophenols.

The wastewater enters the plates either parallels tc corrugations in “Counter Current Flow” or at right angles to the corrugations in “Cross Flow’ under laminar flow conditions. The short distance between the inclined plates is now the only distance over which the oil globule has to rise before it is intercepted and separated from the water.

Due to the laminar flow conditions the separated oil globules coalesce into large droplets and gradually rise to the surface. The film formed on the surface is then skimmed off through slotted pipes.

The efficiency of an oil-water separator is inversely proportional to the ratio of its discharge rate to the unit’s surface area. A separator’s surface area can be increased by the installation of parallel plates in the separator chamber.

The resulting parallel-plate separator will have a surface area increased by the sum of the horizontal projections of the plates added.

In cases where available space for a separator is limited, the extra surface area provided by a more compact parallel-plate unit makes the parallel-plate separator an attractive alternative to the conventional separator. Flow through a parallel-plate unit can be two to three times that of an equivalent conventional separator.

In addition to increasing separator surface area, the presence of parallel plates may decrease tendencies toward short-circuiting and reduce turbulence in the separator, thus improving efficiency.

In this project we will consider the oil separation with plate interceptors , their design calculation, and their comparison with API oil separators.

ACKNOWLEDGEMENT

This report was meant to be sole responsibility of the learner but it was apparent from the start that in the light of its sheer enormity and under such acute time shortage, a project report without the support of many persons would be unimaginable. This page gifts me an opportunity to articulate my gratitude to that entire person who has in some way or other provided the above help.

First of all I would like to thanks to my guide ***MR. S.N.SHARMA, PRODUCTION MANAGER*** for giving me continuous support throughout the project. Without whose cooperation and guidance my all hard work and perspiration would have turned to futile work.

I would like to express my thanks to my ***COURSE COORDINATOR*** *MR.G.SANJAY KUMAR* for giving me guidance and time to time support and kind suggestion.

At the end of this project, I take back with me pleasant memories or warm and consideration shown by person I approach during my project. For that I collectively thank the whole staff of **IOCL** for their kind help and their co-operation.

I would like to express my humble thanks to **training department** without its support my project at **IOCL** would not have been possible at all.

At last but not least, I take an opportunity to appeal my profound gratitude to my adorable and beloved Parents for their everlasting love, strong moral support, encouragement and personal sacrifice without which I was unable to reach the present status of education.

MAYANK KUMAR SHARMA

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Abbreviations

ACF - Activated Carbon Filter
ASP - Activated Sludge Process
BOD - Biochemical Oxygen Demand
COD - Chemical Oxygen Demand
CTBD - Cooling Tower Blow Down
DAF - Dissolved Air Flotation
DMF - Dual Media Filter
DOPE - De oiling Polyelectrolyte
DWPE - Dewatering Polyelectrolyte
FRC - Free Residual Chlorine
LEL - Lower Explosive Limit
MCP - Main Control Panel
MOC - Material of Construction
OWS - Oily Water Sewer
PE - Polyelectrolyte
PPE - Personal Protective Equipment
ppm - parts per million
STEL - Short Term Exposure Limit
TPI - Tilted Plate Interceptor
TSS - Total Suspended Solids
TLV - Threshold Limit Value

Nomenclature

V_t = vertical velocity, or rise rate, of the design oil globule, in cm/s.

g = acceleration due to gravity (981 cm/s^2).

μ = absolute viscosity of wastewater at the design temperature, in poise. Note: 1 P = 1 g/cm.s; 10 P = 1 Pa.s.

ρ_w = density of water at the design temperature, in g/cm^3. Note: 1 g/cm^3 = 1 kg/litre.

ρ_o = density of oil at the design temperature, in g/cm^3.

D = diameter of the oil globule to be removed, in cm.

S_w = specific gravity of the wastewater at the design temperature (dimensionless).

S_o = specific gravity of the oil present in the wastewater (dimensionless, not degrees API).

A_H – total separator surface area.

L = length of separator channel.

B = width of separator channel.

n = number of separator channels.

F = turbulence and short-circuiting factor

Q_m = total design flow to the separator.

V_t = separator's surface-loading rate.

A_c = separator's total cross-sectional area.

V_H = separator's horizontal velocity.

d = depth of separator channel.

Chapter 1

Introduction

Brief details about Mathura Refinery

With about 1050 acres of land, the refinery has been provided with various processing units and Storage facilities. In about 429 Hectares area storage facility for crude oil & various products which includes 430 thousand M^3 storage capacities for crude oil and 858 thousand M^3 capacities of intermediate and finished products with connected offsite facilities has been provided. The main facilities including processing units in the refinery are:-

Process Units –

1. Diesel Hydro Desulphurization Unit (DHDS)
2. Sour Water Stripping Unit (SWS)
3. Amine Regeneration Unit (ARU)
4. Sulphur Recovery Unit (SRU)
5. Hydrogen Generation Unit (HGU)
6. Hydrocracker Unit (HCU)
7. Naphtha Splitter Unit (NSU)
8. Crude Distillation Unit (CDU)
9. Reduced Crude Vacuum Distillation Unit (VDU)
10. Bitumen Blowing Unit (BBU)
11. Naphtha Hydro treating Unit
12. Catalytic Reforming Unit (CRU)
13. Visbreaker Unit (VBU)
14. Polymer Grade Propylene Plant (PRU)
15. Fluidized Catalytic Cracking Unit
16. Kerosene/ ATF Merox Unit
17. Cracked LPG (CR LPG) Merox Unit
18. VB Naphtha Merox Unit
19. LPG Merox Unit
20. FCC Gasoline Merox Unit
21. Amine Absorption and Regeneration Unit (AAU/ ARU)
22. Diesel Hydro treating Unit (DHDT)
23. Hydrogen Generation Unit (HGU)
24. Sour Water Stripping Unit (SWS)
25. Tail Gas Treatment Unit (TGTU)

26. Light Naphtha Hydro treating Unit (NHTU)

Associated Facilities

1. LPG Storage and pumping facilities
2. Propylene Storage facilities
3. LPG Bottling Plant
4. LPG Bulk Loading Gantry
5. White Oil storage and pumping facilities
6. White Oil Rail Loading Gantry
7. Thermal Power Station
8. Cooling Tower (Chlorine dosing facility)
9. Hydrogen Storage facility
10. Gail Natural Gas Receipt Terminal
11. Mathura Jalandhar Pipe Line (MJPL & MTPL) pumping station
12. Salaya Mathura Crude Pipe Line Installation (SMPL)
13. New Flare Stack
14. Nitrogen Plant
15. DM Water Chain
16. Effluent Treatment facility

The refinery is designed to process 8.0 MMTPA of Bombay High and Imported crude oil in the ratio of 50:50. The various products of the refinery are as given below:-

01. Liquefied Petroleum Gas

02. Propylene

03. a) Low Aromatic Naphtha

b) High Aromatic Naphtha

04. Motor Spirit

05. Aviation Turbine Fuel

06. High Speed Diesel

07. Light Diesel Oil

08. Furnace Oil

09. Heavy Petroleum Stock

10. Bitumen

11. Sulphur

PLOT PLAN

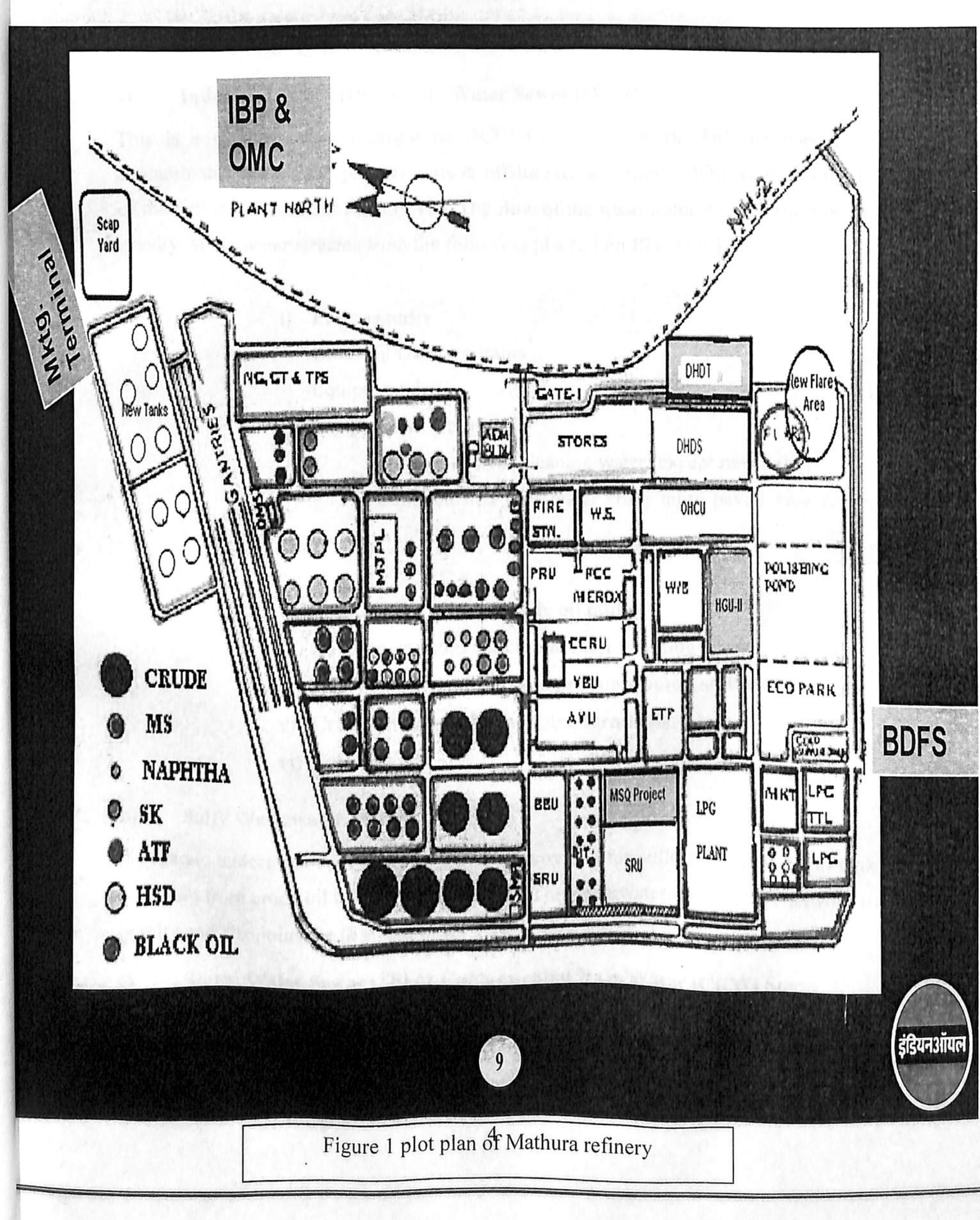


Figure 1 plot plan of Mathura refinery

DETAILS OF ETP (EFFLUENT TREATMENT PLANT) IN MATHURA REFINERY

INLFUENT COLLECTION SYSTEMS

a) Industrial Sewer (IS) or Oily Water Sewer (OWS)

This is a refinery wide underground RCC/ CS pipe network. This network collects oil contaminated water from process units & offsite area and finally delivers it into the IS Sump of the Effluent Treatment Plant (ETP). The flow of the wastewater through this network is by gravity. Wastewater streams from the following places join IS network:

i) **Process units**
- Crude oil Desalter drains
- Equipment drains
- Sample point drains
- Spillage & floor cleaning water (except new units)
- Contaminated rain water from units paved area (except new units)

ii) **Tank drains (except crude oil tanks)**
iii) **Loading gantries spillage & floor cleaning water**
iv) **Intermediate and finished products pump stations**
v) **Crude oil & product pipeline terminals**
vi) **Laboratory**

b) Salty Wastewater Sewer

A separate underground RCC pipe network is provided for collection of crude oil tank drains and drain from crude oil booster pump station. The wastewater through this network flows by gravity and also joins the IS Sump of the ETP.

c) Storm Water Sewer (SS) or Contaminated Rain Water (CRW) Sewer

This is an underground gravity flow RCC/ CS pipe network.

d) Domestic Sewage (DS)

The sanitary sewage from all the toilets and lavatories provided in the refinery (including Administrative Complex) are connected to this sewage system.

e) Alkaline Waste

The alkaline waste or spent caustic streams from Merox Units and from AVU come by two separate above ground pipelines which join together before entering the spent caustic storage tanks provided in the ETP.

f) Sour Water

Normally, the sour water from cracking & desulphurization units goes to the Sour Water Stripper (SWS), but in case of shutdown of the SWS, it is diverted to the spent caustic storage tanks of the ETP through an above ground pipeline under its own system pressure.

g) Cooling Tower Blow down

The blow down from cooling towers is taken to ETP through above ground pipeline, which terminates into the Cooling Tower Blow down (CTBD) Sump of ETP. This stream can be pumped to Guard Ponds or Surge Reservoirs if contaminated with oil.

DESIGN SPECIFICATIONS

1. Primary or physical treatment for oil bearing effluent

   API Oil Separator – 1050 / 750 m^3/hr (Wet / Dry Season Flow)

   TPI Oil Separator / Dissolved Air Floatation (DAF) – 750 m^3/hr

2. Chemical treatment for spent caustic & unstrapped sour water

   The system is designed for flow of 5 m^3/hr having sulphide concentration of 10000 ppm. However, the system can handle hydraulic load of 25 m^3/hr with peak of 50 m^3/hr.

3. Secondary or biological treatment

   Aeration Tank & Bio Tower – 750 m^3/hr.

4. Tertiary treatment

   Filtration – 450 m^3/hr.

Effluent Flow Rate

Table -1

Oil Removal Oil Removal	API Separator TPI & DAF	1050 m^3/hr 750 m^3/hr
Spent Caustic	Reaction Tank	25 m^3/hr
Biological Treatment	Bio Tower & Aeration Tank	750 m^3/hr
Tertiary treatment	Chlorination, DMF & ACF	450 m^3/hr

* Sulphide concentration in unstripped sour water is 10000 mg/l.

** Emulsified Oil

Except pH all units are expressed as mg/l.

PRINCIPLES OF TREATMENT

Broadly, the processing schemes have four types of treatment:

a) Physical treatment
b) Chemical treatment
c) Biological treatment
d) Tertiary treatment

The major operations in the processing scheme are:

- Free Oil Removal
- Emulsified Oil Removal
- Sulphide Treatment
- Biological Treatment
- Tertiary Treatment
- Sludge Thickening & Centrifuge Operation

Pollutant vis-à-vis treatment method:

Table - 2

POLLUTANT	TREATMENT METHOD
Free oil	Gravity separation
Emulsified oil	Chemical destabilization and flotation
Sulphides	Chemical oxidation
Organics (BOD / COD)	Biological oxidation & Sedimentation
Settable Solids	Sedimentation
Microbes (Bacteria, Algae, etc.)	Disinfection by Chlorination
Suspended solids	Sedimentation & Filtration

The principles of the above operations are described below:

FREE OIL REMOVAL

Oil & grease in the wastewater can be present in two forms namely "**FREE OIL**" and "**EMULSIFIED OIL**". Free oil separation is done by **API Oil Separator**

API Oil Separator

The separation of oil from water by gravity differential is based on the rise rate of oil globules. The separation basins are designed to have low velocity (0.6 m/s) and minimum cross or eddy currents, and sufficient retention time to permit the globule to coalesce and rise to the surface. During its upward travel to the surface, particles coalesce to form a film of oil, which is mechanically skimmed and recovered.

TPI Oil Separator

The current trend is to satisfy the increased separating area requirements by providing a number of stacked plates. Thus, the separating surface area is increased vertically. The area is further increased by selecting corrugated plates. The plates are located one on top of the other at specific distance from one another. The entire plate pack is placed in a tank at an approx. angle of 45 degrees. Hence the unit is called as "Tilted Plate Interceptor (TPI)". The wastewater enters the plates either parallels to corrugations in "Counter Current Flow" or at right angles to the corrugations in "Cross Flow" under laminar flow conditions. The short distance between the inclined plates is now the only distance over which the oil globule has to rise before it is intercepted and separated from the water. Due to the laminar flow conditions the separated oil globules coalesce into large droplets and gradually rise to the surface. The film formed on the surface is then skimmed off through slotted pipes.

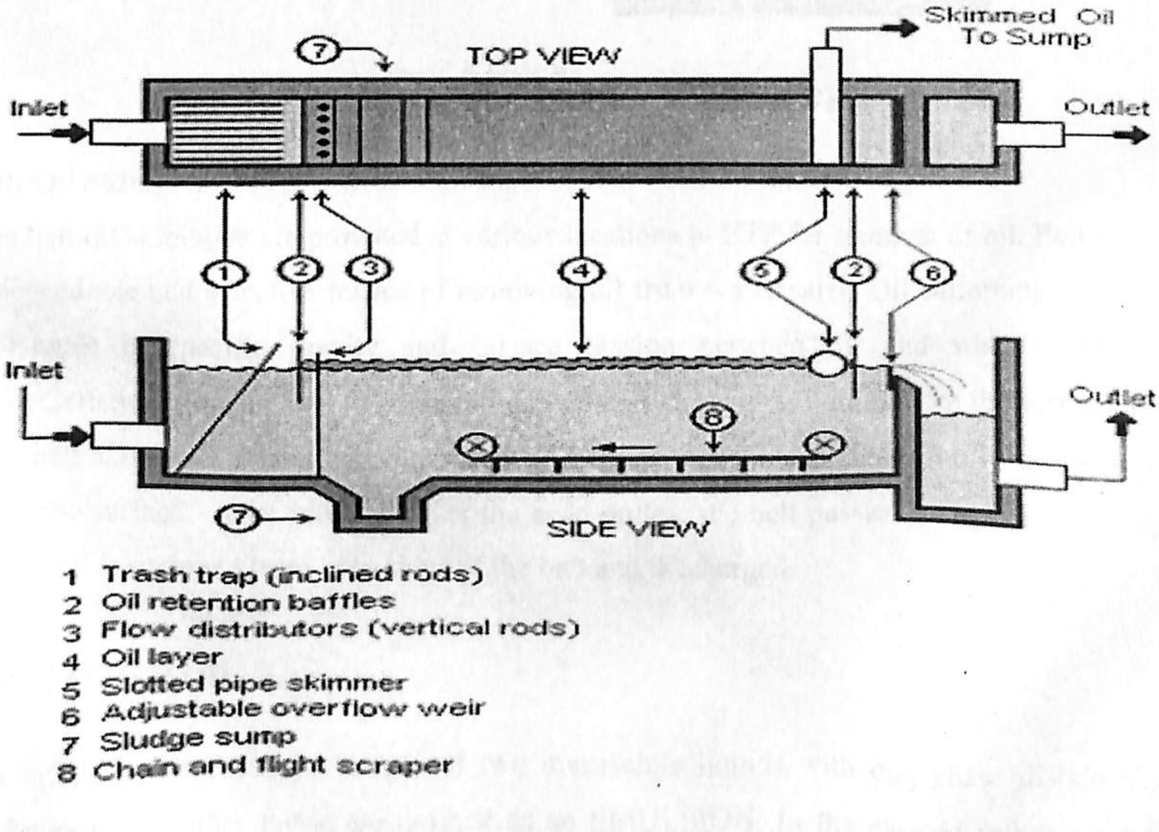


Figure 2 API OIL SEPARATOR

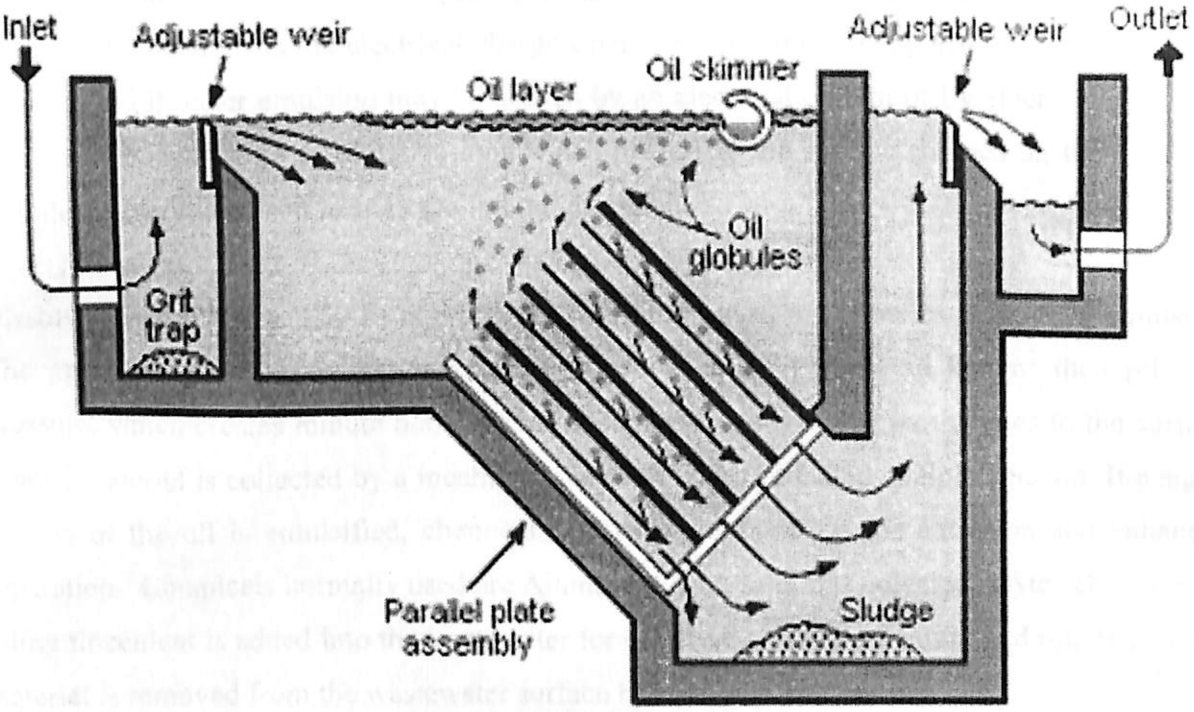


Figure 3 TPI OIL SEPARATOR

Belt Oil Skimmer

The belt oil skimmers are provided at various locations in ETP for removal of oil. Belt oil skimmer is a dependable and effective means of removing oil from wastewater. Oil skimming makes use of the difference in specific gravity and surface tension between oil and water. These physical characteristics allow the belt to attract oil and other hydrocarbon liquids from the surface of the fluid. The belt skimmers, operating on a motor and pulley system, run through oily water to pick up oil from the surface. After traveling over the head pulley, the belt passes through tandem wiper blades where oil is scrapped from both sides of the belt and discharged.

EMULSIFIED OIL

An intimate, two - phase mixture of two immiscible liquids with one phase dispersed as minute globules in the other phase are defined as an EMULSION. In the case of refinery wastes, the oil phase is intimately dispersed in the water phase. Various factors contribute to the stability of this dispersion.

The minute globules are stabilized by an interfacial film or stabilizing agent such that the globules do not coalesce and do not respond to gravity settling. A major factor contributing to the formation and stability of emulsions is the electrical charge carried by the emulsified particles. In general, globules of oil in an oil-water emulsion may be broken by an electrical current or by electrolytes supplying a sufficient concentration of effective ions which neutralize the surface charges on the emulsified oil globules, permitting them to coalesce into larger globules.

Dissolved Air Flotation (DAF) is a process commonly used in refineries to remove emulsified oil. The process involves pressurizing the influent to DAF Unit at 4 – 6 kg/cm^2 then releasing the pressure, which creates minute bubbles that float suspended and oily particulates to the surface. The floated material is collected by a mechanical surface collector called as Spiral Scoop. If a significant portion of the oil is emulsified, chemicals are used for breaking the emulsion and enhancing the separation. Chemicals normally used are Aluminum/ Iron salts and polyelectrolyte. The alum and de-oiling flocculent is added into the wastewater for effective removal of emulsified oil. The floated oily material is removed from the wastewater surface by means of spiral scoop.

SULPHIDE TREATMENT

Sulphur is an inherent impurity in most crude oils, and its concentration depends on the source of the crude. During the crude refining process, this impurity is separated from the product and discharged as a liquid effluent. During the processing step the sulphur is converted to sulphide. The sulphides present in the effluent may be in the form of free sulphides or as hydrogen sulphide depending on the pH of the stream. These compounds are toxic in nature and need to the treated / removed prior to disposal of the effluent. Sulphides are removed by chemically oxidizing them to elemental Sulphur or Sulphate using strong oxidizing agents such as Hydrogen Peroxide (H_2O_2), Ozone & Chlorine. In view of its various advantages, Hydrogen Peroxide is normally the preferred chemical.

The reactions involved are as under:

Acidic Range / Neutral Condition

In acidic range and neutral conditions, sulphides in the effluent are mostly present in the form of H_2S. The H_2O_2 reacts with H_2S to give products of oxidation – water and elemental sulphur as shown below:

$H_2O_2 + H_2S$ → $2\ H_2O + S$

(Stoichiometrically 1.06 kg of H_2O_2 is required for 1 kg of sulphide.)

Alkaline Range

In alkaline range, sulphides present in the effluent are generally in the form of Na_2S. The H_2O_2 reacts with Na_2S to give end products as water and Na_2SO_4 (relatively harmless and impose no oxygen demand), as shown below.

$4\ H_2O_2 + Na_2S$ → $Na_2SO_4 + 4\ H_2O$

(Stoichiometrically 4.25 kg of H_2O_2 is required for 1 kg of sulphide.)

BIOLOGICAL TREATMENT

The objective of biological treatment is to remove oxygen consuming matter from wastewater and reduce, oxidize or stabilize it to the desired degree for safe disposal of the effluent into the receiving stream.

In a biological process, BOD represents food for micro-organisms. This food matter will be attacked by a heterogeneous and varying mass of micro-organisms, all of which commonly occur in natural bodies of water and in earth. Both plant (bacteria) and animal (protozoa) forms of micro-organisms are required to do this work and their relative numbers will vary depending upon the reaction conditions. These micro-organisms are commonly referred as biological sludge or bio sludge.

The first product of the reaction is cellular matter, which under equilibrium operation is usually called as activated sludge. In the presence of excess food, the micro-organisms will grow and multiply. This increase in the population is the synthesis part of the reaction. Parts of the pollutants are converted through synthesis to biological culture and part is completely oxidized to final end product. The aerobic reaction produces carbon dioxide and water. It is through this reaction that the living organisms gain their energy for existence.

BOD (Food) + Micro-organisms → Cellular matter + Energy + $CO_2 + H_2O$

The above biological reaction can be accomplished by two different routes, which are diametrically opposite. In one case presence of free oxygen in the wastewater is absolutely essential for bacterial activity, whereas in the second case the bacterial activity can be ensured only in the absence of free dissolved oxygen. While both routes can breakdown the pollutants present in the water the type of micro-organisms instrumental in these reactions are totally different. The biochemical reaction of the first case is called AEROBIC PROCESS and those of the second case are called ANAEROBIC PROCESS.

The choice between the two processes is determined by the type, complexity of the wastewater and desired end products.

In any biological process, a variety of micro-organisms take part in the reactions. Depending on the type and concentration of the wastewater constituents, particular strains of micro-organisms will dominate the bicultural population that develops.

In the case of refinery wastes all the pollutants present can be treated by the aerobic route. However, many of the constituents are toxic in nature and the common bacterial masses can not take up these constituents as food. To ensure that these pollutants are also biodegraded a process of acclimatization is necessary. Essentially acclimatization is a process where the micro-organisms are allowed to adapt to these unusual constituents. This is accomplished by gradually inoculating the toxic elements at low concentrations in the process. During initial stages many of the strains will die, however, some of the hardier variety will adapt themselves, through mutation, to assimilate the toxic compounds and in course of time will selectively take up the toxic constituents as food matter. This whole process of adaptation and development of mutant strains is called acclimatization. Being a natural phenomenon it is rather time consuming and could take many weeks or even months before the full quantity of the toxic pollutants are totally destroyed.

Some wastewaters contain pollutants that are not only complex but also toxic. In such cases a two stage treatment configuration is adopted. While both steps are aerobic in nature, the methodology of treatment is slightly different. The two types are Suspended Growth Process and Attached Growth Process.

- **Suspended Growth Process** is the biological treatment process in which the micro-organisms responsible for decomposition of the organic matter in the wastewater are maintained in suspension within the liquid.
- **Attached Growth Process** is the biological treatment process in which the micro-organisms responsible for decomposition of the organic matter in the wastewater are attached to some inert medium such as rocks, slag or plastic materials.

Bio Tower

The bio tower is a type of attached growth process. This system of biological treatment is usually used for degrading complex organic toxic compounds. The bio tower consists of a bed of plastic media to which micro-organisms are attached and through which wastewater is percolated. Plastic media used in bio tower provide more surface area for growth of micro-organisms. Plastic media also has more void volume, which helps to circulate the air within media.

The bio tower is constructed with an under drain system for collecting the treated wastewater and any biological solids that may have detached from the media. This under drain system is important both as a collection unit and as a porous structure through which air can circulate freely. The collected liquid is passed through a settling tank where the solids are separated from the treated wastewater. To maintain the hydraulics of the system, part of the wastewater is recirculated back to the filter along with the fresh incoming waste. This helps in maintaining a minimum required water flow through the medium to ensure that the medium is maintained wet at all times.

A population of micro-organisms attached to the media degrades the organic material present in the wastewater. The organic matter from the liquid is adsorbed on to the biological film. In the outer portions of this biological film layer, the organic material is degraded by aerobic micro-organisms. The required oxygen is available from the air circulating in the medium. As the micro-organisms grow, the thickness of the slimy layer increases, and the diffused oxygen is consumed before it can penetrate the full depth of the slime layer. Thus, an anaerobic environment is established near the surface of the media.

As the slime layer increases in thickness, the adsorbed organic matter is metabolized before it can reach the micro-organisms near the media face. As a result of having no external organic source available for cell carbon, the micro-organisms near the media face enter into an endogenous phase of growth and lose their ability to cling to the media surface. The liquid then washes the slime off the media, and a new slime layer starts to grow. This phenomenon of losing the slime layer is called "sloughing"

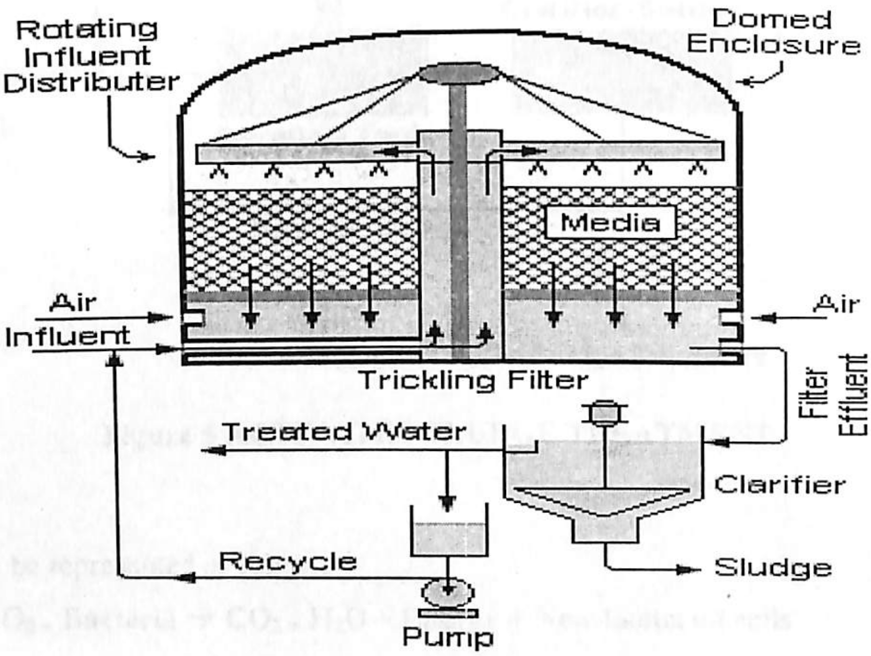


Figure 4 BIO TOWER

A. Activated Sludge Process (ASP)

The Activated Sludge Process (ASP) is a type of suspended growth process. The ensuing biochemical reactions generate further micro-organisms and inert matter, which form a matrix of solids or sludge. Since, it is the micro-organisms in this sludge that take part in the reactions the process is called the Activated Sludge Process. Respiration results in the formation of carbon dioxide and water.

The Activated Sludge Process is the most widely used biological wastewater treatment process in the world, treating both domestic and industrial wastewater. This process relies on a dense microbial population, which is in suspension in the wastewater (i.e. suspended growth process). Under aerobic conditions, the organics in the waste are consume by the microbes as source of energy resulting in the production of oxidized end products (CO_2 and H_2O) and for cell synthesis i.e. new micro-organisms.

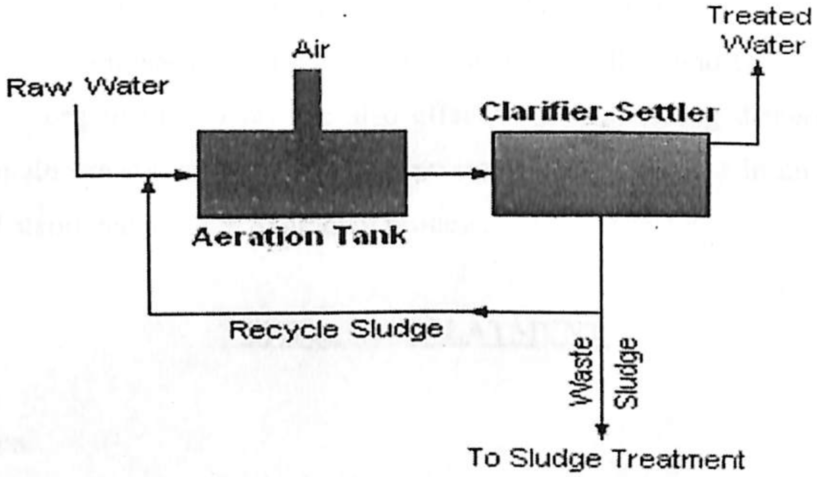


Figure 5 ACTIVATED SLUDGE TREATMENT

The process may be represented as follows:

BOD + N + P + O_2 + Bacteria → CO_2 + H_2O + Energy + New bacterial cells

The soluble organics are represented as BOD. The N is Nitrogen for protein synthesis and P is for Phosphorous that is required for energy transfer. Depending upon the F/M (Food/ Micro-organisms) ratio in the system, there is another process that goes on simultaneously. This process occurs when there is not enough food for bacteria to continuing growing. The microbes utilize organic matter released from dead cells. This is known as endogenous respiration and can be represented as:

Dead bacterial cells + O_2 → CO_2 + H_2O + N + P

Process Microbiology: Bacteria are the most important types of micro-organisms concerned with organics removal.

Bacteria which are most frequently occurring in activated sludge are as follows:- *Pseudomonas, Flavobacterium, Achromobacter, Chromobacterium, Azotobacter, Micrococcus, Bacillus, Alcaligenes, Arthrobacter, Acinetobacter, Mycobacterium, Nocardia, Lophomonas, Escherichia, Zoogloea.* Activated sludge also frequently contains undesirable filamentous organisms: Sphaerotilus, *Thiothrix, Beggiatoa, Geotrichum, Nocardia, Microthrix..*

Protozoa and *Rotifers* : The protozoa act as polishers of the effluents from biological waste treatment processes by consuming bacteria and particulate organic matter. Various types of protozoa are present viz. amoeboid, flagellated, ciliated (both stalked and free swimming). Rotifers are multi-cellular organisms. They are also effective in consuming dispersed and flocculated bacteria and particulate organic matter. Like the protozoa, their presence in an effluent indicates a highly efficient and stabilized aerobic biological process.

TERTIARY TREATMENT

A. Chlorination

The most commonly used disinfection agent is chlorine. When chlorine gas is added to water, two reactions take place, namely, Hydrolysis and Ionization.

Hydrolysis reaction:

$$\mathbf{CI_2 + H_2O \rightleftharpoons HOCI + H^+ + CI}$$

Ionization Reaction:

$$\mathbf{HOCI \rightleftharpoons H^+ + OCI^-}$$

The quantity of HOCI and OCI^- that is present in water is called the "Free Available Chlorine". The relative of these two species is very important because the killing efficiency of HOCI is 40 – 80 times that of OCI^-. The distribution of the two species is pH dependent. At a pH of about 6.5 almost 90-95% of the chlorine is present as HOCI, while at a pH of 8.5, 90% is present as OCI^-. Hence chlorine acts as a more effective disinfectant at a neutral to slightly acidic pH rather than at an alkaline pH. Chlorine reacts with the enzymes of the bacterial cells and denatures them resulting in bacterial kill. Factors affecting germicidal efficiency are pH, temperature, contact time & mixing efficiency.

B. Filtration

The clarified outlet from the secondary clarifier is generally expected to contain some suspended solids, along with some residual organics in the form of BOD and COD, colour matter and odor. These need to be reduced further by tertiary treatment, which comprises of pressure filtration using Dual Media Filters (DMF) and Activated Carbon Filters (ACF). DMF consists of a pressure vessel filled with layers of various grades of sand and anthracite as the filtering media. Water at high pressure is passed downwards through the media. The fine suspended solids get entrapped in the anthracite and sand media layer. Over a period of time the suspended solids accumulates in the surface layers of the media thereby causing pressure drop to develop across the filter. When the pressure drop reaches a value of 0.8 - 0.9 kg/cm^2 the filter is backwashed for 10 -15 minutes to clean the top layer. The filtration cycle can be continued after the backwash cycle.

The residual COD, color and odor remaining at the outlet of DMF is subjected to adsorption on activated carbon by filtering the same in Activated Carbon Filters (ACF). The ACF is also subjected to backwash as in the case of DMF with loss of head across the filter.

SLUDGE THICKENING AND CENTRIFUGE OPERATION

Biological sludge generated from Activated Sludge Process (ASP) is thickened for volume reduction. Thickening is done by gravity separation in a sedimentation tank called thickener and by high-speed centrifuge operation. The thickened sludge is stabilized in drying beds. The weathered sludge from the drying beds is used as bio manure in the green areas of the plant.

the volume of oily sludge generated from API/ TPI Oil Separators, DAF & basins of ETP is reduced by heat application followed by oil recovery. The sludge after oil recovery is further thickened by centrifuge operation and the residual sludge is transferred to secured landfill site.

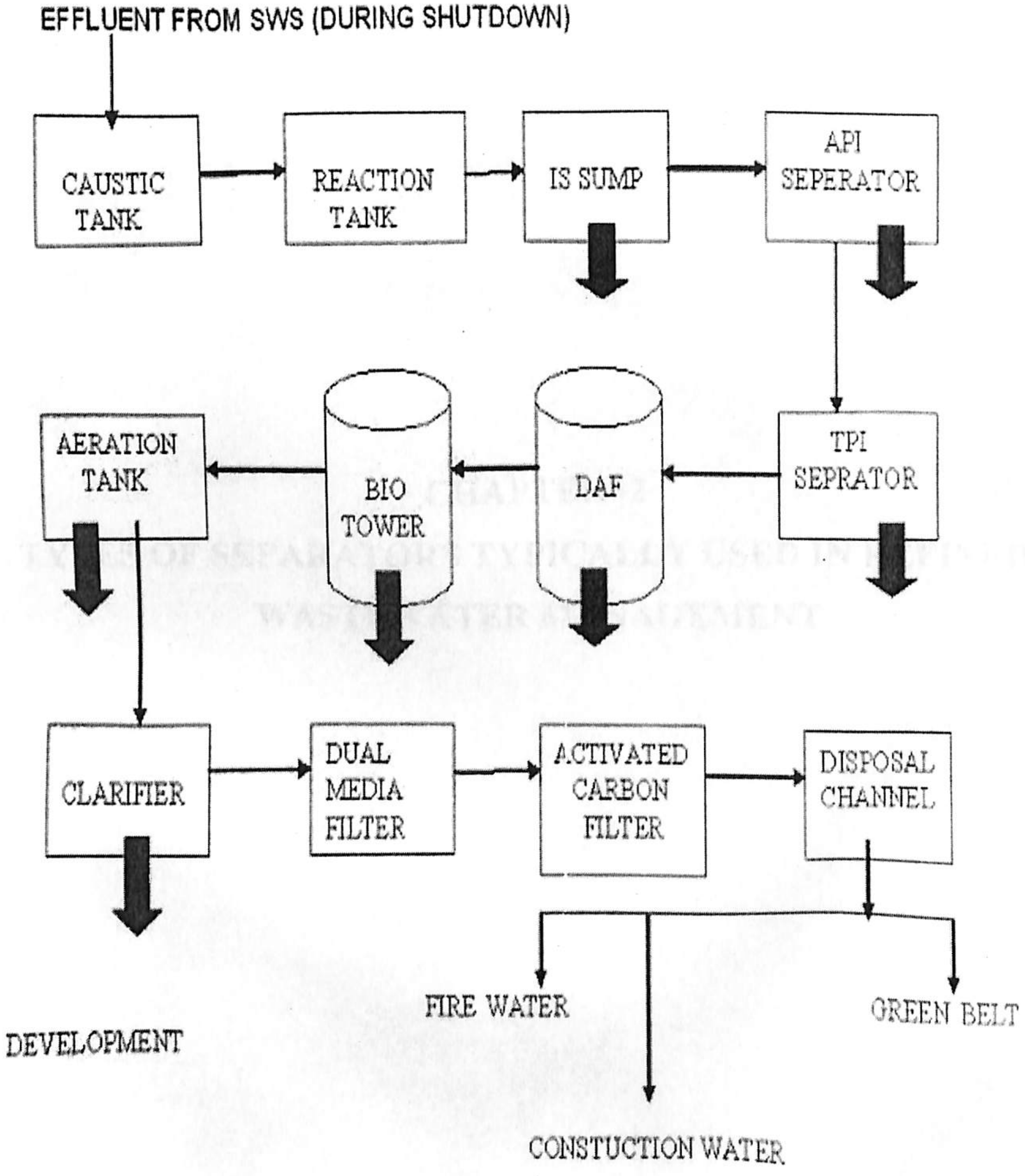


Figure 6 ETP FLOW DIGRAM

CHAPTER -2

TYPES OF SEPARATORS TYPICALLY USED IN REFINERY WASTEWATER MANAGEMENT

Many types of separation methods have been used to remove oil & grease from refinery wastewater with varying degrees of success. Some of the systems currently in use are:

- API separators
- Dissolved and Induced Air flotation (DAF and IAF) units
- Multiple angle separators

API (American petroleum Institute) Separators

The design of API separators is based on the criteria developed for the API during a three-year study begun in 1948 at the University of Wisconsin. These criteria were developed to be voluntary guidelines for designing separation systems. API separators are designed to remove 150 micron and larger droplets and to generate effluent oil & grease concentrations down to about 150 mg/L. Because this does not meet the requirements of the Clean Water Act, API separators are usually not adequate to meet environmental requirements for discharge.

In addition, the large size required by the API separation design criteria leads to Reynolds Numbers on the order of 104 to 105, ensuring that turbulence is present, thus contributing to mixing and subsequent re-entrainment of oil & grease droplets. API separators are normally provided as part of the refinery operation because of the large amount of recoverable oil & grease in refinery wastewater.

Oil & grease droplets rise according to Stokes's law, but considerable turbulence and short-circuiting usually prevails in an API separator. For this reason, an API separator will usually not perform as well as predicted by Stokes's law, because Stokes's law is only valid under laminar flow conditions. Variable turbulent and/or short-circuiting operating conditions can also result in variable effluent oil & grease and grease concentrations.

It is reported oil & grease removals by an API separator in an oil & grease refinery to be about 70%, with effluent hydrocarbon content averaging about 75 mg/L, although the content varied widely. Subsequent treatment with flocculation and a Dissolved Air Flotation (DAF) unit reduced the concentration to about 20 mg/L. To make this separation, about 40 mg/L of aluminum sulfate (alum) was required and 300 m3/day of sludge was produced. Hydrocarbons in effluent water from API separators have been reported to be as low as 20 mg/L, but average about 35-60 mg/L with quantities up to 115 mg/L reported.

Multiple Angle Separators/ tilted plate interceptor

The phenomenon of "Garvity Separation" is used by engineers extensively for separating the solids from the liquid or fluid as the case may be. It is therefore apparent that material with high density will settle and with lower density float to the surface of fluid. However, the effectiveness of this technique is subjected to various factors such as difference in the density, viscosity, factors of the medium, temperature, turbulence, and also the nature of impurity etc. In some cases chemical coagulation and flocculation is needed for removal of the impurity by making them heavier or lighter.

In separation technique while considering the above referred factors, which affects the separation of impurities, an overflow rate (m3/m2/day) or settling velocity (m/hr) is arrived at, which inturn determines the surface area required for the gravity separation. Incidentally it proves the fact that it is independent of the depth of basin.

The gravitational system offered by Paramount with technology acquired from M/s. PWT, Holland provides an extensive reduction in surface area requirement of a separator by introducing multi layer separation wherein area required is reduced considerably depending upon number of such layers. It is feasible to achieve almost complete removal of all the particles which would not have normally be achieved by a single large surface separator. This is possible because of considerable increase in the surface area of the unit, within the same depth. In most of the cases the plates are installed at an angle of 45°deg. or more and thus the separated material can be collected and removed by gravity.

Significance

The corrugated plate pack is the heart of our various purification systems consisting of number of parallel corrugated plates. These are framed in a housing of flat plastic plates and then is stiffened by a frame made from plastic material and/or stainless steel.

Plate Pack System

The liquid to be treated flows through the spaces between the Corrugated Plates. Flow through the plate pack is maintained under laminar condition thus allowing the separation to take place under ideal conditions. In addition, much attention has been given to the profile of the corrugated plates.

This has been chosen so that a smooth transfer and compaction of the separated particles is effected.

In order to reduce the frictional resistance between the separated material and the corrugated plates to the minimum, particular attention is paid to the smoothness and hardness of the plate surface. The Corrugated Plates as well as the casing are made from glass fiber reinforced polyester resin. This material is resistant to the most frequently used chemical additives and temperature.

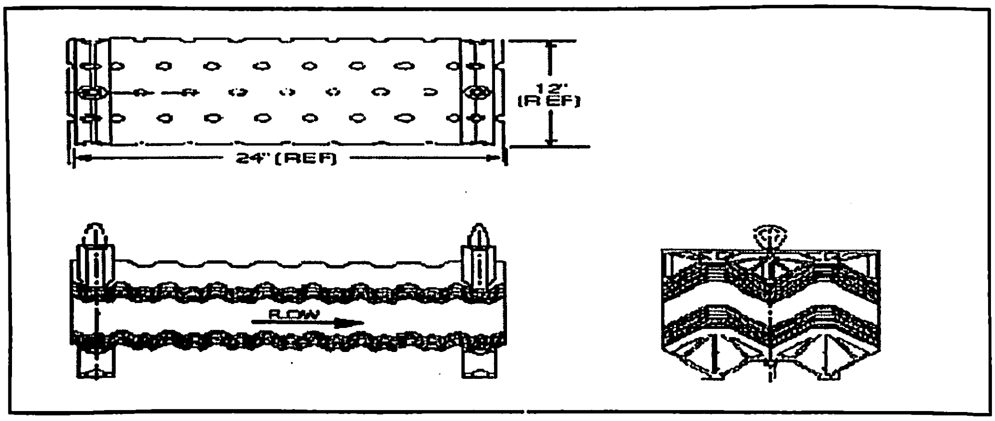


Figure 7 PLATE PACK SYSTEM

ADVANTAGES

- Low space requirement.
- Very low maintenance cost since no moving parts.
- High efficiency and capacity combined with compact volume.
- Low installation cost since units are mostly prefabricated.
- Handles shock loads of flow without affecting effluent quality.
- Continuous operation without major down time.
- Insensitive to weather condition, variation in temperature and composition of incoming liquid.

Description of Titled Plate Interceptor Unit

High efficient oil removal systems are required to recover maximum quantity of hydrocarbons as well as to make effluent amicable for further treatment & also to meet the pollution control requirements. The existing API type units need vast extensions of the surface area to take care of oil globules of smaller size so as to meet these requirements.

An enlarged separating surface, as discussed earlier can be achieved by placing various smaller planes on the top of each other in a tank. If these planes are subsequently inclined in a fitted position, the oil/solids separated between the plates can be removed by gravity. This principle has been realized in the counter current tilted plate interceptor unit. With the objective of not disturbing the particle size distribution unnecessarily, This system has preferably to be fed by gravity. The oily water flows into the interceptor through various components and oil gets separated as described below:

- A double slotted baffle at inlet includes evently distributes incoming water at the entrance of the corrugated plate pack.

- In the plate pack, the oil droplets are intercepted and coalesce into large droplets. They leave the pack rapidly countercurrent upwards against the liquid flow to the surface.

- Settle able material, if the present in the aqueous phase is similarly separated in the plate pack and then slides down to the sludge compartment.

- The treated clear water leaves the plate pack at the bottom and gets discharged over the weir to outlet nozzle. PWT is the first manufacturer to succeed in launching the corrugated plate interceptor in a commercial and technically attractive construction. Hundreds of complete advanced wastewater treatment plants have since been put into operation throughout the world. The compact design and the high separating efficiency which are so characteristic, for this gravitational system have unmistakably proven their value in practice in the course of the time.

Multiple angle separators were developed to correct some of the problems associated with the use of coalescing plate separators, notably plugging with solid particles. Multiple angle separators utilize coalescing plates that are corrugated in two directions instead of only one.

The current trend is to satisfy the increased separating area requirements by providing a number of stacked plates. Thus, the separating surface area is increased vertically. The area is further increased by selecting corrugated plates. The plates are located one on top of the other at specific distance from one another. The entire plate pack is placed in a tank at an approx. angle of 45 degrees. Hence the unit is called as **"Tilted Plate Interceptor (TPI)"**.

The wastewater enters the plates either parallels to corrugations in "Counter Current Flow" or at right angles to the corrugations in "Cross Flow" under laminar flow conditions. The short distance between the inclined plates is now the only distance over which the oil globule has to rise before it is intercepted and separated from the water. Due to the laminar flow conditions the separated oil globules coalesce into large droplets and gradually rise to the surface. The film formed on the surface is then skimmed off through slotted pipes.

In testing after initial development of the multiple angle separators, it was found that oil & grease removal was also enhanced over standard coalescing plate separators. It is thought that this is due to enhanced shedding of oil & grease film from the plates, but no research has been completed to substantiate this mechanism.

The wastewater enters the plates either parallels to corrugations in "Counter Current Flow" or at right angles to the corrugations in "Cross Flow" under laminar flow conditions. The short distance between the inclined plates is now the only distance over which the oil globule has to rise before it is intercepted and separated from the water. Due to the laminar flow conditions the separated oil globules coalesce into large droplets and gradually rise to the surface. The film formed on the surface is then skimmed off through slotted pipes.

The efficiency of an oil-water separator is inversely proportional to the ratio of its discharge rate to the unit's surface area. A separator's surface area can be increased by the installation of parallel plates in the separator chamber. The resulting parallel-plate separator will have a surface area increased by the sum of the horizontal projections of the plates added.

In cases where available space for a separator is limited, the extra surface area provided by a more compact parallel-plate unit makes the parallel-plate separator an attractive alternative to the conventional separator. Flow through a parallel-plate unit can be two to three times that of an equivalent conventional separator.

In addition to increasing separator surface area, the presence of parallel plates may decrease tendencies toward short-circuiting and reduce turbulence in the separator, thus improving efficiency. In this project we will consider the oil separation with plate interceptors , their design calculation, and their comparison with API oil separators.

Advantages:

Multiple angle separators are designed to ensure low Reynolds numbers and therefore laminar flow. In laminar flow regimes, Stokes's Law requirements are met and oil & grease and solids removals are predictable. Multiple angle separators are efficient at removing the oil & grease droplets from the water as a film on the underside of the plates well as shedding the accumulated oil & grease film to the top of the separator for removal and recycling.

Other advantages of multiple-angle separators include low operating and maintenance costs because operation is by gravity. Short travel distances along the plates for solid particles before the particles can be dumped to the bottom of the separator help eliminate plugging by solids particles. Low concentrations of hydrocarbons in the effluent water may be attained.

Chapter – 3

Designing of API and TPI

Design calculations for API separators

Oil-water separation theory is based on the rise rate of the oil globules (vertical velocity) and its relationship to the surface-loading rate of the separator. The rise rate is the velocity at which oil particles move toward the separator surface as a result of the differential density of the oil and the aqueous phase of the wastewater. The surface-loading rate is ratio of the flow rate to the separator to the surface area of the separator. The required surface-loading rate for removal of a specified size of oil droplet can be determined from the equation for rise rate.

The following parameters are required for the design of an oil-water separator:

a. Design flow (Q_m), the maximum wastewater flow. The design flow should include allowance for plant expansion and stormwater runoff, if applicable.

b. Wastewater temperature. Lower temperatures are used for conservative design.

c. Wastewater specific gravity (S_w).

d. Wastewater absolute (dynamic) viscosity (μ). Note: Kinematic viscosity (ν) of a fluid of density (ρ) is $\nu = \mu / \rho$.

e. Wastewater oil-fraction specific gravity (S_o). Higher values are used for conservative design.

f. Globule size to be removed. The nominal size is 0.015 centimetres (150 micrometres), although other values can be used if indicated by specific data.

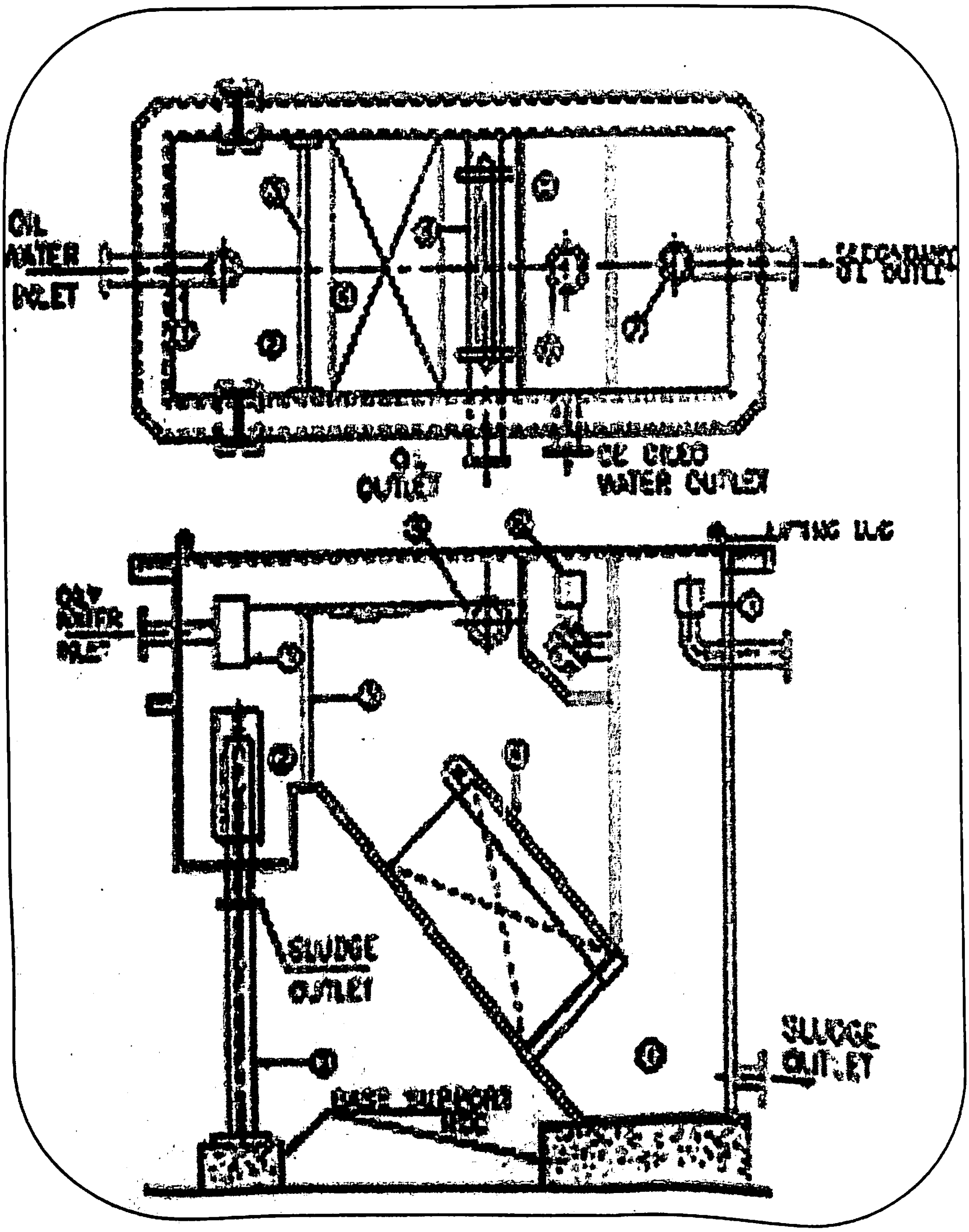


Figure 8 DESIGN VIEW OF PLATE INTERCEPETORS

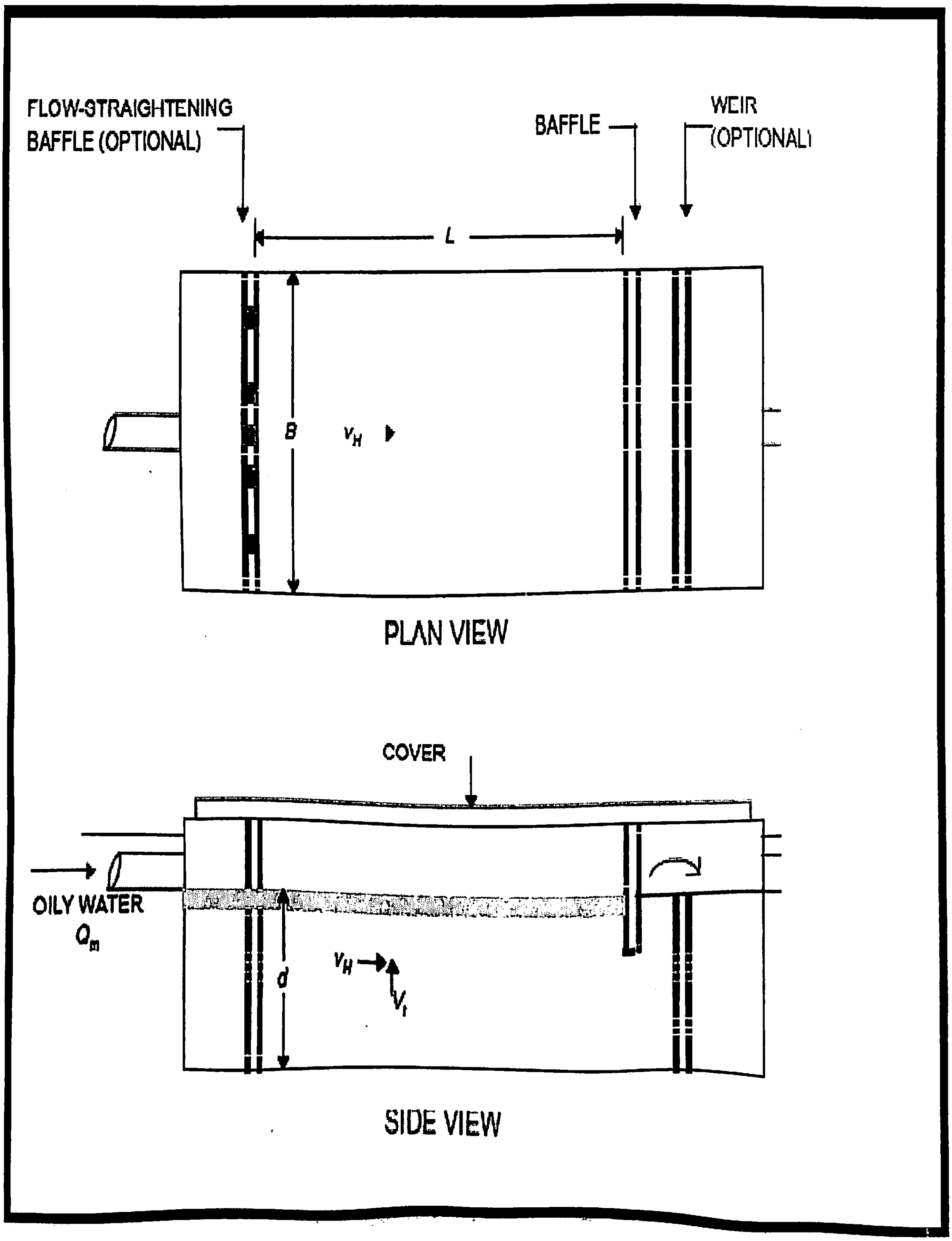


Figure 9 SIDE AND PLANE VIEW OF TPI

OIL GLOBULE RISE RATE(V_t)-

The oil-globule rise rate (V_t) can be calculated by Equation 1 or 2 shown below.

$$V_t = \frac{g}{18\mu}(\rho_w - \rho_o)D^2 \qquad (1)$$

$$V_t = 0.0123\left(\frac{S_w - S_o}{\mu}\right) \qquad \text{(where } D = 0.015 \text{ cm)} \qquad (2)$$

where:

V_t = vertical velocity, or rise rate, of the design oil globule, in cm/s.

g = acceleration due to gravity (981 cm/s^2).

μ = absolute viscosity of wastewater at the design temperature, in poise. Note: 1 P = 1 g/cm.s; 10 P = 1 Pa.s.

ρ_w = density of water at the design temperature, in g/cm^3. Note: 1 g/cm^3 = 1 kg/litre.

ρ_o = density of oil at the design temperature, in g/cm^3.

D = diameter of the oil globule to be removed, in cm.

S_w = specific gravity of the wastewater at the design temperature (dimensionless).

S_o = specific gravity of the oil present in the wastewater (dimensionless, not degrees API).

Mean horizontal velocity (V_H) —

The design mean horizontal velocity is defined by the smaller of the values for v_H in cm/s obtained from the following two constraints:

$$v_H = 15V_t \leq 1.5 \qquad (3)$$

Minimum Vertical Cross-Sectional Area (A_c)

Using the design flow to the separator (Q_m) and the selected value for horizontal velocity (v_H), the minimum total cross-sectional area of the separator (A_c) can be determined from the following equation:

$$A_c = \frac{Q_m \times 100}{v_H} \tag{4}$$

Where :

A_c = minimum vertical cross-sectional area, in m^2.

Q_m = design flow to the separator, in m^3/s.

v_H = horizontal velocity, in cm/s.

Note: The 100 factor is to convert from cm/s to m/s.

DESIGN FACTOR(F)

The design factor or F

The turbulence and short-circuiting factor (F) is a composite of an experimentally determined short-cutting factor of 1.21 and a turbulence factor whose value depends on the ratio of mean horizontal velocity (v_H) to the rise rate of the oil globules (V_t).

V_H/V_t	Turbulence factor (F_t)	$F=1.2F_t$
3	1.07	1.28
6	1.14	1.37
10	1.27	1.52
15	1.37	1.64
20	1.45	1.74

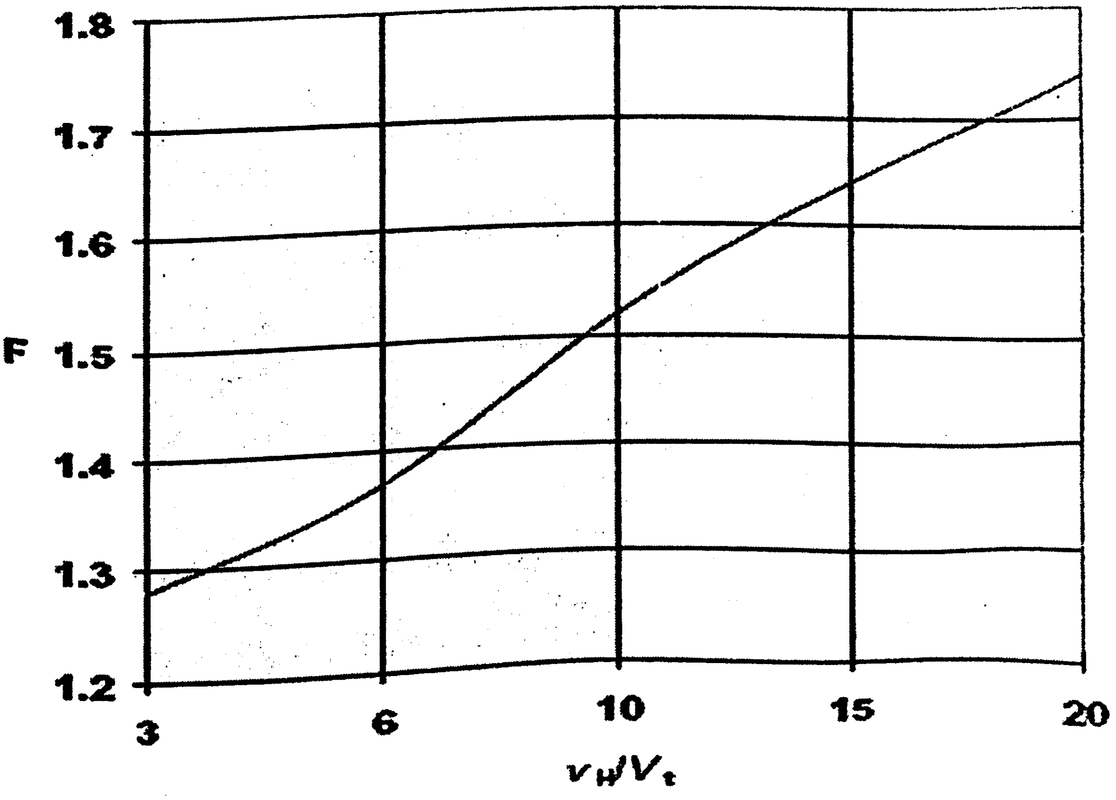


Figure 10 design factor values

Recommended values of F for various values of V_h/V_t

Minimum horizontal area(m^2)-

$$A_H = F^*\left(\frac{Qm}{Vt}\right)$$

Minimum vertical cross sectional area required(a_b)-m^2

$$A_c = \frac{Qm}{Vt}$$

No.of api channels required…

$$\frac{\text{Minimum cross section area required}}{\text{cross section area of available API channel}}$$

CHANNEL WIDTH AND DEPTH-

$$d = \frac{A_c}{Bn}$$

A channel width (B), generally between 1.8 - 6 m

where:

d = depth of channel, in m.

A_c = minimum vertical cross-sectional area, in m^2.

B = width of channel, in m.

n = number of channels (dimensionless)

SEPARATOR LENGTH(L)--

Once the separator depth and width have been determined, the final dimension, the channel length (L), is found using the following equation:

$$L = F\left(\frac{V_H}{V_t}\right)d$$

where:

L = length of channel, in m.

F = turbulence and short-circuiting factor (dimensionless).

v_H = horizontal velocity, in cm/s.

V_t = vertical velocity of the design oil globule, in cm/s.

d = depth of channel, in m.

Design calculations of TPI separators

OIL GLOBULE RISE RATE(V_t)-

$$V_t = 0.0123\left(\frac{S_w - S_o}{\mu}\right)$$

where:

V_t = rise rate of oil globule (0.015 cm in diameter) in wastewater, in cm/s.

S_w = specific gravity of wastewater at the design temperature of flow.

S_0 = specific gravity of oil in wastewater at the design temperature of flow.

TPI SEPERATORS LENGTH (L)-

Separator length is calculated from the following equation:

$$L = F\left(\frac{\sqrt{H}}{\sqrt{t}}\right)d$$

Derivation of Equation f

$$L = \frac{A_H}{Bn}$$

$$= \frac{A_H}{\frac{A_c}{d}}$$

$$= \frac{A_H d}{A_c}$$

$$= \frac{\frac{FQ_m}{\sqrt{t}} d}{\frac{Q_m}{\sqrt{H}}}$$

$$= F\left(\frac{\sqrt{H}}{\sqrt{t}}\right) d$$

where:

A_H = total separator surface area.

L = length of separator channel.

B = width of separator channel.

n = number of separator channels.

F = turbulence and short-circuiting facto

Q_m = total design flow to the separator.

$\sqrt{t}$ = separator's surface-loading rate.

A_c = separator's total cross-sectional area.

$\sqrt{H}$ = separator's horizontal velocity.

d = depth of separator channel.

CHAPTER –4

RESULTS

CALCULATIONS OF API

For example

for the flow rate of 1050 m^3/hr and oil globule size is 100μ then **rise rate in ft/min=**

$$V_t = 0.0123\left(\frac{S_w - S_o}{\mu}\right)$$

So, = {0.0123(.995-.90)}/0.0065 = 0.1797 ft/min.

As per API **mean horizontal velocity (V_h)**= 15*0.1797=2.696 ft/min.

Designed factors—

(a) for turbulence (F_t) $= \frac{Vh}{Vt} = \frac{2.696}{.1797} = 15.002$

for Vh/Vt= 15 the F is 1.37

(b) for short circuiting=F_s=1.2

Total designed factor=F

=F_t*F_s=1.37*1.2=1.644

Minimum horizontal area (A_h)

=F*$\frac{Qm}{Vt}$=1.644*617.57/.1797

Since Qm=1050 ^{3}/hr=617.57ft^3/min.

=5649.8ft^2=551.7 m^2

Minimum vertical cross section area (A_c)

=Q_m/V_h=617.57/2.696=229.06ft^2=22.37m^2

If Cross section area of available API channel is = 2.8*1.15=3.22m^2

Hence no of channels required are

= 22.37/3.22=6.9=7

Oil removal in API

=at the 3 outlet 2000 mg/l or (ppm),it is the design capacity of API for oil removal.

So,(2000*1050*24)/1000=50400 kg/day

If oil density = 900 kg/m^3

Then volume of oil removed = 56m/^{3}

Calculations of TPI

Rise rate =

$$V_t = 0.0123\left(\frac{S_w - S_o}{\mu}\right)$$

So as in the above case for the flow rate of 1050 m^3/hr or 617.57ft^3/min.

Assuming oil globule size = 100μ

Vt will be = 0.1797ft/min.

Total design factor(F)=1.644 as above.

$A_h = \frac{F*Qm}{\sqrt{Vt}}$ =1.644*(1050/√.1797)

=4080.04Ft^2=398.4m^2

V_h=15*Vt= 15*.1797

=2.68 ft/min.

Length of TPI

$= f*(\sqrt{Vh}/\sqrt{Vt}) * d$

Assuming d=4m

Then $L= 1.644(\frac{\sqrt{2.68}}{\sqrt{.1797}}) * 4=25.39m$

$A_b=Qm/\sqrt{Vh}$

$=617.57/1.63=378.87ft^2= 36.99\ m^2$

since

A_b =dbn

where

d=depth of the separator.

b = width of the separator.

n = no. of plates required in TPI

so,

n= 36.99/(4*3)=3.08=4

hence for the efficient separation with TPI the no. of plate required for the designed flow rate of 1050 ^{3}/hr=617.57ft^3/min.and the oil globule size will be 100μ *must be* 4.

TPI OIL REMOVAL PER DAY

=From the outlet of TPI 4000ppm,it is the design capacity of TPI for oil removal.

So ,(4000*1050*24)/1000=100800kg/day

Considering oil density = 900kg/m^3

Then, 100800/900=112m$^{3/}$day

Table - 3

LAB TEST RESULTS FOR OIL & GAS				
DATE (APRIL09)	API(PPM)		TPI(PPM)	
	INLET	OUTLET	INLET	OUTLET
1	122.5	35.0	35.0	16.5
2	98.3	32.0	32.0	17.2
3	46.4	33.0	33.0	18.3
4	42.5	34.1	34.1	15.9
5	40.6	31.5	31.5	18.3
6	41.3	35.4	35.4	15.9
7	48.5	36.6	36.6	14.6
8	47.9	35.7	35.7	17.4
9	45.1	30.0	30.0	16.4
10	44.3	29.9	29.9	15.6
11	46.4	28.8	28.8	16.4
12	48.1	32.2	32.2	15.6
13	49.2	31.0	31.0	19.4
14	42.7	33.0	33.0	18.5
15	42.5	32.0	32.0	13.9
16	41.7	31.4	31.4	16.5
17	39.8	27.5	27.5	17.2

LAB TEST RESULTS FOR OIL & GAS			
API(PPM)		TPI(PPM)	
INLET	OUTLET	INLET	OUTLET
122.5	35.0	35.0	16.5
98.3	32.0	32.0	17.2
46.4	33.0	33.0	18.3
42.5	34.1	34.1	15.9
40.6	31.5	31.5	18.3
41.3	35.4	35.4	15.9
48.5	36.6	36.6	14.6
47.9	35.7	35.7	17.4
45.1	30.0	30.0	16.4
44.3	29.9	29.9	15.6
46.4	28.8	28.8	16.4
48.1	32.2	32.2	15.6
49.2	31.0	31.0	19.4
42.7	33.0	33.0	18.5
42.5	32.0	32.0	13.9
41.7	31.4	31.4	16.5
39.8	27.5	27.5	17.2

18	38.8	29.4	29.4	18.3
19	39.9	28.3	28.3	15.9
20	43.2	31.5	31.5	14.6
21	46.0	32.7	32.7	17.4
22	45.4	33.5	33.5	16.4
23	40.5	31.6	31.6	15.6
24	40.0	35.4	35.4	19.4
25	42.2	33.4	33.4	18.5
26	41.0	33.0	33.0	16.8
27	47.5	32.0	32.0	16.4
28	42.1	31.0	31.0	15.6
29	44.0	28.0	28.0	19.4

COMPLIANCE OF EFFLUENT DISCHARGE STANDARDS

Table - 4

Parameter	MINAS Quality mg/ lit except pH
	Standard
pH	6.0 – 8.5
Oil & Grease	10 (max.)
Phenol	1.0 (max.)
Sulphides	0.5 (max.)
BOD	15 (max.)
TSS	20 (max.)

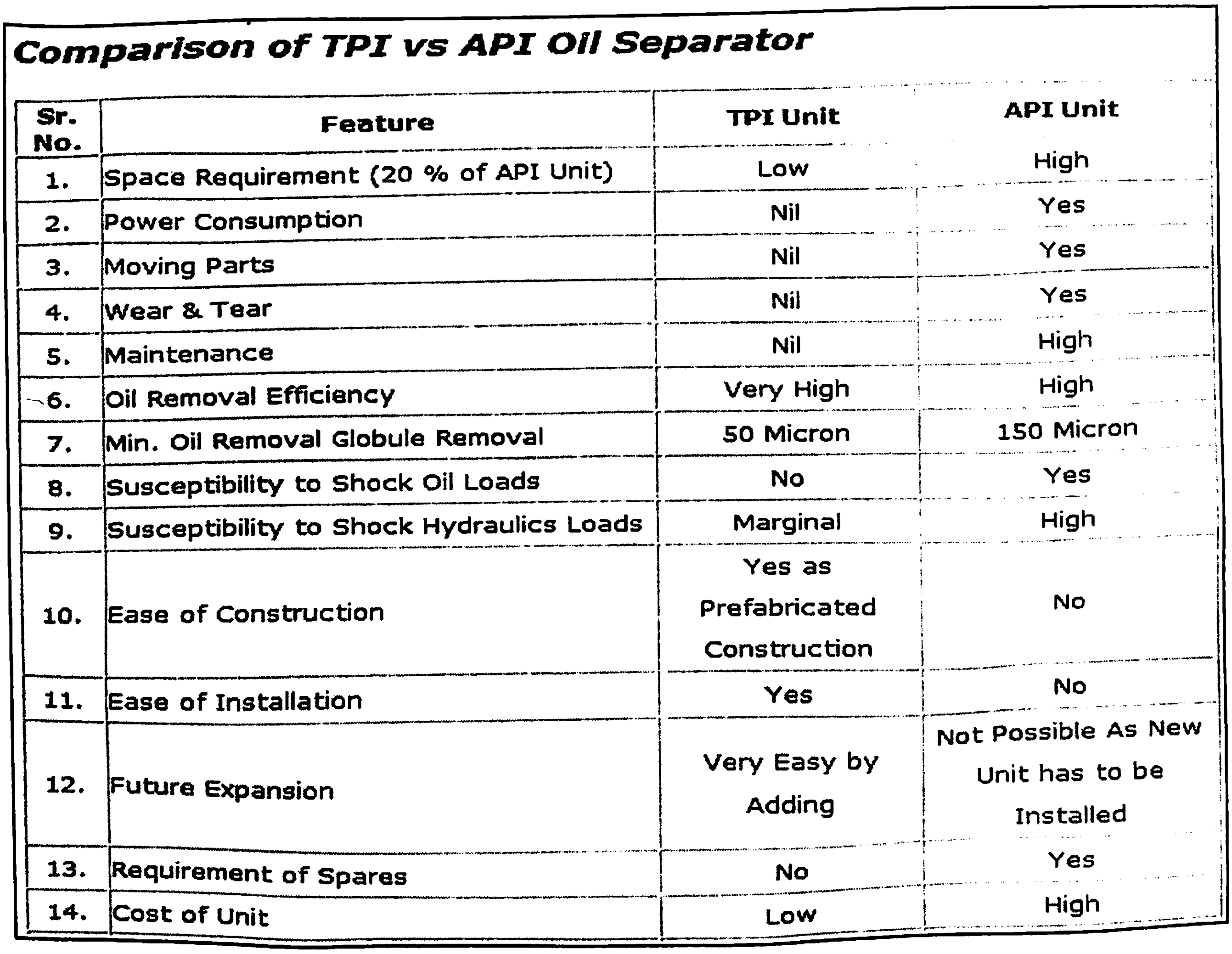
Chapter – 5

Conclusion and recommendations

CONCLUSIONS AND RECOMMENDATIONS

The lab test result shows that the TPI OIL separators are more efficient in oil and grease removal than API OIL separators. According to the national standards requirement the TPI leads to the closest results that shows that TPI are more efficient in oil separation than API.

Table - 5



Comparison of TPI vs API Oil Separator

Sr. No.	Feature	TPI Unit	API Unit
1.	Space Requirement (20 % of API Unit)	Low	High
2.	Power Consumption	Nil	Yes
3.	Moving Parts	Nil	Yes
4.	Wear & Tear	Nil	Yes
5.	Maintenance	Nil	High
6.	Oil Removal Efficiency	Very High	High
7.	Min. Oil Removal Globule Removal	50 Micron	150 Micron
8.	Susceptibility to Shock Oil Loads	No	Yes
9.	Susceptibility to Shock Hydraulics Loads	Marginal	High
10.	Ease of Construction	Yes as Prefabricated Construction	No
11.	Ease of Installation	Yes	No
12.	Future Expansion	Very Easy by Adding	Not Possible As New Unit has to be Installed
13.	Requirement of Spares	No	Yes
14.	Cost of Unit	Low	High

FIGURE 1 COMPARISION OF API AND TPI

There are some recommendations that refinery has to follow for the better oil separation. Equalization tanks should be used for better oil separation as it provides better oil and water separation and better settling time of oil. So by using equalization tanks with TPI it can be a better approach for obtaining good results of oil removal that can lead to the closer results to the MINAS standard values of oil and grease removal. Use of equalization tanks can lead to the results to 10 – 12 ppm of oil and grease.

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