ENGINEERING STANDARD

FOR

PROCESS DESIGN OF PLANT WASTE WATER

SEWER SYSTEMS

CONTENTS :

PAGE No.

APPENDICES:

0. INTRODUCTION

"Design of Miscellaneous Processes in OGP Industries" are broad and contain various subjects of paramount importance. Therefore, a group of Process Engineering Standards are prepared to cover this subject. This group includes the following Standards:

STANDARD CODE	STANDARD TITLE
IPS-E-PR-690	"Process Design of Refrigeration"
IPS-E-PR-700	"Process Design of Crude Oil Electrostatic Desalters"
IPS-E-PR-725	"Process Design of Plant Waste Water Sewer Systems"
IPS-E-PR-730	"Process Design of Plant Waste Water Treatment and Recovery Systems"
IPS-E-PR-735	"Process Design of Plant Solid Waste Treatment & Disposal Systems"

This Standard covers:

"PROCESS DESIGN OF PLANT WASTE WATER SEWER SYSTEMS"

Effluents in form of waste water are a combination of the liquid and water-carried wastes from buildings, industrial plants, plus ground water, surface water, or storm water. Waste water may be grouped into the following classes:

Class 1:

Effluents that are nontoxic and not directly polluting but liable to disturb the physical nature of the receiving water. They can be improved by physical means.

Class 2:

Effluents that are nontoxic but polluting because they have an organic content with high oxygen demand. They can be treated for removal of objectionable characteristics by biological methods.

Class 3:

Effluents that contain poisonous materials and therefore are often toxic. They can be treated by chemical methods.

Class 4:

Effluents that are polluting because of organic content with high oxygen demand and, in addition are toxic. Their treatment requires a combination of chemical, physical, and biological processes.

The final disposal of effluents and surface water drainage is subject to the approval of the Department of Environment, a factor which must be borne in mind in the early stages of design. In general, the aim of any drainage/effluent disposal system should be to segregate uncontaminated water from contaminated water or effluents and to segregate different types of effluents in order to reduce the size, complexity and costs of any treatment. Units which may be required for handling the contaminated water and effluents before they are discharged from the "Company" property.

1. SCOPE

This Engineering Standard covers minimum requirements for the process design of plant waste water sewer systems as well as plant waste effluent sources and disposals relevant to oil and gas refineries, chemical plants, oil terminals, petrochemical plants and other facilities as applicable. The following subjects are excluded from the scope and are covered through the Standards listed herein below:

	STANDARD CODE	STANDARD TITLE
1)	IPS-E-CE-380	"Sewerage & Surface Water Drainage System"
2)	IPS-E-CE-390	"Rain & Foul Water Drainage of Buildings"
3)	IPS-E-CE-400	"Sewage Treatment"
4)	IPS-C-CE-342	"Construction Works for Water Supply & Sewerage System"
5)	IPS-I-CE-344	"Water Supply & Sewerage Disposal"
6)	IPS-M-CE-345	"Water Supply & Sewerage Equipment"
7)	IPS-E-PI-240	"Plant Piping Systems"
8)	IPS-C-PI-240	"Plant Piping Systems"
9)	IPS-G-SF-130	"Solid Waste Disposal"
10)	IPS-E-SF-880	"Water Pollution Control"
11)	IPS-E-PR-730	"Process Design of Plant Waste Water Treatment and Recovery Systems"
12)	IPS-E-PR-735	"Process Design of Plant Solid Waste Treatment & Disposal Systems"

2. REFERENCES

Throughout this Standard the following standards and codes are referred to. The editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standards and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor/Consultant:

P. ACKERS

"Resistance of Fluids Flowing in Channels and Pipes", Hydraulic Research Paper No. 1, HMSO 1958

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-M-CE-345	"Water Supply & Sewerage Equipment"
IPS-E-CE-380	"Sewerage and Surface Water Drainage System"
IPS-E-CE-390	"Rain & Foul Water Drainage of Buildings"
IPS-E-CE-400	"Sewage Treatment"
IPS-E-PI-240	"Plant Piping Systems"
IPS-E-PR-491	"Process Requirements of Refinery Non-Licenced Units"
IPS-E-PR-730	"Process Design of Plant Waste Water Treatment and Recovery Systems"
IPS-E-PR-735	"Process Design of Plant Solid Waste Treatment and Disposal Systems"
IPS-E-SF-220 "	"Fire Water Distribution and Storage Facilities"

J. A. FOX

"An Introduction to Engineering Fluid Mechanics", Published by Macmillan Press, London

ISO (INTERNATIONAL ORGANIZATION FOR STANDARDIZATION)

ISO 748, 1979	"Liquid Flow Measurement in Open Channels Velocity-Area Methods"
ISO 772, 1988	"Liquid Flow Measurement in Open Channels-Vocabulary and Symbols"
ISO 1070, 1973	"Liquid Flow Measurement in Open Channels Slope-Area Method"
ISO 1100, 1981/ 1982	"Liquid Flow Measurement in Open Channels-Establishment and Operation of a Gaging Station and Determination of the Stage-Discharge Relation"
ISO 3847, 1977	"Liquid Flow Measurement in Open Channels By Weirs and Flumes"

API (AMERICAN PETROLEUM INSTITUTE)

API PUBL. 4296	"Analysis of Refinery Waste Waters for the EPA Priority Pollutants", 1st. Ed., 1978
API PUBL. 4346	"Refinery Waste Water Priority Pollutant Study-Sample Analysis and Evaluation of Data", 1st. Ed., 1981.
API PUBL. 4388	"Land Treatment-Safe and Efficient Disposal of Petroleum Waste", 1st. Ed., 1988

HRS (HYDRAULIC RESEARCH STATION)

"Charts for the Hydraulic Design of Channels and Pipes", 5th. Ed., HRS 1983
"Tables for the Hydraulic Design of Pipes and Sewers", 4th. Ed., HRS 1983
"Hydraulic Research" Paper No. 4

3. DEFINITIONS AND TERMINOLOGY

For definition of the particular terms/words of this Standard not outlined herein below, reference should be made to the latest revision of the following standards/publications:

API Vol. I	"Manual on Disposal of Refinery Wastes, Liquid Wastes"
IPS-E-CE-380	"Sewerage and Surface Water Drainage System"
IPS-E-CE-390	"Rain & Foul Water Drainage of Buildings"
IPS-E-CE-400	"Sewage Treatment"
IPS-E-PR-730	"Process Design of Plant Waste Water Treatment and Recovery Systems"

3.1 Biochemical Oxygen Demand (BOD)

Biochemical oxygen demand is oxygen demand by microorganisms during stabilization of organic matter under prescribed conditions, usually over a 5 day peroid, BOD_5 specifically denotes the oxygen demand over a 5 day period at 20°C.

3.2 Branches

Branches are collection from various drain funnels, catch basins and area drains and tie into sublaterals. They are called T, Y, T-Y, double Y, and V branches according to their respective shapes.

3.3 Catch Basins

Catch basins are used to collect surface drainage and process wastes in individual drainage areas and to trap sediment at the point nearest the source.

3.4 Catchment Area

Catchment area is an area defined by a number of effluent streams which have a common discharge directed into a surface water drainage system, or water course.

3.5 Chemical Oxygen Demand (COD)

Chemical oxygen demand (COD) is the equivalent amount of oxygen consumed under specified conditions in the chemical oxidation of the organic and oxidizable inorganic matter contained in a waste water,corrected for the influence of chlorides. In American practice, unless otherwise specified, the chemical oxidizing agent is hot acid dichromate.

3.6 Contractor

Contractor is the person, firm or company whose tender has been accepted by the Company and includes the Contractor's personnel representative, successors and permitted assigns.

3.7 Disposal Well

Disposal well is a deep well used for the disposal of liquid wastes.

3.8 Dissolved Oxygen (DO)

Dissolved oxygen (DO) is the oxygen dissolved in sewage, water, or other liquid, usually expressed in milligrams per liter or percent of saturation. It is the test used in BOD determination.

3.9 Drains

Drains are small sewer connections discharging through a sealed connection to the nearest catch basin from points such as pump bases, equipment drips, low points of floors, funnels, etc.

3.10 Drip System

Drip system is a separate drain system for recovery of oil from contaminated fluids.

3.11 Effluent

Effluent is (1) a liquid which flows out of a containing space, and/or (2) sewage, water or other liquid, partially or completely treated, or in its natural state, as the case may be flowing out of a reservoir, basin, or treatment plant, or part thereof.

3.12 Effluent Limitation

Effluent limitation is any restriction (including schedules of compliance) established by a governmental authority on quantities, rates and concentrations of chemical, physical, biological and other constituents which are discharged from point sources into navigable waters, the waters of the contiguous zone, or the ocean.

3.13 Employer/Company/Owner

Employer/Company/Owner refers to any of the related affiliated companies of the petroleum industries of Iran such as National Iranian Oil Company (NIOC), National Iranian Gas Company (NIGC), National Petrochemical Company (NPC), etc., as a part of the Ministry of Petroleum.

3.14 Immediate Oxygen Demand (IOD)

Immediate oxygen demand (IOD) is the amount of oxygen that is utilized by the components of a waste water within 15 minutes (unless otherwise specified) after being introduced into water that contains dissolved oxygen.

3.15 Laterals

Laterals is sewers collecting the effluent from two or more sublaterals discharging to "Mains".

3.16 Lagoon Sludge

Lagoon sludge is a relatively shallow basin, or natural depression, used for the storage or digestion of sludge, sometimes for its ultimate detention or dewatering.

3.17 Mains

Mains are sewers collecting effluent from laterals or sublaterals.

3.18 Manholes

Manholes are used in sewer mains as junction points and sediment traps, and to provide access for maintenance and inspection.

3.19 Oil Interceptor

Oil interceptor is a device designed to remove small oil globules by gravity from the water by limiting the flow velocity and the overflow rate.

3.20 Oxidation Ponds

Oxidation ponds are basins in which waste water undergoes a biological oxidation treatment by action of algae and bacteria.

3.21 Oxidation Direct

Oxidation direct is oxidation of substances in sewage without the benefit of living organisms, by the direct application of air or oxidizing agents such as chlorine.

3.22 Oxidation Sewage

Oxidation sewage is the process whereby, through the agency of living organisms in the presence of oxygen, the organic matter that is contained in sewage is converted into a more stable or a mineral form.

3.23 Oxygen Consumed

Oxygen consumed is the quantity of oxygen taken up from potassium permanganate in solution by a liquid containing organic matter. Commonly regarded as an index of the carbonaceous matter present. Time and temperature must be specified.

3.24 Parts Per Million (ppm)

Parts per million (ppm) is parts by mass in sewage analysis, ppm by mass is equal to milligrams per liter divided by the relative density (specific gravity). In water analysis ppm is always understood to imply mass/mass ratio (mg/kg), even though in practice a volume may be measured instead of a mass.

3.25 Primary Treatment

Primary treatment is water purification based on the difference in density of the polluting substance and the medium, the former being removed either by rising or settling. This process can include screening, grit removal, sedimentation, sludge digestion, and sludge disposal.

3.26 Run-off

Run-off is that part of rainfall which flows off the surface to reach a sewer or river.

3.27 Seals (Hydraulic Seals)

Seals (Hydraulic Seals) are used to isolate various parts of a sewer system, preventing vapor travel and spread of fire or explosion.

3.28 Sewage

Sewage is the fuid discharged from medical, domestic, and industrial sanitary appliances.

3.29 Sewage System

Sewage system is any of several drainage systems for carrying surface water and sewage for disposal.

3.30 Sewer

Sewer is an underground pipe or open channel in a sewage system for carrying water or sewage to a disposal area.

3.31 Sewerage

Sewerage is a system of sewers and ancillary works to convey sewage from its point of origin to a treatment works or other place of disposal.

3.32 Springing

Springing is separation of acid oils, either phenolic or naphthenic, by neutralization of spent caustic solutions. The acid oils are known as "sprung acids".

3.33 Storm Water

Storm water is rain water discharged from a catchment area as a result of a storm.

3.34 Sublaterals

Sublaterals are sewer branches [min. 150 mm (6 inch) Diameter Nominal size] collecting effluents from catch basins and convey it to the laterals.

3.35 Surface Water

Surface water is natural rain water from the ground surface, paved areas and roofs plus occasional courtyard and car washing waste waters and incidental fire fighting water.

3.36 Toe Walls

Toe walls are raised curbs which control spillage and drainage of storm, process and fire water.

3.37 Total Organic Carbon (TOC)

TOC is a measure of the amount of carbon in a sample originating from organic matter only. The test is run by burning the sample and measuring the CO_2 produced.

3.38 Unit or Units

Unit or Units refer to one or all process, offsite and/or utility Units and facilities as applicable to form a complete operable refinery and/or complex.

4. SYMBOLS AND ABBREVIATIONS

4.1 General

Symbols and abbreviations referred to in this Standard are as follows:

SYMBOL / ABBREVIATION	DESCRIPTION
BOD_5	The 5 Day Biochemical Oxygen Demand at 20°C
COD	The Total Chemical Oxygen Demand
DN	Diameter Nominal, in (mm)
DO	Dissolved Oxygen
DOD	Dissolved Oxygen Demand
EPA	United State Environmental Protection Agency
GRE	Glass-Fiber Reinforced Epox
IOD	Immediate Oxygen Demand
LNG	Liquefied Natural Gas
MEK	Methyl Ethyl Ketone
NGL	Natural Gas Liquids
TDS	Total Dissolved Solids
TEL	Tetra Ethyl Lead
TOC	Total Organic Carbon
TSS	Total Suspended Solids.

4.2 Sewer Systems Symbols

Symbols referred to in this Standard for the sewer systems are as follows. These symblols shall also be used in all engineering documents and drawings as applicable.

SYMBOL	DESCRIPTION
AMN	Amine Drains
CAU	Spent Caustic Sewer
CDH	Closed Drain Headers
CSW	Chemical Sewer
DWA	Desalter Waste Water
NSW	Non Oily Sewer Water
OSW	Oily Sewer Water
SSW	Sanitary Sewer Water
SWA	Stripped Sour Water
WAT	Treated Water
WSW	Storm Water Sewer.

5. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

6. GENERAL

All waste water effluents from the industries which are discharged to public and/or natural water sources or directed to recycling purpose inside the industry and may contain a wide variety of matters in solution or suspension should be controlled according to the requirements imposed by the final destination. However, in any case elimination of the waste or the hazard potential of the waste shall be ultimate goal in the management of hazardous wastes. Under no circumstances shall the effluent water cause oil traces on the surface or embarkments of the receiving water, or affect the natural selfpurification capacity of the receiving water to such an extent that it would cause hindrance to others.

Under no conditions shall polluted streams be combined with unpolluted streams if the resultant stream would then require purification. In general main sewer systems in the industry shall be segregated according to the following categories:

- Storm Water Sewer System.
- Oily Water Sewer System.
- Non Oily Water Sewer System.
- Chemical Sewer System.
- Sanitary Sewer System.
- Special Sewer Systems.

In all areas including process, offsite and utility Units, provisions shall be made to foresee any of the above mentioned sewer systems as required.

7. INDUSTRIAL MAIN SEWER SYSTEMS

7.1 Storm Water Sewer System

This system shall consist of pipes and open ditches collecting clean and/or oily storm waters, fire and washing waters from the non-polluted areas.

The storm water shall be disposed to the oily storm water basin located in the waste water treatment area through the storm water network. It shall mainly collect the following non-polluted areas clean waters:

- Diked and undiked tank areas.
- Unpaved areas.
- Process and utilities non-polluted paved areas (excluding concrete paved areas).
- Roads, yards and roofs.

The collected storm water after oil removal in the oily storm water basin shall be stored in the clean storm water basin. The final disposal of such clean waters will be to:

- Waste water treating Unit at API separator(s) effluent for further oil removing.
- Evaporation pond(s).
- Ocean/river if complies with the local conditions of effluent waste streams.

7.2 Oily Water Sewer System

This sewer shall collect:

- Process spillages and drainages.
- Drains of all hydrocarbon equipment.
- Pumps and compressors cooling water.
- Oily condensate.
- Cooling water drains which have a chance of becoming polluted with oil.
- Waters coming from all hydrocarbon pollutable paved areas mainly including the following:

  a) Process Units.
  b) Utilities.
  c) Non-volatile products truck loading stations.
  d) Workshop.
  e) Transport & mobile plant garage.
  f) Pump stations.

- Pipe trench drains.
- Sample point drains.
- Drainage from level gages, cocks and similar equipment.
- Drains of the following fluids are excluded because of flowing in pit for truck disposal:

  a) Heavy viscous fluids such as asphalt.
  b) Motor gasoline contaminated with TEL.
  c) Any fluid containing hazardous materials with concentrations more than allowable figures set out by the environmental and/or biological treatment restrictions.

The system shall consist of drains, funnels, underground piping, clean-outs, catch basins, manholes, sealed manholes and vent pipes. The final main of the oily water sewer shall flow into API separator(s) in Waste Water Treating Area through a dedicated underground gravity flow network. Open ditches shall be avoided. Leakages of manifolds can be collected in a suitable collecting basin, located underneath the manifold. The basin shall drain into a sump located out-side the manifold/piping area. The sump can be emptied intermittently (e.g., by vacuum truck) or it can be connected to the continuously oil contaminated drain system.

7.3 Non-Oily Water Sewer System

The system shall collect special oil free waters containing high total dissolved solids such as:

- Boiler blow-down.

- Desalination Unit blow-down.

- Brine drainage.

- Neutralized effluents from all neutralization sumps through the plant.

- Storm, fire and washing run-off waters from sulphur solidification and crushing area after removal of sulphur particles through a sedimentation sump.

- Tempered water system drains.

- Cooling water (circulated) blow-down and drains, provided that there is no possibility of oil contamination.

The system shall consist of drains, funnel, underground piping, clean-outs, catch basins, manholes, sealed manholes and vent pipes. The non-oily water sewer system can be directed to the following disposals where required:

a) Waste Water Treatment Plant Effluent, if it is intended to reuse the treated waste waters as cooling tower make-up. In this case, the recycled treated water should meet the cooling tower make-up minimum requirements. If needed, total hardness removal facilities should be provided on the non-oily water system before any disposal (see also item b below).

b) Waste Water Treatment Plant Infflulent [at API separator(s) outlet], if non-oily waters need further physical and/or biological treatment in order to meet the final disposal requirements. In this case the following conditions should be met.

1) Non-Oily waters should be treated for total hardness removal before any disposal to the API separator(s) effluent (if required).

2) All materials which will suffer the biological treatment activities should be removed from the non-oily waters.

c) Evaporation pond(s).

d) Public waters (if non-oily waters are complied with the Environmental Regulations).

However, non-oily water sewer system should be investigated for an appropriate disposal considering the following aspects:

- Environmental Regulations.
- Availability of refinery/plant raw water.
- Economical aspects.
- Operability of equipment furnished.

7.4 Chemical Sewer System(s)

7.4.1 General

In this Engineering Standard all sewer systems containing acids, alkalides, chemicals and all other special organic materials such as Furfural, MEK, etc. are designated by "Chemical Sewer". Number and route of chemical sewer systems in a plant shall be studied based on the geographical location of various Units and more feasibility of the gathering and disposal systems. Chemical sewer streams shall include but not be limited to:

- Polluted drains from chemical additives dosing pumps (excluding tetraethyl lead).

- Laboratory building drains (excluding oily drains).

- Drainage and storm water polluted by acid and/or other chemicals.

- Caustic drains (caustic dissolving Unit drains are excluded and shall have a closed circuit network inside the Unit).

- All waters contaminated with acids and/or chemicals.

7.4.2 Disposal of chemical sewers

In general, disposal of any chemical sewer before neutralization/treatment to the environment should be avoided. Segregated chemical sewer network(s) shall be provided depending on variety of the chemicals disposed. Neutralization ponds effluent shall be connected to the non-oily sewer. The volume of the neutralization pond shall be minimum equal to the highest batch volume among the streams disposed. Chemical effluents from the laboratory building shall flow into a dedicated neutralization pit near the laboratory itself.

7.4.3 Neutralization systems

7.4.3.1 Adequate facilities for acid and caustic injection systems, agitator, pumps, eductor (if required), steam coil (if required for winterization), etc., shall be provided for each neutralization pond.

7.4.3.2 Necessary instrumentation such as acid and caustic flow indicator, pH indicator, pH low and high alarm in the control room, temperature controller, etc. to be foreseen for each pond.

7.4.3.3 Type of operation (manual or automatic) for the neutralization ponds will be instructed by the Company.

7.4.3.4 All acid and caustic handling facilities such as pipes, tanks, pumps, etc., shall be traced for proper temperature maintaining.

7.4.4 Type of chemicals wastes

Chemical wastes shall include all wastes contaminated with acids, alkalides, chemicals and additives and waters containing hazardous liquids. Disposal of any stream containing hazardous materials to the oily sewer and/or non-oily sewer systems should be avoided before implementation of the necessary treatment processes for removal of the hazards. Method and extent of treatment will be instructed by the Company. The final treated water specifications shall be complied with the Environmental Pollution Requirements set out by the authorities concerned in Iran. Type of chemical wastes in general shall include but not be limited to:

a) Waters containing hazardous materials which shall be segregated and handled separately (see also 7.6 below).
b) Special chemicals with dedicated network as mentioned in Article 7.6.
c) Chemical terminated at the neutralization ponds as described in Articles 7.4.1 and 7.4.2 above.

7.5 Sanitary Sewer System

This sewer shall collect non-polluted raw sanitary from sanitary facilities of all buildings as required. The final main shall flow into sanitary sewage treatment Units. The sanitary sewage treatment plant effluent in case of compliance with the required effluent characteristics can be routed to the Waste Water Treating Plant (at the biological treatment outlet) for recycling purpose.

7.6 Special Sewer Systems

Special sewer systems shall be provided where required. In general all fluids containing poisonous/hazardous materials and/or fluids subject to recovery shall be segregated and handled apart from the all other sewer systems mentioned in this Engineering Standard. The systems shall include but not be limited to the following streams:

- Caustic drains inside the Caustic Dissolving Unit .

- Amine drains.

- Solvent drainage.

- Motor gasoline drainage contaminated with TEL.

- Hydrocarbon drains containing benzene in concentrations more than allowed by the Environmental Regulations.

- All drains contaminated with toxic components such as cyanide, phenol, lead, etc.

- Aluminum chloride drainage.

- Hydrofluoric acid drainage.

- Spent catalysts.

- Others.

Any special requirement for segregation of the above streams, methods of in-plant pretreatment and the ultimate disposal shall be in accordance with the Company's instructions and/or the Environmental Regulations.

8. EFFLUENT SOURCES AND DISPOSALS

8.1 General

The majority of effluent source streams can be broadly characterized as one or more of the following types:

a) High or low dissolved solids content;
b) oily or non-oily;
c) high or low in phenols and/or sulfides;
d) chemical or non-chemical;
e) high or low in suspended solids.

Using these broad characteristics, the effluent source streams shall be investigated for a suitable disposal.

8.1.1 Unpaved areas

The effluent from unpaved, non-process, and non-tank areas will be clean storm water. The word "clean" is defined as meaning non-oily.

8.1.2 Undiked tank areas

The effluents from undiked tank areas will be oily storm water.

8.1.3 Diked tank areas

The normal effluent from diked hydrocarbon tank areas will be oily storm water. If a tank should rupture, the residual oil after clean up will probably be washed down and routed to oily storm water sewer. Diked area drains should be valved at outlet of dike, so that any accumulation of oily water or oil can be impounded and released under controlled conditions.

8.1.4 Tank bottom draws

The water periodically drained from hydrocarbon tanks will be "oily foul water" and these drains should be valved. These waters may contain salt and other dissolved solids if the tanks are storing crude oil, sulfides and/or phenols, if the tanks are storing untreated intermediate products, and free or emulsified oils. These waters normally are discharged to the oily water sewer except the cases that the drains are rich in the hazardous materials such as phenols or lead which should be segregated from the ordinary sewer systems. Drains of slops and any other tanks which are rich in H_2S should be routed to the Sour Water Stripper Unit for treatment.

8.1.5 Concrete paved process and utility areas drains

The effluent from concrete paved process and utility areas which are contaminated from various sources of oily drips and drains shall be connected to the oily water sewer system unless otherwise specified in this Engineering Standard.

8.1.6 Process and utility paved areas

Drains from all clean areas adjacent to the streets around process and utilities areas and/or other clean paved areas which are not subject to any oil spillage shall be routed to the storm water sewer system.

8.1.7 Pump and compressor cooling

Some amount of water cooling will usually be used for hot pump pedestals and glands and compressor jackets. Additionally, some water and/or oil may be used in pump and compressor seals. The drips and drains from these systems shall constitute another source of oily sewer system. Should the utility area include pump or compressor, then drain of such areas which will be subject to oil contamination shall be connected to the oily water sewer system.

8.1.8 Boiler blow down and water treating rinses

These waters will be free of oil but high in dissolved solids. Hence, they shall be discharged to the non-oily sewer system.

8.1.9 Cooling water drains

If the tubes in the water cooled heat exchangers in an once-through cooling water and/or circulating cooling water develop leaks, then these waters are liable to contamination with process fluids. Due to characteristics of the process fluids (light oils or heavy oils) and also cooling water (once-through or circulated) the following four categories shall be taken into consideration. Light oils refers to pentane and lighter.

a) Once-through cooling water (light ends)**:** This will be clean water and shall be considered as non-oily water.

b) Once-through cooling water (heavy oils): This will be oily water to acknowledge the possibility of exchanger tube leaks of non-volatile oil.

c) Circulating cooling water blow down (light ends): This will be high solids clean water and shall be considered as non oily water.

d) Circulating cooling water blow down (heavy oils): This will be high solids oily water to acknowledge the possibility of exchanger tube leaks of non-volatile oil. These waters can be routed to the oily water sewer if the quality of final waste treated water is not suffered from receiving of such amount of high solids content.

8.1.10 Process drums drains

Water that has been withdrawn from process drums containing H_2S or H_2S and NH_3 will be designated as "sour water" and if the water is principally condensed steam, it will be called "sour condensate". The destination of such drains shall be Sour Water Stripper Unit through pump. For non-oily, gravity and low flow cases the destination can be non-oily sewer system and/or the oily water sewer system under controlling conditions and not in such amounts that suffers biological treatment operation. See Item 8.2.4 below for details.

8.1.11 Laboratory waste water

8.1.11.1 Oily wastes

Wastes from laboratory oily sinks which are not contaminated with chemicals shall be routed to the oily water sewer system.

8.1.11.2 Chemical contaminated wastes

All chemical contaminated wastes shall be directed to the non-oily sewer system after neutralization in the dedicated neutralization pit adjacent to the laboratory building.

8.1.12 Flare seal drum blow down

Continuous drain from main flare and acid flare seal drums located at bottom of the flare stack(s) which are rich in H_2S shall be pumped to the Sour Water Stripper Unit for treating. Make-up water to the flare seal drum/pot shall be condensate.

8.1.13 Floating roof drain of tanks

The roof drain(s) of the floating roof tanks shall be discharged to oily water sewer system due to the possibility of hydrocarbon leakage from rubber seals.

8.2 Particular Effluents in Refinery and Petrochemical Plants

8.2.1 Caustic used to scrub pentanes and lighter will contain essentially sodium sulfide. Such streams shall be neutralized in the chemical neutralization pit, and to be sent to the non-oily sewer after neutralization.

8.2.2 Caustic scrubs (heavy oils)

Caustic used to scrub gasoline, kerosene, and distillate oils may contain naphthenic acids, phenols, and cresols in addition to spent caustic. These drains shall be segregated from the non-oily and chemical sewer systems and shall be neutralized before entering the oily water sewer.

8.2.3 Desalter waste water

Desalter waste water effluent shall be piped in a pressure line to the dedicated desalter oil-water separator in Waste Water Treatment Area. It shall also have possibility to be routed to the main API separator influent under controlled conditions. Effluent water of the desalter water oil-water separator can be directed into the main API separator effluent water pond if the pollutable materials do not exceed allowable figures.

8.2.4 Foul or sour waters

In petroleum refining, various processing operations produce waste water solutions; principally, they are condensates containing sulfides-generally as hydrogen sulfide-ammonia, mercaptans, phenolics, and possibly, small amounts of water-soluble organic acids, nitrogen bases, and cyanides. These waste waters generally are referred to as "foul waters" or "sour waters". The principal sources of foul waters are condensates from accumulators, reflux drums and knockout pots in catalytic reformers, cracking, hydrocracking, coking, and crude distillation Units.

Foul waters generally are neither highly alkaline nor highly acidic. Their content of pollutants is relatively low compared to that of spent caustics. However, the high oxygen demand and the odorous or toxic nature of foul waters make it desirable to treat them for the reduction of these objectionable characteristics before they undergo biological treatment or are discharged into the waste water system. Foul waters shall be stripped in the sour water stripper(s), where removal of a single/multiple contaminants is desirable. The final scheme of the foul waters treating shall be approved by the "Company".

Stripped water from sour water stripper Unit shall be piped in an underground pressure line into the main oily sewer system terminating in the waste water treating plant. The stripped water should also have disposal access to the desalter water as make-up and evaporation pond(s)/public water in case of being in congruent with the local regulations. Characteristics of the stripped water which is normally instructed by the "Company" should be properly controlled such that disposal of this water does not impede any operation/environmental pollutions in the upset conditions. The waste gases from the stripping operations shall be routed to the sulphur recovery Unit and/or incinerated.

8.2.5 Spent caustic solutions

8.2.5.1 Sources and characteristics

Typically, uses of caustic solutions are to neutralize and extract:

a) Acidic materials that may occur naturally in crude oil and in any of its fractions.
b) Acidic reaction products that may be produced by various chemical treating processes.
c) Acidic materials formed during thermal and catalytic cracking such as hydrogen sulfide, phenolics, and organic acids.

Spent caustic solutions may therefore contain sulfides, mercaptides, sulfates, sulfonates, phenolates, naphthenates, and other similar organic and inorganic compounds.

8.2.5.2 Disposal methods

An adequate handling system to be provided for effective disposal of the spent caustic. The system shall include tankage and pipelines to segregate, accumulate, and transfer the spent caustic solutions to the disposal site. The following disposal methods to be taken into consideration in each plant. The final scheme will be instructed by the "Company".

- Direct disposal methods.
- Chemical methods.
- Chemical-physical methods.
- Biological methods.

The soundness of these methods must be determined by the individual refiner, paying due regard to applicable laws and regulations. Reference should also be made to IPS-E-PR-491, "Process Requirements of Refinery Non-Licensed Units".

8.2.5.2.1 Direct disposal methods

8.2.5.2.1.1 Dilution

Controlled disposal of spent caustic solutions into large bodies of water, particularly brackish or salt water, or into rivers capable of adequate dilution may be considered if under any circumstances the maximum concentration of sulfates (as SO_4) does not exceed the value set by Environmental Regulations. Disposal into fresh water lakes and streams must be given more critical consideration, particularly if the waters are used as a source of potable water supplies or for recreation purposes.

8.2.5.2.1.2 Disposal ponds

Disposal of spent caustic solutions by means of ponds to be avoided unless otherwise specified for disposal of small quantities of caustic waste. The following factors are to be considered to prevent subsequent air or water pollution in case of disposal ponds are concerned:

a) Location

Odor nuisances within the vicinity will affect site selection. Furthermore, geologic formations at the site must be such that contamination of potable water supplies by seepage will not occur.

b) Capacity

To prevent pollution of surface water, the pond must have sufficient capacity to hold the maximum amounts of rainfall, as well as the maximum amounts of waste chemicals to be received and stored. Adequacy of size depends not only on the volume of spent waste to be handled, but also on the anticipated evaporation, seepage, and annual rainfall.

c) Equipment

Pressurized pipelines shall be provided to transfer the spent caustic solutions from the process Units or the central collection system to the pond. Disposal of any spent caustic stream contaminated with oil to the pond to be avoided. If the spent solutions carry entrained oil to the pond, necessary equipment for oil removal are required for purposes of safety, as well as prevention of pollution and loss of oil.

8.2.5.2.1.3 Disposal wells

Using of disposal wells for handling of spent caustic solutions is not permitted.

8.2.5.2.2 Chemical methods

The following methods for chemical treatment of spent caustic can be considered:

- Regeneration.
- Air oxidation.
- Neutralization.

8.2.5.2.2.1 Regeneration

Caustic used to extract mercaptans from hydrocarbon streams can be regenerated by:

a) Steam stripping the mercaptans from the solution followed by incineration or recovery of the mercaptans.

b) Oxidation of the mercaptans to disulfides which can be separated as an oil phase. Oxidation of mercaptans shall be accomplished by electrolysis or air blowing. The latter should be conducted under pressure, or with the use of oxidation catalysts, or both.

8.2.5.2.2.2 Air oxidation

Spent caustics that contain sulfides or sulfites can be pretreated by air oxidation to reduce their high oxygen demand before they are diluted or further processed by biological treatment.

8.2.5.2.2.3 Neutralization

Spent caustics containing hydrogen sulfide, phenolics, or naphthenates (acid oils) can be pretreated by acid or flue gas neutralization followed by separation and recovery or incineration of these constituents.

8.2.5.2.3 Chemical-physical methods

Stripping and extraction following neutralization operation can be used to treat spent caustic solutions. After neutralization, stripping removes residual hydrogen sulfide, mercaptans, and possibly some phenolic compounds. In the neutralization of spent caustics with flue gas, stripping of the volatile components from the solution occurs simultaneously with the neutralization.

8.2.5.2.4 Biological methods

Biological treatment following pretreatment can be applied, particularly in areas where the refinery/plant effluent is discharged into brackish or salt water. Due to high biochemical oxygen demand of spent caustic solutions, the solutions shall not be amenable to biological treatment unless highly diluted or pretreated by the chemical or physical methods described previously.

8.2.5.3 Caustic lines maintaining temperature

Maintaining temperature of the aboveground caustic lines shall be at least 22°C above their freezing points.

8.2.6 Leaded contaminated streams

8.2.6.1 Sources

Sources of the leaded contaminated streams will be mainly of the following areas already allocated for the finished gasoline production facilities:

- Finished gasoline tanks drainage.
- Finished gasoline transfer pumps area drainage.
- Finished gasoline loading area drainage.
- Tetra-ethyl lead (TEL) storage and injection facilities drainage.

8.2.6.2 Disposal

Disposal of all leaded contaminated streams shall be "TEL contaminated water pond" provided near the spillage area for further transferring to outside of the plant battery limit by truck for incineration or safe disposal. The pond shall be a covered concrete pit equipped with flame arrester and sample, inspection and pump-out connections.

8.2.7 Benzene contaminated streams

8.2.7.1 Sources

Drains of all hydrocarbons containing benzene more than allowed, such as straight run naphtha, platformate, etc. will be sources for such waste liquids. Drainage of all other hydrocarbon streams containing allowable amount of benzene component can be handled through ordinary waste water sewer systems in the plant. However, special attention should be made to the reduction of benzene content in the sources concerned to the maximum extent possible.

8.2.7.2 Disposal

Segregated drainage system terminating to dedicated covered pond shall be provided to handle all contaminated benzene drains. The recovered waste streams can be routed to the refinery slops tanks. Method of benzene removal from the wastes concerned, and maximum allowable benzene content in either drainage systems or waste water treatment plant effluent shall be instructed by "Company".

8.2.8 Amine drainage

A segregated closed drain system shall be provided to handle all drains relevant to the Amine lines and equipment particularly in the Amine Treating Units. The system shall consist of underground gravity piping flowing into a sump located in the Amine Treating Area. Contents of the sump shall be pumped to the Amine storage tank for Amine make-up purpose.

8.2.9 Furfural and MEK contaminated waste waters

8.2.9.1 Contaminated stream drains

Segregated underground closed systems to be provided for either Furfural or MEK drains. These systems shall consist of underground gravity piping flowing into the dedicated covered sumps located in the Furfural and MEK Units boundary for further recovery.

8.2.9.2 Area spillage

Water effluents including storm water and fire water from the Furfural Extraction Unit and the MEK dewaxing Unit which may be contaminated with Furfural and MEK, shall be routed to a dedicated API oil water separator through a segregated oily sewer system. Effluent water from API separator can be connected to the refinery/plant main API separator effluent under controlled conditions. The recovered oil may be routed to the plant fuel tanks for burning purpose and/or plant slops tanks. Disposal of such oils contaminated with MEK/Furfural to the slops tanks is not allowed if the catalysts of the relevant catalytic Units in the plant suffer from such materials.

8.2.10 Caustic dissolving unit wastes

8.2.10.1 Caustic drains

All caustic drains in the boundry shall be directed to a caustic sump through a closed underground gravity piping for further recovery.

8.2.10.2 Area spillage

All waste waters effluent including storm water and fire water from the caustic dissolving Unit shall be routed to the chemical sewer system.

8.2.11 Spent sulfuric acid products

8.2.11.1 Sources and characteristics

In general, sulfuric acid is used extensively both as a treating agent and as a catalyst. The principal sources of sulfuric acid sludges are from the treatment of lubricating oils, heating and diesel oils, and gasoline and naphthas. The principal sources of spent catalyst acids are alkylation and the manufacture of alcohol and similar products. The hydrocarbon content in spent acids and sludges varies from a few percent up to as much as 60 percent. The acidity in titratable sulfuric acid can vary from 20 to 90 percent.

8.2.11.2 Disposal methods

Disposal of the sludges or spent catalyst acid in the refinery or plant effluent stream is not permissible and should be avoided. The following disposal methods are listed only as reference applicable methods allowed by the principle. The final scheme shall be instructed by the "Company".

8.2.11.2.1 Thermal decomposition

Thermal decomposition is the most important method of recovering sulfuric acid from spent acids and sludges. Thermal decomposition consists of heating or burning the sludge in the presence of a reducing agent. The organic or carbonaceous material in the spent acid or sludges serves as the reducing agent.

8.2.11.2.2 Manufacture of ammonium sulfate

Fertilizer-grade Ammonium Sulfate is also made from spent sulfuric acid products. In these processes, acid recovered by a hydrolysis operation is reacted with Ammonia, and the resulting Ammonium Sulfate is crystallized from the water solution.

8.2.11.2.3 Burning

Some sludges are low in sulfur content and contain enough combustible material to make them utilizable as fuel, either alone or mixed with fuel oil. Due to air pollution problems, use of this method of disposal should be avoided.

8.2.11.2.4 Sale or reuse

In the case of spent caustic solutions, spent sulfuric acid catalysts and sludges may be sold or reused in other operations wherein the remaining acid quality can be utilized.

8.2.11.2.5 Offshore dumping into the ocean

This method is not permitted unless otherwise allowed by the Environmental Protection Regulations.

8.2.11.2.6 Burying or dumping on waste land

This method can be used only in rare cases and under permission of Local Authorities and/or Environmental Regulations. In this case the sludge must be either a solid or a semisolid, and special precautions must be taken to prevent underground drainage and pollution of surface waters.

8.2.12 Nitrogen bases components

Nitrogen bases materials such as pyridine and quinoline, may be produced in the thermal processing of high nitrogen content crudes or distillates. They may enter the refinery/plant effluent in wastes from acid treating operations or in waste waters from cracking operations. Due to the fact that nitrogen bases of high molecular mass are relatively insoluble in water at pH values above 4, therefore, neutralization and "springing" shall be applied to reduce gross amounts of these compounds. In such cases the streams rich in nitrogen base components shall be segregated and routed to the non-oily sewer system after neutralization.

8.2.13 Cyanides

Normally, cyanides are not found in refinery/petrochemical waste waters in significant concentrations. Small amounts may be found in accumulator condensate waters from catalytic cracking Units when processing high nitrogen containing oils. In such cases, when concentration of cyanides will affect biological treatment operation, the streams concerned should be segregated and treated to convert cyanides to less toxic thiocyanates or ammonia and sodium formate.

8.2.14 Aluminum chloride

8.2.14.1 Sources

Usually, sources are sludge from isomerization or treating processes in which aluminum chloride is the catalyst.

8.2.14.2 Disposals and treating

The sludge shall be neutralized quickly and disposed of as silt or by controlled discharge into the non-oily sewer if it does not include oil and to the oily sewer system in case of containing oily materials. The aqueous solution from hydrolyzed sludge can be utilized as a flocculating agent.

8.2.15 Polyelectrolyte

Although liquid or dry powder polyelectrolyte is not a hazardous material, but its buffered acidic action is, in some instances, irritating when in contact with the eyes, skin or mucous membranes. Normal precautions should be employed to prevent the spraying or splashing of liquid polyelectrolyte, particularly if the material is hot. Areas of special concern include the concentrated liquid polyelectrolyte receiving area hose connections, the transfer pumps, and associated valves and piping. All structures, equipment, valves and piping with surfaces exposed to the polyelectrolyte should be flushed with plant water prior to being handled. Disposal of all drains contaminated to polyelectrolyte shall be chemical sewer.

8.2.16 Ferric chloride

Ferric chloride is not toxic for inhalation at ambient temperature. At high temperature (over 70°C) hydrochloric acid exhalation can form with its irritant properties on skin, upper respiratory tract and lung tissue. Disposal of all contaminated waste drainages shall be chemical sewer system.

8.2.17 Phosphoric acid

The spent phosphoric acid catalyst wastes shall be neutralized by spreading it in pits filled with limestone, lime, oyster shells, or spent caustic waste. The waste land shall be well isolated because these catalysts are deliquescent, and absorbed water will leach the acid from the catalyst.

8.2.18 Hydrofluoric acid

Hydrofluoric acid tars and gaseous hydrogen fluoride are wastes from alkylation processes in which hydrofluoric acid is the catalyst. The tars and the gas shall be disposed by burning/scrubbing.

8.2.19 Other spent catalysts

Spent catalysts that contain high value metals such as nickel, cobalt, molybdenum, platinum, etc., shall be reprocessed to recover the metal by catalyst manufacturer or in recovery plants. Discarding of this type of spent catalyst to the environment should be avoided.

8.2.20 Chemical cleaning wastes

Spent chemicals from the cleaning of equipment may produce emulsions if discharged directly into the sewer systems. Therefore, spent cleaning solutions should be treated separately to remove iron and solids before being discharged to the waste water sewer systems. In general, such streams should be neutralized and directed to the evaporation pond through the non-oily sewer system.

8.2.21 Sulphur solidification and crushing facilities and loading systems drainage

The sewer system of this area shall collect water drainage (including storm water) and sends it to the non-oily sewer system by gravity. The water drainage from the sulphur solidification and crushing facilities and loading systems area shall be free of sulphur particles.

8.2.22 Water containing solids, emulsifying agents, etc.

Streams impairing gravity separation, such as streams containing solids, emulsifying agents and/or contaminants that tend to flocculate upon dilution, shall not be compiled with the continuously oil contaminated water. The streams concerned shall be treated and disposed separately in compliance with the Local Environmental Regulations.

8.2.23 Heavy viscous oils drainage

Drainage of any heavy viscous oil (e.g., asphalt) which may be congealed and make clogging along the sewer system should be avoided. Such streams should be routed to the dedicated pits near the sources.

8.2.24 Toxic metal contaminated streams

All drains contaminated with toxic metals such as Arsenic, Chromium, Mercury, Cadmium, Lead, Selenium, etc., which most likely are found in refinery/petrochemical plants waste water streams in a concentrations more than allowable shall be segregated. Method of treatment and disposal should be in accordance with the Environmental Regulations.

8.2.25 Solvent processes drainage

The local sewer system in a solvent process such as extractive distillation, liquid extraction, physical absorption, chemical absorption, and etc. should segregate and reuse if practical the unavoidable and inadvertent solvent losses from pump seals, flange leaks, etc., (see 8.2.8 and 8.2.9 above). The design of a solvent process plant should give very careful consideration to the possible effluent problems. Every effort should be made to limit/exclude the amount of the solvents entering the plant effluent system. It should also be abundantly clear that the aqueous effluents to be expected from the solvent processes may contain a very wide range of organic and inorganic chemical pollutants. Generally, solvents involved in the solvent processes are phenol, mixtures of phenol, glycols, amines, furfural, sulfolane, sulfur dioxide, sulfuric acid, ammoniacal copper acetate, acetonitrile, ketones, urea, and etc.

8.2.26 Treating processes drainage

These are a broad category of processes for upgrading various intermediate and final product streams. In many cases, the treating process involves the use of a solvent. All of the treating processes are potential sources of highly undesirable aqueous effluents which should be segregated and treated with the similar streams through the refinery/plant.

8.3 Petrochemical Plants Special Effluents

8.3.1 General

A careful check should be made of processes proposed or used for the manufacture of petrochemicals to decrease the possibility of water soluble organics entering water supplies. In general, in order to minimize the waste waters resulting of petrochemical processes, the following methods are to be taken into consideration:

a) Recycling and reuse of waste streams.

b) Quenching with oil or chemicals other than water, which do not produce waterborne wastes.

c) Use of alternative processes that do not produce waterborne wastes.

d) Use of air coolers or of cooling towers in place of once-through cooling water.

e) Elimination of waste products in the manufacturing operation before they become associated with waste streams.

f) Processing of waste streams to reduce the amount of chemicals in waste waters leaving the plant.

In design of petrochemical plant processing Units, special attention should be made for the following design notes:

a) Extensive use of instruments, alarms, and checks by the operators shall be provided to prevent loss of chemicals.

b) Adequate facilities shall be installed to prevent uncontrolled release of chemicals and wastes to sewers or receiving waters.

c) A large storage capable of holding several days production of waste water shall be provided to allow the water to be checked before being released to final destination.

8.3.2 Summary of disposal/treatment methods

The disposal/treatment methods applied to the reduction/removal of the various compounds that may be found in the petrochemical operations shall be selected based on the following factors:

a) Plant production and/or type of pollutants.
b) Final destination of the waste water effluent.
c) The processes ordinarily used for waste disposal.
d) Economical aspects.
e) Environmental Pollution Regulations.

8.3.2.1 Treatment

The following methods can be evaluated for waste water recovery in the petrochemical plants and refineries. The final scheme shall be approved by "Company".

8.3.2.1.1 Physical treatment methods

8.3.2.1.1.1 Gravity separation

Gravity separation is the usual method of physical treatment for separation of oil-water. It has limitations that may make it necessary to resort to other methods.

8.3.2.1.1.2 Stripping

Steam or flue gas stripping, by which phenolics, mercaptans, hydrogen sulfide, and other compounds can be removed is the widely used as disposal method for petrochemical wastes. Waste gases from stripping shall be burned to prevent air pollution.

8.3.2.1.1.3 Adsorption and extraction

Many compounds can be removed from water either by adsorption or by extraction such as extraction applied for removal of phenolics by using isopropyl ether or other suitable solvents.

8.3.2.1.1.4 Other physical methods

Other processes of physical methods which can be evaluated are:

- Sedimentation.
- Filtration.
- Flotation.
- Evaporation.

8.3.2.1.2 Chemical treatment methods

8.3.2.1.2.1 pH adjustment

8.3.2.1.2.2 Coagulation and chemical precipitation

Where emulsions cause difficulty, the addition of a flocculating agent may permit these emulsions to be treated successful by filtration or sedimentation.

8.3.2.1.2.3 Chemical oxidation

For certain specific wastes,chemical oxidation method may be applied.

8.3.2.1.3 Biological treatment processes

8.3.2.1.3.1 Activated sludge process

Activated sludge process is the most popular treatment for the the complicated petrochemical and refinery wastes.

8.3.2.1.3.2 Biological filters and oxidation towers

Under some conditions, processing of petrochemical wastes through biological filters or biological oxidation towers can be applied.

8.3.2.2 Ultimate disposal

8.3.2.2.1 Controlled dilution

This method can be used only on materials that are relatively small in quantity and nontoxic, and then only under certain special conditions. A large volume of dilution water in the receiving stream is usually necessary. This method, as with others, must have adequate controls to ensure that the aquatic life and the quality of the receiving waters are not being harmed. In some cases, improved dilution control is obtained by releasing the effluent to the stream through diffusers or jets to obtain better dispersion in the body of the stream.

8.3.2.2.2 Incineration

This method can be applied only where wastes cannot be successfully disposed of by other methods. In such cases, special incinerator designs shall be carried out to handle the various types of wastes that may be encountered with careful consideration to the resulting air pollution problems. Some of the more important variables to be considered in the design and operation of incinerators are time, temperature, percent of excess air, turbulence, and heat release per unit volume of combustion chamber. When disposal by incineration is contemplated, composition of the wastes must be considered insofar as it might cause the emission of irritating or odorous gases, chlorine and fluorine, visible plumes, or particulate matter.

8.3.2.2.3 Salvage

Careful consideration should be given to disposal by salvage, particularly if the waste products are not too dilute. Segregated sewer systems frequently shall be used to recover losses with a minimum of dilution, permitting reuse of the material in the manufacturing process.

8.3.2.2.4 Deep well injection

The disposal of waste streams from petrochemical plants into underground strata, which do not contain potable water, may be applied only under certain conditions and if allowed by the Local Authorities. Very careful pretreatment or control, or both, of the materials introduced into the strata is necessary to prevent precipitaion that would halt the continuation of the injection. It is also important that the disposal well does not contaminate fresh water sources.

8.3.2.2.5 Other disposal methods

Application of any other disposal method such as disposal at sea, disposal on waste land surfaces, dumping or burial, and spray irrigation is not allowed unless permitted by the "Company" and Environmental Regulations.

8.4 NGL, LNG and LPG Areas Effluents

Two specific situations shall be considered for effluents from NGL, LNG and LPG production, handling and storage areas:

a) A liquefied gas spill.

b) A fire situation.

8.4.1 Liquefied gas spill

Accidentally spilled liquefied gas shall be drained away as quickly as possible from the equipment to a safe distance where it shall be allowed to evaporate in a collecting pit. For properly supervised areas a maximum spill of 25 m^3 shall be assumed. It is assumed that approximately 15 m^3 will evaporate (under dry weather conditions), leaving a balance of minimum 10 m^3 which shall be caught in a collecting pit/liquid gas trap. Spilled liquefied gas and water shall be separated as much as possible and the liquefied gas shall never be allowed to enter any underground flooded drainage system to avoid blocking due to freezing. It is assumed that only one spill or one fire at the time will occur.

8.4.2 Fire situation

For fire situation reference to be made to Article 9.4.1.3.6 below. Effluent during normal operation from the NGL, LNG and LPG areas is routed to the storm water sewer system. To prevent liquid gas entering the underground flooded drainage system, a seal shall be constructed to prevent direct contact of the effluent within the underground system.

8.5 Gas Treatment Facilities Effluents

In view of the low risk of encountering heavy pollution (except during line cleaning) the drainage system in a gas treatment plant can be routed to the storm water sewer system. For line cleaning, the polluted effluent shall be discharged into a neutralization pond. The effluent from the neutralization pond shall be tested to justify discharge via the non-oily water sewer system for further treatment. Direct discharge from line cleaning into the drainage system is not allowed.

8.6 Effluents from Terminals, Depots and Product Handling Areas

Effluents from terminals, depots and product handling areas shall be in line with the requirements as described under Section 8 of this Standard. Due to the economical considerations drainage of terminals, depots and product handling areas can be integrated with the same type drainage of the refinery or petrochemical plants installed adjacent to the areas concerned. Special attention shall be made to the geographical location and elevations of the areas.

8.7 Marketing Wastes

An extensive network of pipelines, terminals, truck fleets, marine tankers and storage and loading equipment must be used to deliver the finished petroleum product to the user. In the marketing and transportation phase of the industry, waste-water containing oil may be discharged during the cleaning of ballast tanks of ships, tank trucks and tank cars. Leaky valves and connections and flushing of pipelines are other sources of effluents. The methods used for treatment and disposal of these waters are similar to those used in the other phases of the industry. The following Table 1 lists practical methods of minimizing the emissions from the petroleum marketing equipment/facilities:

TABLE 1 - SOURCES AND CONTROL OF HYDROCARBON LOSSES FROM PETROLEUM MARKETING

SOURCE	CONTROL METHOD
- STORAGE VESSELS	FLOATING ROOF TANKS; VAPOR RECOVERY; VAPOR DISPOSAL; VAPOR BALANCE; PRESSURE TANKS; PAINTING TANKS WHITE
- BULK LOADING FACILITIES	VAPOR COLLECTION WITH RECOVERY OR INCINERATION; SUBMERGED LOADING, BOTTOM LOADING
- SERVICE STATION DELIVERY	VAPOR RETURN; VAPOR INCINERATION
- AUTOMOTIVE FUELING	VAPOR RETURN
- PUMPS	MECHANICAL SEALS; PROPER MAINTENANCE
- SEPARATORS	COVERS; USE OF FIXED ROOF TANKS
- SPILLS, LEAKS	MAINTENANCE; PROPER HOUSEKEEPING

9. SEWER SYSTEMS DESIGN CONSIDERATIONS

9.1 Flow Rate Reduction and In-Plant Waste Elimination or Abatement

Consideration should be given to the control and progressive replacement of products, installations and industrial or other processes causing significant pollution. In this regard, particular attention shall be given, but not limited, to the following factors:

a) Curtailment and/or regulation of import transportation, manufacturing or processing of certain harmful substances;

b) change of raw materials;

c) change of manufacturing processes;

d) good operating and housekeeping practices;

e) segregation of waste streams and minimization of pollutant dilution prior to treatment;

f) implementation of source control in the process Units;

g) recovery, reuse and recycling.

9.2 Collection and Disposition

The contaminant concentrations of waste water streams are subject to wide variations from changes in Unit operations and feed characteristics. One must consider these variations when specifying contaminant removal facilities. The chemical sewer and oily water sewer streams shall be sent separately to the destinations outlined in Section 7 of this Standard for initial treatment.

Water discharged from the clean water sewer should meet anticipated local discharge requirements at the time of start-up. This sewer system may contain a high oil concentration, from a leaking process cooler. Therefore, a positive means of detecting a process cooler leak into the clean water sewer, such as a clean water pond before discharge, should be provided. Furthermore, some means of temporarily diverting clean sewer water to the main oily water treatment system must be provided to handle these high oil contents.

In the case of once-through cooling water systems, high cooling water flow rates may make it impractical to divert and treat the entire clean water sewer system. Consideration should be given to providing the ability for diverting the effluent to a retention pond and skimming prior to reduced rate discharge to the treatment system. In some instances it may be practical to use the rain water retention pond as temporary hold-up for contaminated effluent (see Appendix F, Fig. F.1 for segregated sewer systems).

9.3 Basis of Design

9.3.1 For design of sewer systems, reference should also be made to IPS-E-PI-240, "Plant Piping Systems".

9.3.2 The drainage systems, collection points and treatment facilities (to the maximum extent possible) shall be based on the gravity flows.

9.3.3 In line with the upgraded safety and pollution requirements, sufficient allowance within the drainage design for proper segregation of the various effluents and ample space (access) for maintenance and effective housekeeping shall be made.

9.3.4 The effluent entering any of the drain systems shall not give a resultant temperature higher than 45°C. If a higher temperature cannot be avoided,suitable design and materials to be used and to be discussed with the "Company".

9.3.5 To prevent the purification of the effluent water from becoming more difficult than is necessary, polluted streams shall not be combined with unpolluted streams if the resultant stream would then require purification. For the same reason, dispersion of oil in water by excessive turbulence should be avoided, so that the use of pumps and weirs is not allowed in oil-polluted streams unless approved by the "Company".

9.3.6 A curb with drain to chemical sewer should be provided around all equipment and facilities containing chemicals.

9.3.7 Sewer lines shall be sized as flowing full with a 25% excess allowance for future sewage requirements in the design capacity.

9.3.8 Headers and mains shall be buried below the frost line, unless protected from freezing by a sufficiently large continuous stream of warm water or other suitable means. Sewers subject to wheel loads shall require additional protection from frost.

9.4 Basis for Line Sizing

9.4.1 Design flow rate

9.4.1.1 For design and configuration of the sewer lines in each drainage area, see also IPS-E-PI-240, "Plant Piping Systems".

9.4.1.2 Design flow rate shall be based on the most severe of the following combinations of normal continuous process flows plus:

- Storm run-off,	at	70%	depth.
- Firewater run-off,	at	100%	depth.
- Largest single process intermittent flow,	at	100%	depth.

9.4.1.3 Loading on drainage systems

9.4.1.3.1 General

The loading on a drainage system consist mainly of:

- process water, (Q_p) (including tank bottom drainage) (see 9.4.1.3.4 below);
- rain water, (Q_r) (see 9.4.1.3.5 below);
- fire fighting water, (Q_f), (see 9.4.1.3.6 below), for NGL, LNG and LPG areas see also Article 8.4 above.

Whereby consideration shall be given to:

a) Safety and pollution requirements;
b) lifetime of the plant;
c) future developments;
d) acceptable surcharging for a short period.

9.4.1.3.2 Industrial sewers within process unit areas

The plant drainage system within process Unit areas shall be designed for the maximum discharge from either one of the following two loading combinations:

a) $Q_p + Q_r$;
b) $Q_p + Q_f$.

9.4.1.3.3 Industrial sewers outside process unit areas

9.4.1.3.3.1 Laterals and sublaterals

Laterals and sublaterals serving equipment and facilities (such as loading stations, pumphouses, etc.) outside process Unit areas shall be designed as follows:

a) The sewer design flow shall be for storm water or fire water, whichever is greater.

b) Fire water quantities shall be included to the following extent:

1) Sublaterals: 110 m^3/h from each catch basin.

2) Laterals: Cumulative flow from the catch basins served but not less than 276 m^3/h.

9.4.1.3.3.2 Industrial sewer mains

Industrial sewer mains receiving the combined flow from tank areas, process Units, street drains, etc. shall be sized for the larger of the following:

a) Total process waste water plus estimated storm run-off (both of which shall be cumulative throughout the system); or

b) total process waste water, plus a single allowance for fire water.

The fire water allowance shall be the largest single quantity of fire water discharging into the main from any facility or process Unit but not less than 572 m^3/h. The loads in "a" and "b" above shall not include chemical sewer loads until after any neutralization. In addition, chemical sewer loads shall not be included if separate waste treatment is required.

9.4.1.3.3.3 Industrial sewers from tankage areas to open ditches:

a) Water in unlined ditches shall have a maximum velocity of 0.6 m/s. In lined ditches the water velocity is unlimited.

b) Ditches from offsite areas shall carry the total estimated storm run-off from roads and open areas or 276 m^3/h whichever is greater. The estimated storm run-off shall exclude the deferred run-off from the area within the tankage dike.

c) Deferred run-off from individual tank areas to the ditches shall be based on the following requirements to provide for both fire water and storm water flow for each tank:

SIZE OF TANK DIAMETER IN meter, (m)	FLOW REQUIREMENTS IN (m^3/h)
≤ 12	110
> 12 TO 20	204
> 20	276

Specific requirements: Nominal pipe size shall not be less than 200 mm (8 inch).

Rainfall frequency and intensity shall be considered in establishing deferred run-off rates from combustible fluid stock tankage areas (if enclosed in a single peripheral dike). Final run-off ratio shall be approved by the "Company".

9.4.1.3.4 Process water

The quantities of process water (Q_P) are normally determined based on the operational experiences and/or available design manuals/specifications. In areas where tank bottom drainage joins an oily water sewer or runs direct to a treatment facility, the following minimum quantities shall be used unless otherwise specified by the "Company".

1) 100 m^3/h for a crude tank.

2) 50 m^3/h for a product tank.

9.4.1.3.5 Rain water

The quantity of rain water depends on a number of factors such as geographical location, intensity, duration, run-off factors, etc. Rainfall data are mostly available in the form of rainfall intensity-duration-frequency curves. These curves define the average rainfall intensity of individual rains of a specific duration and recurrence. The intensity curves form the basis for the rain water drainage design. The rational method provides an acceptable basis for estimating the rain water run-off. The following rational formula shall be used:

$$Q_r = C.\ I.\ A \qquad \textbf{(Eq. 1)}$$

Where:

- Q_r is quantity of rain water run-off, in (m^3/h);
- C is run-off coefficient;
- I is design rainfall intensity based on the time of concentration (T_c), in (m/h), [I = 0.245/(Tc + 23)];
- A is catchment area (or sub catchment area), in (m^2).

Values of the C factors are shown in Appendix A and an example of a rainfall intensity-duration-frequency curve is shown in Appendix B. The time of concentration (T_c) consists of entry time (T_e) plus the time of flow (T_f) in the drainage system from the most remote inlet to the outflow point of the (sub) catchment area under consideration as follows:

$$T_c = T_e + T_f \qquad \textbf{(Eq. 2)}$$

Where:

- T_c is time of concentration;
- T_e is time of entry (time required for overland run-off to gain entrance to a drain or sump);
- T_f is time of flow in the system to be considered the sum of the quotients of the length of constituent drains and their velocity when flowing full.

Time of entry (T_e) varies from 5 to 30 min. depending on the slope of the catchment areas, surface roughness, percolation, etc. However, for refineries a T_e of 5 min. is mostly applicable. A recurrence period of 2 (two) years shall be used when selecting the rainfall intensity. Time of concentration for any cross section of a gravity sewer line shall be evaluated as follows:

$$T_C = T_O + \frac{L_r}{60¢\ V_r} + \frac{L_s}{60¢\ V_s} \qquad \textbf{(Eq. 3)}$$

Where:

- T_o is 12 minutes = minimum concentration time required to actually start water run-off;
- L_r is length of water path from the most remote corner of drainage area to relevant drain or catch-basin, in (m);
- V_r is run-off velocity depending upon roughness of drainage area:

roofs and paved areas	V_r	**= 0.25 (m/s)**
gravel areas		**0.15**
soil		**0.05**

- L_s is length of sewer line from drain or catch-basin to examined cross section, in (m);
- V_s is flow velocity in sewer line to be evaluated according to Manning's formula (see Appendix D), in (m/s).

Storm water capacity requirements shall be based on the cumulative throughout the system. Storm water run-offs shall be based on 100% for paved areas and 50% for unpaved areas. Unpaved areas designated as "future paving" shall be considered paved for sizing mains.

9.4.1.3.6 Fire fighting water

9.4.1.3.6.1 General

The calculation of the quantity of fire-fighting water to be discharged through the drainage system shall be based on the assumption that there will be one major fire in process area and one major fire in the off-site area simultaneously.

It should be realized that this is a minimum requirement and that fire-fighting water quantity is dependent on factors such as nature and physical condition of flammable products present, equipment installed, plant lay-out, etc. It is therefore impossible to give a fixed fire-fighting water requirement applicable to all cases, and therefore the value quoted below should be considered as indicative only and the final figures shall be approved by the "Company". There is no restriction for the velocity within the drainage system under fire-fighting conditions and both storm water and oily water systems can be used to discharge the fire-fighting water run-off.

Controlled flooding (surcharging) under the most extreme conditions is allowed for a short period. However, special precautions are required to prevent fire spreading in case of a fire. Note that the discharge capacity of the underground drain line is directly related to the maximum level of flooding (hydrostatic head). No flooding is allowed for areas around control rooms, switch houses and furnaces. Distribution of the fire water to catch basins and dry boxes shall be assumed minimum as follows:

Water flow rates of the fixed water monitors or sprinkler systems if provided around the equipment (e.g., vessels, tanks, etc.) should also be taken into consideration in addition to the following quantities. Special attention shall also be given to the requirements stipulated in IPS-E-SF-220 , "Fire Water Distribution and Storage Facilities".

- **a)** 110 m^3/h to each of the first and the second box in each main system.
- **b)** 55 m^3/h to the third and each subsequent box in each main system.
- **c)** 55 m^3/h to a single box joined by a lateral to a box in any main system.
- **d)** Total quantity of fire water shall not exceed the following requirements:
  - **1)** 817 m^3/h after 2 main systems are joined.
  - **2)** 572 m^3/h for individual main systems of 6 or more boxes.
  - **3)** 204 m^3/h from any separately high pointed heater or vessel area.

9.4.1.3.6.2 Process and utility areas

For process and utility areas, the minimum water quantity is 817 m^3/h applied over an area of $60 \times 40\ m^2$. It is assumed that approx. 30% will evaporate, leaving a balance of 572 m^3/h to be discharged into the drainage system equally distributed over the sumps (drain channels) within the $60 \times 40\ m^2$ area under consideration and starting at the upstream section of the relevant (sub)-catchment area (see Appendix C).

The cooling water from vessels within the area under consideration protected by automatic sprinklers shall also be taken into account.

Note:

In areas where flooding under the most extreme conditions is considered acceptable (see 9.4.1.3.6.1), an increase in fire-fighting water will result in excessive unacceptable flooding. The recommended maximum flooding level is 50 mm above the top of the sump.

9.4.1.3.6.3 Tank farms

Where automatic sprinklers are installed, the discharge capacity of the system shall be used as basis. The cooling/fire-fighting water inside the tank pit shall be discharged through a valve controlled outlet.

The underground drain pipe and outlet valve shall be designed for a discharge capacity such that the water level inside the tank pit will not exceed the height of 0.3 m above the lowest tank pad. A practical valve size is 300 mm. If the design requires a larger outlet, additional valves should be installed. The drainage of one tank pit via another tank pit is not allowed.

9.4.1.3.6.4 Off-plot areas

For all areas other than the process/utility areas and tank farms fire-fighting water shall be considered in relation to the available fire hydrants around the area under consideration. A minimum of 8 (eight) hoses shall be considered when calculating the fire-fighting water quantity. The average amount of water supply per hose is 60 m^3/h.

9.4.1.3.6.5 NGL, LNG and LPG areas

Fire fighting/cooling water quantities within NGL, LNG and LPG production, handling and storage areas shall be according to the following requirements:

- In the event of a fire, a maximum of 1000 m^3/h fire fighting water shall be supplied either at one specific place or over a spread area. The net run-off for the fire fighting water is 750 m^3/h, as 250 m^3/h is assumed to be blown away and evaporated.

- At the same time cooling water with a maximum of 1000 m^3/h may be used within the adjacent sub-catchment areas (modules). The total maximum run-off per sub-catchment area (module) shall be taken as 1000 m^3/h and the total max. run-off per drain line for the sub-catchment areas (modules) shall be taken as 1750 m^3/h.

- The total amount of fire-fighting water can be supplied at one specific place and as such the drainage system capacity is always governed by the total amount of fire fighting water.

9.4.2 Velocities

9.4.2.1 The sanitary drains are to be designed to attain a velocity of at least 0.8 m/s during periods of daily peak flow without surcharge.

9.4.2.2 The design velocity for the oily water drains should be 0.9 m/s when flowing half full, as emulsification occurs at higher rates and silting at lower rates. Lower velocities are acceptable in drains from storage tanks and also where silt is not expected.

9.4.2.3 All other piped drains should be designed to produce a velocity of at least 1.1 m/s whether flowing half full or full.

9.4.2.4 Where practicable, the velocity in open ditches is to be kept sufficiently low to prevent scouring of the bed and sides.

9.4.2.5 Minimum allowable velocity for lines flowing full shall be 0.6 m/s, this limit shall be increased to 0.9 m/s where water should carry solid particles, such as sand from unpaved areas.

9.4.2.6 Maximum velocity shall be 1.5 m/s except for short runs of approximately 5 meter or less. Any design for higher velocities shall be approved by the "Company". The maximum flow velocity is not applicable for deballasting systems to avoid uneconomical pipe sizes. However, care should be taken to keep the flow as uniform as possible, i.e., large radius bends, no tee junctions, etc.

9.4.3 Minimum pipe diameter

9.4.3.1 The minimum standard Diameter Nominal of branches shall be DN 100 (4 inch).

9.4.3.2 The minimum standard Diameter Nominal of mains shall be DN 150 (6 inch).

9.4.3.3 Reference should be made to IPS-E-PI-240, "Plant Piping Systems" for single equipment drain, catch basin outlet, etc.

9.4.4 Hydraulic design calculations

9.4.4.1 General

9.4.4.1.1 All piping, sewers and channels shall be designed in accordance with accepted standard formula, including sump influence and weir overflows and using a friction coefficient which takes into account the anticipated future condition of the system.

9.4.4.1.2 The methods presented in Appendix D herein may be used for gravity sewers. Either Chezy formula or Manning's formula as described in Appendix D can be used for design of gravity sewer lines in order to simplify the design method and presentation. The small discrepancies between the various design methods can be seen as part of the anticipated future condition of the drainage system and in line with the selection of assumed friction coefficients for new/existing pipes, sediment layer etc.

Moreover the design is based in general on the maximum flow ($Q_p + Q_r$) which might occur once in two years where a rain storm is considered, or ($Q_p + Q_f$) resulting from one major fire at any one time without a recurrence indication but a net estimated run-off minimum of 572 m^3/h. As the sumps of the drainage systems for oily and non-oily sewers can accumulate hydrocarbons, the liquid levels in the sumps, when calculated on the basis of water , shall be converted into levels corresponding to a density of 800 kg/m^3. For such a conversion, only the height of the liquid above the invert of the pipe shall be used. The converted levels shall remain at least 150 mm below the top of the sump under rain water conditions and during fire-fighting condition for areas around control rooms, switch houses and furnaces.

9.4.4.1.3 For nonstandard situations, where the following formulas can not be applied, clear reference shall be made to the formula and literature being used for each specific situation uppon approval of the "Company".

9.4.4.1.4 For design of surface water drainage (open ditches) and sanitary sewer systems, reference should be made to IPS-E-CE-380, "Sewerage and Surface Water Drainage System". However, reference should also be given to the following ISO Standards for complete description of the methods used in open channels.

- ISO 748, "Liquid Flow Measurement in Open Channels by Velocity Area Methods"
- ISO 772, "Liquid Flow Measurement in Open Channels-Vocabulary and Symbols"
- ISO 1100, "Liquid Flow Measurement in Open Channels-Establishment and Operation of a Gaging-Station and Determination of the Stage-Discharge Relation"
- ISO 1070, "Slope Area Method"
- ISO 3847, "By Weirs and Flumes"

10. GENERAL CONSIDERATIONS AND CONDITIONS FOR RELEASE OF WASTES

With a view to guidelines, standards or criteria, as well as to regulations, programmes, measures and discharge permits for release of refinery/plant wastes, particular attention shall be given to the following factors:

10.1 Regional guidelines, standards or criteria, as appropriate, for the quality of waste water used for specific purposes that is necessary for the protection of human health, living resources and ecosystems.

10.2 Regional regulations for the waste discharge and/or degree of treatment for all significant types of sources.

10.3 Stricter local regulations for waste discharge and/or degree of treatment for specific sources based on local pollution problems and desirable water usage considerations.

10.4 Polluters shall be required to obtain a permit to discharge from the competent Local Authorities (if needed). Such permits shall allow for review and modification of discharge conditions reflecting the periodic update of regulations.

10.5 Characteristics and Composition of Waste

The following requirements should be considered:

a) Type and size of waste source, e.g., industrial process.
b) Type of waste (origin, average composition).
c) Form of waste (solid, liquid, sludge, slurry).
d) Total amount (volume discharged, e.g., per year).
e) Discharge pattern (continuous, intermittent, seasonally variable, etc.).
f) Concentrations with respect to major constituents.
g) Properties:

- Physical, e.g., solubility and density.
- Chemical and biochemical, e.g., oxygen demand, nutrients.
- Biological, e.g., presence of viruses, bacteria, yeast, parasites.

h) Toxicity
i) Persistence:

- Physical, chemical and biological.

j) Accumulation and biotransformation in biological materials or sediments.
k) Probability of producing taints or other changes reducing marketability of resources, e.g., fish, shellfish, etc.
l) Susceptibility to physical, chemical and biochemical changes and interaction in the aquatic environment with other dissolved organic and inorganic materials.

10.6 Characteristics of Discharge Site and Receiving Environment

The following requirements should be considered:

a) Hydrographic, meteorological, geological, biological and topographical characteristics of the discharge site.

b) Location and type of discharge (outfall, canal, outlet, etc.) and its relation to other areas, e.g., agricultural areas, spawning, nursery and fishing areas.

c) Rate of disposal per specific period, e.g., quantity per day, per week and per month.

d) Initial dilution achieved at the point of discharge into the receiving marine environment if any.

e) Methods of packaging and containment, if any.

f) Dispersion characteristics such as effects of currents, tides and wind on horizontal transport and vertical mixing (in case of disposal to sea or lake).

g) Water characteristics (in case of discharge to sea/river), e.g., temperature, pH, salinity, stratification, oxygen indices of pollution dissolved oxygen (DO), chemical oxygen demand (COD), biochemical oxygen demand (BOD) - nitrogen present in organic and mineral form including ammonia, suspended matter, other nutrients and productivity.

h) Existence and effects of other discharges which have been made in the discharge site, e.g., heavy metal background levels and organic carbon content.

10.7 Availability of Waste Technologies

The methods of waste reduction and discharge for industrial effluents as well as domestic sewage should be selected taking into account the availability and feasibility of:

a) Alternative treatment processes.
b) Re-use or elimination methods.

c) On-land disposal alternative.
d) Appropriate low-waste technologies.

10.8 General Considerations

Due considerations to be given to the followings:

a) Possible effects on amenities, e.g., presence of floating or stranded materials, turbidity, objectionable odor, discoloration and foaming.

b) Effects on human health through pollution impact on:

Edible marine organisms; bathing waters; aesthetics, etc.

c) Effects on marine ecosystems, in particular living resources, endangered species and critical habitats.

d) Possible effects on other uses of the water (in case of discharging to sea/river), e.g., impairment of water quality for industrial use, underwater corrosion of structure, interference with ship operations from floating materials, interference with fishing or navigation through deposit of waste or solid objects on the sea floor and protection of areas of special importance for scientific or conservations purposes.

11. EFFLUENT WASTE WATER CHARACTERISTICS

11.1 General

The quantities and characteristics of the waste water differ considerably for different processes. In general, the major sources of waste contribution in a petroleum refinery, are storage tank drain-offs, crude desalting and distillation, and the thermal and catalytic cracking processes, followed by the solvent refining, dewaxing, and drying and sweetening. Appendix E presents a semigraphic table with major waste contributing fundamental processes shown with 3x's, moderate contributors with 2x's , and minor contributors with only 1x. The table is based on grams per day of contaminates from each fundamental process in a typical refinery, with throughput of each fundamental process taken into consideration.

11.2 Flow

Based on total water usage, crude and vacuum distillation Units are the largest water users mainly because of the large volumes required by the barometric condensers, desalters and vacuum ejectors. Catalytic cracking and drying and sweetening are the next largest water users. The extent of water use is significantly affected by the technology level of the processes employed.

11.3 Temperature

Crude desalting, especially the electrostatic process, contributes substantial thermal waste loads, as do distillation and cracking. The increased use of cooling towers has played an important role in the reduction in quantities of water discharged and not necessarily by reduction in effluent temperature. Effluent heat loads can have significant adverse effects on the receiving waters since the increased temperature causes decreased oxygen solubility and greater oxygen utilization, both of which reduce the ability of the stream to handle waste loads.

11.4 pH

pH indicates the hydrogen ion concentration of a waste water. However, the extreme values often observed do not truly reflect the buffering capacity of a waste or its ultimate effect upon a receiving water course. Most refinery waste waters are alkaline, with the cracking (both thermal and catalytic) and crude desalting processes as the principal problem sources; some solvent refining processes also contribute substantial alkalinity. Power house boiler treatment produces alkaline waste waters and sludges. Hydrotreating also contributes definite alkaline wastes.

Alkylation and polymerization utilize acid processes and have severe acidity problems. In general, petroleum refinery effluents have pH variations, but this is not a major problem from the standpoint of effluent standards. Where pH range is outside the normal limits, equalization of caustic wastes (and sometimes acid wastes) before bleeding into the sewer system is usually sufficient to maintain pH control. In general, large volumes of cooling and wash waters dilute out strong acid or caustic discharges; thus, pH may become a more significant problem as cooling water volumes decrease.

pH control is also important in regard to the waste water treatment operation. Very low or very high pH can cause worsen emulsification of oils already in the sewer. The pH of the waste water influent to biological treatment processes is an important consideration for effective treatment.

11.5 Oxygen Demand

The measurement of the biological and/or chemical oxygen demand of an effluent will exert on the oxygen resources of a stream. COD (chemical oxygen demand) and BOD (biochemical oxygen demand) are standard analysis used in this evaluation.

Waste waters from petroleum refineries or petrochemical plants exert a major, and sometimes severe, oxygen demand. The primary sources are soluble hydrocarbons and sulfides. The combination of small leaks and inadvertent losses that occur almost continuously throughout a complex can become principal pollution sources.

Crude and product storage and the product finishing operations are the major contributors of COD and BOD, mainly because of the many tanks and vessels used, and the number of times a barrel of oil or product is handled in these operations. The waste water discharges from these operations are intermittent. The cracking and solvent refining processes are the major BOD contributors on a continuous basis.

11.6 Phenol Content

Catalytic cracking, crude oil fractionation, and product treating are the major sources of phenolic compounds. Catalytic cracking produces phenols by the decomposition of multicyclic aromatics, such as anthracene and phenanthrene. Some solvent refining processes use phenol as a solvent, and although it is salvaged by recovery processes, losses are inevitable. Phenols, particularly when chlorinated, cause taste and odor problems in drinking water.

11.7 Sulfide Content

Sulfide waste streams generally originate from the crude desalting, crude distillation, and cracking processes. Sulfide herein discussed are considered to include mercapatns also. Sulfides interfere with subsequent refinery operations and are removed by caustic or diethanolamine scrubbing or appear as sour condensate waters. Hydrotreating processes which are used to remove sulfides from the feeds or products naturally produce a rich sulfide waste stream; however, most of the sulfide is removed as H_2S and is usually recovered or burned.

11.8 Oil Content

This is a major pollutant characterized of the refinery/plant waste waters. As free oil, it produces oil slicks and iridescence and coats boats and shorelines if permitted to discharge to the receiving stream. Oil coated solids are particularly troublesome since they are usually of neutral relative density (specific gravity), and are not readily removed by conventional gravity separation techniques. Oil or oil coated solids in the receiving stream also may have a serious detrimental effect on the aquatic life.

Oil has limited solubility in water and therefore would be expected to contribute little to effluent BOD or COD. However, crude petroleum and its refined products contain a wide range of soluble hydrocarbons which can ultimately find their way into waste streams through product washes, etc. These product wash streams contribute to effluent BOD and COD.

APPENDICES

APPENDIX A
RUN-OFF COEFFICIENTS

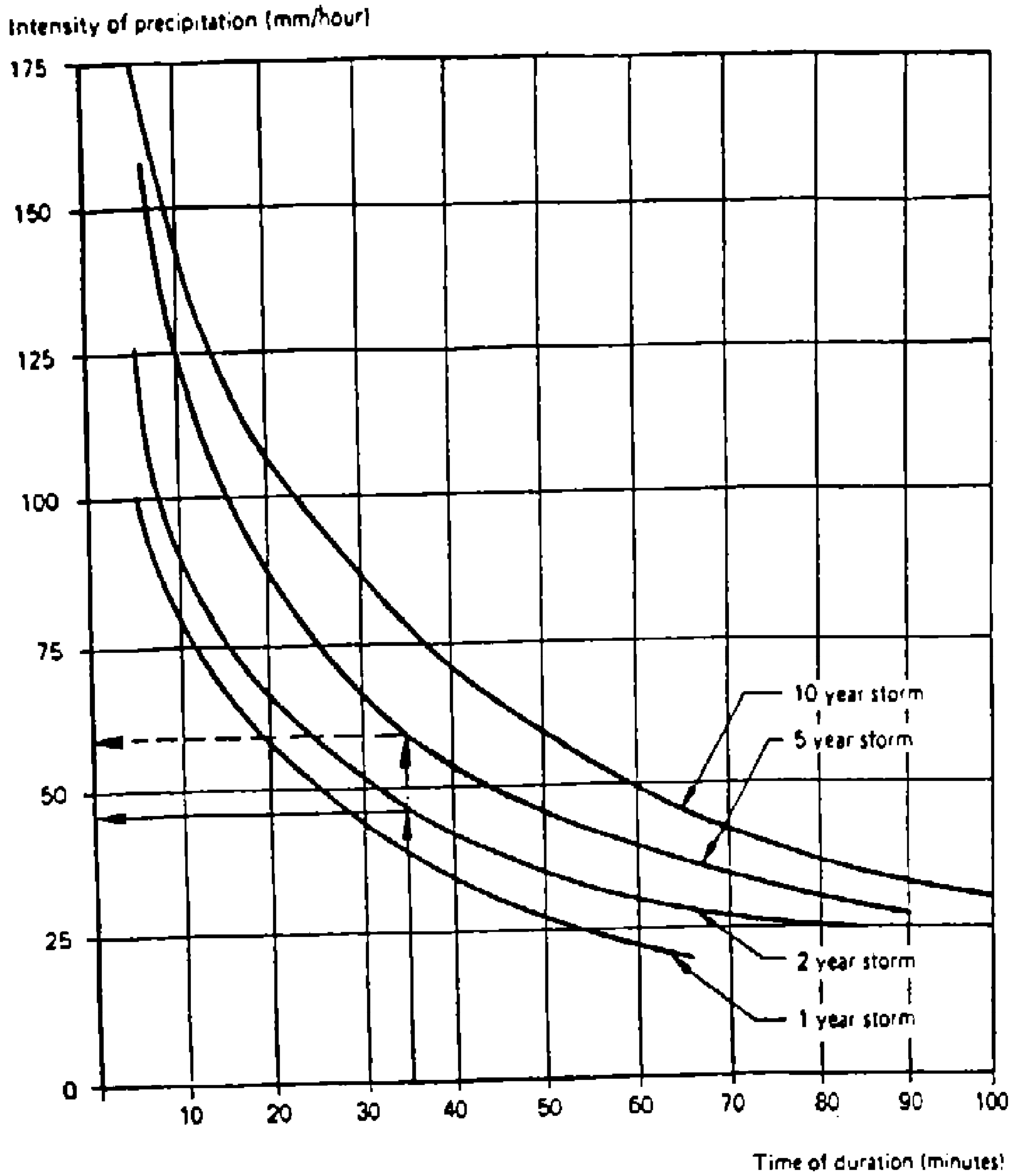
a) Plant area/utility area (paved)	1.0
Evaporation/percolation coefficient (see below)*	
b) Manifolds	1.0
c) Roads and road shoulder	0.95
Brick roads/tiled areas	0.75
d) Pipe trenches (general)	0.50
Pipe trenches concrete finish	0.90
e) Bundwalls (average)	0.55
Bundwalls with seepage prevention	0.90
f) Tank roof	1.0
g) Tank compound (unpaved)	0.3
Grassed areas (sandy soil, flat)	≈0.1
Grassed areas (clayey soil,flat)	≈0.5
Tank compounds with seepage prevention	0.9

*** EVAPORATION/PERCOLATION COEFFICIENT IS APPLICABLE FOR:**

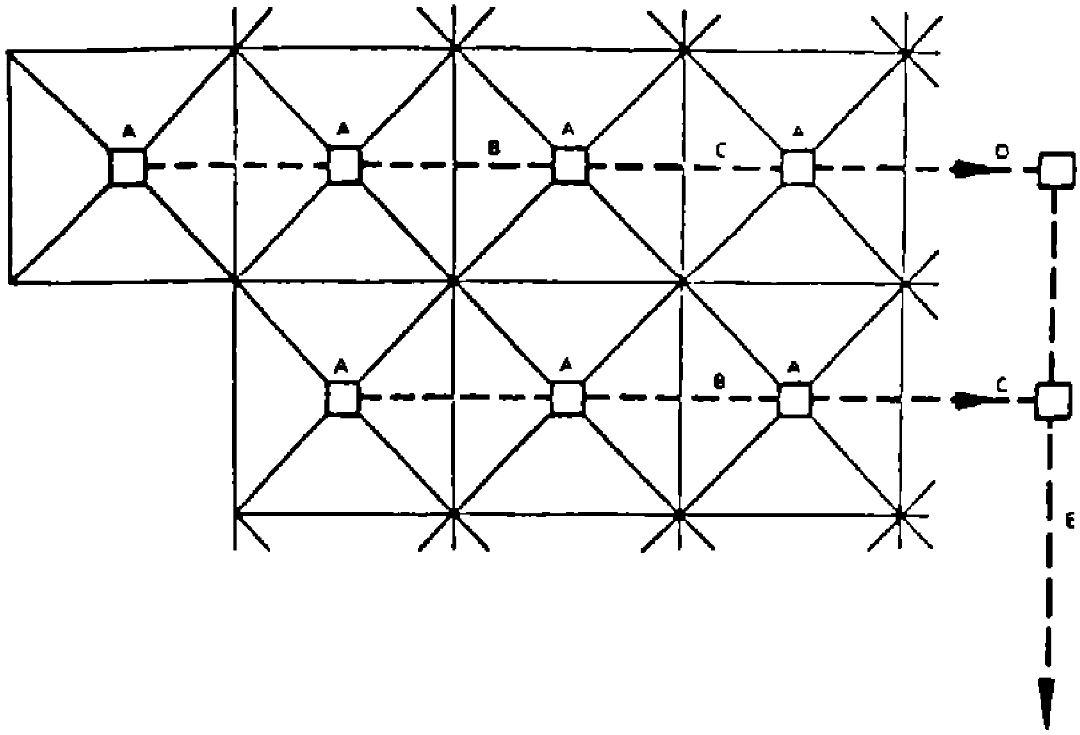
1) Densely built-up plants
2) Where Equipment and Pipes Generate a Great Deal of Heat

These two points together resulted in the introduction, for existing plants,of an (so-called) evaportion/percolation coefficient 0.7, by which the original run-off coefficient may be multiplied.

APPENDIX B
EXAMPLE OF RAINFALL INTENSITY-DURATION-FREQUENCY CURVE



APPENDIX C
QUANTITIES OF FIRE-FIGHTING WATER IN PROCESSING/UTILITY AREAS



Maximum Quantities of Q_f Discharging To Sump (A)	:	31 dm^3/s (110 m^3/h)
Maximum Quantities of Q_f Discharging Through Branch Line (B)	:	61 dm^3/s (220 m^3/h)
Maximum Quantities of Q_f Discharging Through Main Line (C)	:	76 dm^3/s (275 m^3/h)
Maximum Quantities of Q_f Discharging Through Main Line (D)	:	92 dm^3/s (330 m^3/h)
Maximum Quantities of Q_f Discharging Through Main Line (E)	:	159 dm^3/s (572 m^3/h)

Q_r is rain water run-off
Q_p is process water
Q_f is net fire-fighting water

The calculation of the size of each drain line shall be in conformity with Article 9.4 of this Standard and be based either on ($Q_f + Q_p$) or ($Q_r + Q_p$). The largest diameter calculated shall be taken.

APPENDIX D
HYDRAULIC CALCULATIONS AND METHODS

D.1 Colebrook-White equation

The Colebrook-White equation presents a complex and accurate formula which is commonly used in the design of sewers. Design charts and tables are available as described in the following references:

- Hydraulic Research Station "Charts for the Hydraulic Design of Channels and Pipes", 5th. Ed., HRS 1983.
- Hydraulic Research Station "Tables for the Hydraulic Design of Pipes and Sewers", 4th. Ed., HRS 1983.
- Hydraulic Research Paper No. 4.

D.2 Chezy formula

The Chezy formula holds for head loss in conduits and gives reasonably good results for high Reynolds numbers. The Chezy formula can be used for either open drain channels or liquid filled pipes, sumps and weir overflows.

D.2.1 Open drain channel

$$V = C\sqrt{R.I} \quad or \quad I = \frac{V^2}{C^2.R} \qquad \textbf{(Eq. D.1)}$$

Where:

V is velocity, in (m/s);
C is Chezy coefficient, in (m/s), (see Note 1);
R is hydraulic radius (hydraulic mean depth), in (m);
I is incline (slope).

Note 1:

For a full discussion of Chezy's coefficient C, see "An Introduction to Engineering Fluid Mechanics" by J.A.FOX, published by Macmillan Press, London.

The value C given in Appendix D1 is related to the material being used, size of the channel, etc., and is based on the Bazin formula:

$$C = \frac{87}{1+\sqrt{\frac{a}{R}}} \qquad \textbf{(Eq. D.2)}$$

Where:

a is a channel wall factor related to the material being used.

The hydraulic radius or hydraulic mean depth (R) is the relationship between the amount of liquid being conveyed and the contact area between this liquid and the inside of channel.

$$\boldsymbol{R = \frac{CROSS\ \ SECTIONAL\ \ AREA\ \ OF\ \ FLOW}{WETED\ \ PERIMETER}}$$

For a rectangular drain, R will be:

$$R = \frac{a.b}{2a+b} \qquad \textbf{(Eq. D.3)}$$

If precast drain channels are proposed, design charts by the supplier may be used to establish I,V, and C, but clear reference shall be made and a copy should be included with the detailed design package.

D.2.2 Liquid filled pipes

The Chezy formula may also be used for the design of drainage pipes. In view of the fact that all plant drainage system, i.e., underground pipes, are liquid-filled, the Chezy formula can be simplified as follows:

$$I = \frac{V^2}{C^2.R} \qquad \textbf{(Eq. D.4)}$$

For liquid filled pipes R can be derived as follows:

$$R = \frac{\pi.D^2/4}{\pi.D} = \frac{D}{4} \qquad \textbf{(Eq. D.5)}$$

V is derived as follows:

$$V = \frac{Q}{\pi\,(D^2/4)} \qquad \textbf{(Eq. D.6)}$$

Inserting Eqs. D.5 and D.6 into D.4 gives:

$$I = \frac{64}{\pi^2.D^5.C^2} \cdot Q^2 \qquad \textbf{(Eq. D.7)}$$

The relationship between I and Q^2 can be written as:

$$I = \alpha \,.\, Q^2 \qquad \textbf{(Eq. D.8)}$$

Where:

I is, in m;
Q is, in m^3/s.

$$\alpha = \frac{64}{\pi^2.D^5.C^2} \qquad \textbf{(Eq. D.9)}$$

α(alpha) is related to the pipe material. The "a" factors are shown in Appendices D2, D3 and D4, using C values calculated with Kutters formula:

$$C = \frac{100\sqrt{R}}{M+\sqrt{R}} \quad \text{using the following figures for M} \qquad \textbf{(Eq. D.10)}$$

M = 0.35 for concrete pipes
M = 0.25 for steel pipes
M = 0.084 for GRE* pipes < Ø 1.0 m
M = 0.080 for GRE* pipes Ø 1.0 - Ø 1.2 m
M = 0.075 for GRE* pipes > Ø 1.2 m

*** GRE stands for glass-fibre reinforced epoxy pipes.**

D.3 Manning's formula

The Manning's formula which is calculated based on the Chezy's formula by defining a new coefficient of C, is widely used because of its simplicity. A special form of this, the Crimp And Bruges Equation, is also still widely used, but incorporates a constant hydraulic roughness value.

$$V = C\sqrt{RI}, \quad C = \frac{R^{1/6}}{n}$$

(Eq. D.11)

n = Manning Roughness Coefficient, dependent on surface roughness, in (s/m$^{1/3}$)

$$V = \frac{1}{n} . R^{2/3} . I^{1/6}$$

(Eq. D.12)

Manning Roughness Coefficient (n) can be extracted from the following Table D.1:

TABLE D.1 - VALUES OF "n" FOR PIPES, TO BE USED WITH THE MANNING FORMULA

MATERIAL OF PIPE	VARIATION		USE IN DESIGNING	
	FROM	TO	FROM	TO
CLEAN CAST IRON	0.011	0.015	0.013	0.015
DIRTY OR TUBERCULATED CAST IRON	0.015	0.035		
RIVETED STEEL	0.013	0.017	0.015	0.017
WELDED STEEL	0.010	0.013	0.012	0.013
GALVANIZED IRON	0.012	0.017	0.015	0.017
WOOD STAVE	0.010	0.014	0.012	0.013
CONCRETE	0.010	0.017		
- GOOD WORKMANSHIP			0.012	0.014
- POOR WORKMANSHIP			0.016	0.017
ASBESTOS CEMENT			—	0.011
EARTHEN DITCHES			—	0.025

Note:

See the following reference for more information for selection of the appropriate coefficient and constant.

Ackers P. "Resistance of Fluids Flowing in Channels and Pipes"- Hydraulic Research Paper No. 1, HMSO 1958.

D.4 Head losses

D.4.1 Head loss due to friction in ditches/pipings

a) Full flow

The following equation shall be applied where water fully flows in the piping:

$$h = f . \frac{L}{D} . \frac{V^2}{2g}$$

(Eq. D.13)

b) Flow in open ditch

The following equation shall be applied where water partially flows in the open ditch:

$$h = f' \cdot \frac{L}{R} \cdot \frac{V^2}{2g} \qquad \text{(Eq. D.14)}$$

Where:

- ***h*** is friction loss in ditches/pipings, in (m);
- ***f*** is friction factor in piping $= \frac{124.5\, n^2}{D^{1/3}}$:
- ***f'*** is friction factor in open ditch $= \frac{2g.n^2}{R^{1/3}}$:
- ***L*** is length of pipe or ditch, in (m);
- ***D*** is pipe diameter, in (m);
- ***R*** is hydraulic mean depth, in (m);
- ***V*** is mean velocity, in (m/s);
- ***g*** is acceleration of gravity = 9.8 (m/s^2).

D.4.2 Head losses at manholes and bends

In addition to the energy losses that are induced by friction on the surface of the pipe, other losses will occur at manholes and bends as a result of sudden changes in velocity and in direction. These additional losses are usually small in relation to the frictional losses, and are not normally considered (see D.4.2.1). The equation for the energy loss is usually of the form:

$$energy\ loss = \frac{k \cdot V^2}{2g} \qquad \text{(Eq. D.15)}$$

Where:

k is the energy loss coefficient;
V is the mean velocity in sewer, in (m/s);
g is the gravitational constant, in (m/s^2).

D.4.2.1 Energy losses at manholes

Table D.2 gives values of energy loss coefficient, k, derived from experiments on manholes where the sewer is surcharged. The energy losses when the sewer is only just full (i.e., with the flow confined by the manhole benching) will be less than those obtained using these coefficients. When the manhole incorporates a junction, the energy losses will be increased and willl depend on the geometry of the junction and on the flows in the branches.

TABLE D.2 - ENERGY LOSS COEFFICIENT, k, FOR MANHOLES

PLAN SHAPE OF MANHOLE	TYPE OF MANHOLE		
	STRAIGHT TROUGH	30° BEND	60° BEND
Rectangular	0.10	0.40	0.85
Circular	0.15	0.50	0.95

D.4.2.2 Energy losses at bends

a) Circular bends

Table D.3 gives values of k for 90° circular bends, flowing full, for various ratios of bend radius, R, to nominal pipe bore, D.

TABLE D.3 - ENERGY LOSS COEFFICIENT, k, AT BENDS

BEND RADIUS/PIPE DIAMETER R/D	k
0.5	1.0
1.0	0.25
1.5	0.18
2.0	0.16
5.0	0.18
10.0	0.24

The values given in Table D.3 apply when the straight length of pipe downstream from the bend is greater than 30 pipe diameters.

b) Mitre bends

The energy loss coefficient, k, for a single mitre bend is given by:

$$k = 1.4 \frac{\theta^2}{90} \qquad \textbf{(Eq. D.16)}$$

Where:

θ(theta) is the bend angle (in degrees).

Table D.4 gives the loss coefficient for a 90° Lobster-back bend comprising 4/22.5°, 3/30°, or 2/45° mitre bends.

TABLE D.4 - ENERGY LOSS COEFFICIENT k, FOR LOBSTER-BACK-BANDS

1/D	4/22.5°	3/30°	2/45°
	LOSS COEFFICIENT K		
0.5	0.40	0.45	0.55
1.5	0.25	0.30	0.40
3.0	0.32	0.35	0.48
6.0	0.32	0.37	0.50

Notes:

1) 1 is the centreline length of one of the individual short pieces of pipe (which are all of equal length) from which the bend is made.

D is the nomial pipe bore.

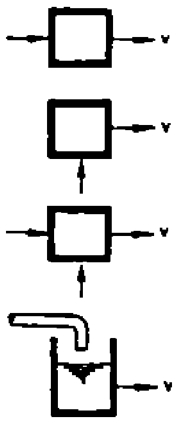
2) The values given are for a rough pipe; the loss coefficients for a smooth pipe will be approximately 75% of these values.

D.4.3 Sump losses

The simplified formula illustrated below may be used for the calculation of the sump losses (pipe flush with inside of the sump):

Where:

- *V* is mean velocity, in (m/s);
- *h* is head loss, in (m).



$$h = 0.3\frac{V^2}{2g} = \frac{V^2}{66}$$ **(Eq. D.17)**

$$h = 1.5\frac{V^2}{2g} = \frac{V^2}{33}$$ **(Eq. D.18)**

$$h = \left(0.3 + 0.6\right)\frac{V^2}{2G}$$ **(Eq. D.19)**

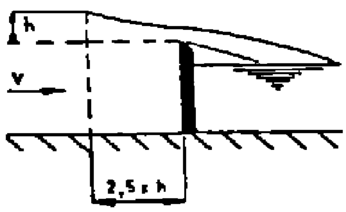
$$h_{max} = 1\frac{V^2}{2g} = \frac{V^2}{20}$$ **(Eq. D.20)**

$$h = 1\frac{V^2}{2g} = \frac{V^2}{20}$$ **(Eq. D.21)**

D.4.4 Weir overflow

The liquid depth over a weir which is required for the calculation of the total hydraulic loss within the drainage system (network) under consideration may be calculated as follows:

a) Free weir

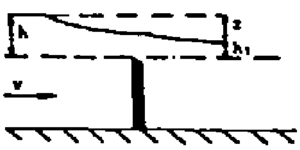


$$Q = 1.84.L.h^{3=2}$$ **(Eq. D.22)**

or

$$h = \left(\frac{Q}{1.84¢ L}\right)^{2=3}$$ **(Eq. D.23)**

b) Submerged weir



$$Q = 1.84¢\ L.Z^{3=2} + 2.8.L.h.\sqrt{z}$$ **(Eq. D.24)**

Where:

Q	is flow rate, in (m^3/s);
L	is length of weir, in (m);
h and Z	are liquid depth over the weir, in (m).

D.5 Pressure sewers

For force mains (pressure sewers), velocity is the primary design factor, and it is dependent on roughness associated with the pipe material. Typically, a design velocity of 0.6 m/s at average daily flow is used. Maximum velocities are considered in the range of 1.2 to 4 m/s depending on the line size and material. The maximum velocity dictates the pressure condition for design of fittings and reaction blocking.

The Hazen-Williams formula is used commonly for force main design. The velocity equation form is:

$$V = 0.85\, C \,.\, R^{0.63} \,.\, S^{0.54} \qquad \textbf{(Eq. D.25)}$$

Where:

V	is mean velocity, in (m/s);
C	is roughness coefficient;
R	is hydraulic radius;
S	is slope of the energy grade line.

The value of the Hazen-Williams "C" varies with the type of material as shown in Table D.5 and is influenced by the type of construction and age of the pipe. Common design practice uses values of 100 for unlined and 120 for lined force mains as representative of conditions during normal service periods.

TABLE D.5 - RANGES OF HAZEN - WILLIAMS "C"

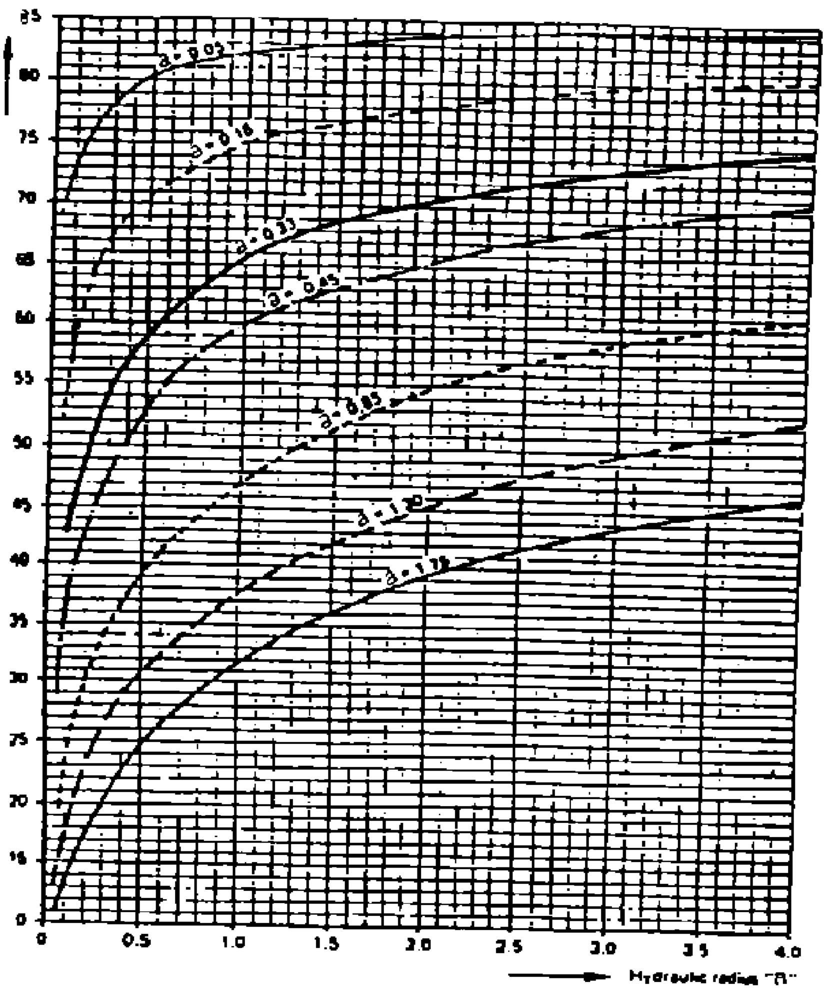
PIPE MATERIAL	HAZEN - WILLIAMS "C"
Abestos cement	120-140
Clay	100-130
Concrete*	100-140
Iron*	100-130
Plastic	130-140
Steel	110-120

*** Upper range for lined pipe.**

APPENDIX D1 (continued)

"C" VALUES

C value for Bazin's fromula $C = \frac{87}{1+p\frac{a}{R}}$



a	= 0.05	very smooth cement lining
a	= 0.16	cement lining
a	= 0.33	average concrete channels
a	= 0.45	average masonry
a	= 0.85	earth ditches with stone lining
a	= 1.30	earth ditches straight and well maintained
a	= 1.75	earth ditches average condition

APPENDIX D2 (continued)

"α" VALUES-CONCRETE PIPES

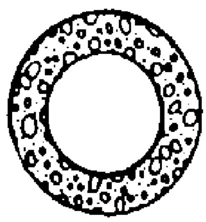
For head loss calculations through drainage pipes flowing full, based on Chezy formula.

CONCRETE PIPES					
Diameter in inches	Area A = m²	α	Diameter in meters	Area A = m²	α
4	0.008	635.00	0.10	0.0079	669.37
6	0.018	64.00	0.15	0.0177	67.30
8	0.032	12.66	0.20	0.0314	13.33
9½	0.046	4.58	0.25	0.0491	3.675
10	0.050	3.63	0.30	0.0707	1.385
11	0.062	1.99	0.35	0.0962	0.589
12	0.073	1.26	0.40	0.1257	0.281
13	0.086	0.80	0.50	0.1953	0.082
14	0.099	0.54	0.60	0.2827	0.030
16	0.129	0.26	0.70	0.385	0.0130
18	0.164	0.13	0.80	0.503	0.0063
20	0.202	0.08	0.90	0.636	0.0033
24	0.291	0.03	1.00	0.785	0.0019
26	0.342	0.02	1.10	0.950	0.0011
27	0.369	0.0146	1.20	1.131	0.00070
28	0.396	0.012	1.30	1.327	0.00045
30	0.455	0.010	1.40	1.539	0.00031
32	0.518	0.006	1.50	1.767	0.00021
33	0.55	0.005	1.60	2.010	0.000149
36	0.655	0.003	1.70	2.269	0.000108
39	0.77	0.002	1.80	2.544	0.000079
40	0.810	0.00172	1.90	2.835	0.000060
42	0.893	0.0013	2.00	3.141	0.000045
44	0.980	0.0016			
48	1.166	0.0006			
52	1.366	0.0004			
54	1.476	0.0003			
60	1.823	0.0002			

Note:

The C-value is calculated with Kutters formula using a roughness factor M = 0.35 for concrete pipes.

Concrete e



APPENDIX D3 (continued)

"α" VALUES-STEEL PIPES

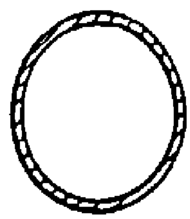
For head loss calculations through drainage pipes flowing full, based on Chezy formula.

STEEL PIPES					
Diameter in inches	Area A = m²	α	Diameter in meters	Area A = m²	α
4	0.008	410.00	0.10	0.0079	432.02
6	0.018	43.00	0.15	0.0177	44.82
8	0.032	8.64	0.20	0.0314	9.09
10	0.050	2.52	0.25	0.0491	2.66
12	0.073	0.894	0.30	0.0707	0.976
14	0.099	0.389	0.35	0.0962	0.420
16	0.129	0.189	0.40	0.1257	0.203
16	0.164	0.099	0.50	0.1964	0.0505
20	0.202	0.056	0.60	0.2827	0.0226
24	0.291	0.0208	0.70	0.385	0.00985
26	0.342	0.0135	0.80	0.503	0.00481
28	0.396	0.00912	0.90	0.636	0.00256
30	0.455	0.00628	1.00	0.785	0.00146
32	0.518	0.00444	1.10	0.950	0.00088
36	0.655	0.00237	1.20	1.131	0.00055
40	0.810	0.00134	1.30	1.327	0.00036
42	0.893	0.00104	1.40	1.539	0.00024
44	0.960	0.00081	1.50	1.767	0.00016
52	1.366	0.00033	1.70	2.269	0.000087
54	1.476	0.00027	1.80	2.544	0.000065
60	1.823	0.00016	1.90	2.835	0.000049
64			2.00	3.141	0.000037

Note:

The C-value is calculated with Kutters formula using a roughness factor M = 0.25 for steel pipes.

Steel



APPENDIX D4 (continued)

"α" VALUES-GRE PIPES

For head loss calculations through drainage pipes flowing full, based on Chezy formula.

GLASSFIBRE REINFORCED EPOXY PIPES (GRE)			
Factor M	**Diameter in meters**	**Area A= m^2**	α
0.084	0.10	0.0079	152.05
	0.15	0.0177	17.55
	0.20	0.0314	3.84
	0.25	0.0491	1.19
	0.30	0.0707	0.456
	0.35	0.0962	0.204
	0.40	0.1257	0.101
	0.50	0.1963	0.032
	0.60	0.2827	0.0124
	0.70	0.385	0.0056
	0.80	0.503	0.0028
	0.90	0.636	0.0015
0.080	1.00	0.785	0.00087
	1.10	0.950	0.00054
0.075	1.20	1.131	0.00034
	1.30	1.327	0.00022
	1.40	1.539	0.00015
	1.50	1.767	0.000108
	1.60	2.010	0.000077
	1.70	2.269	0.000057
	1.80	2.554	0.000042
	1.90	2.835	0.000032
	2.00	3.141	0.000025

Note:

The C-value is calculated with Kutters formula using roughness factors M=0.084, 0.080-0.075 for GRE pipes.

GRE

APPENDIX E

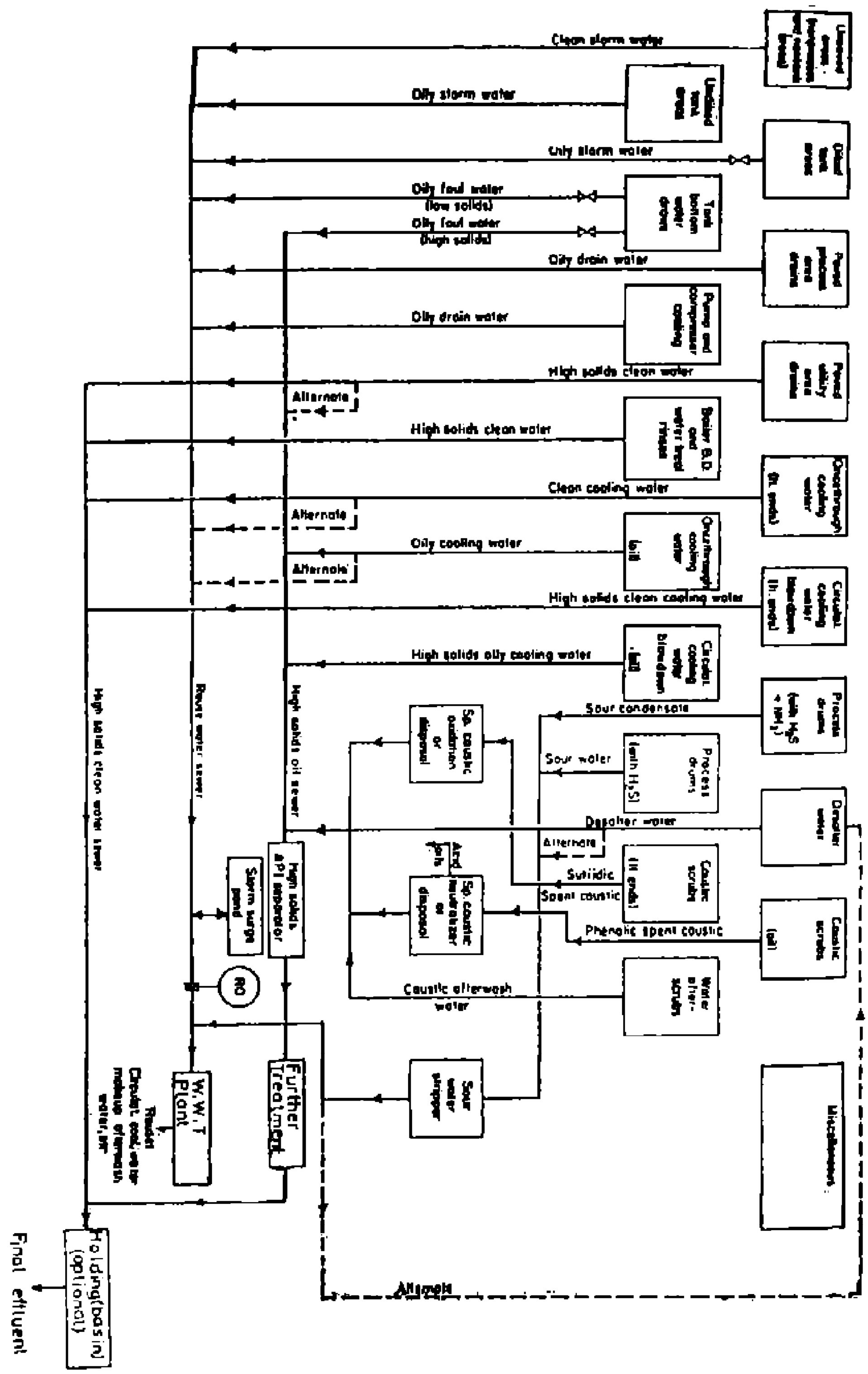
QUALITATIVE EVALUATION OF WASTEWATER FLOW AND CHARACTERISTICS BY FUNDAMENTAL REFINERY PROCESSES

Fundamental Processes	Flow	BOD	COD	Phenol	Sulfide	Oil	Emulsified Oil	pH	Temp.	Ammonia	Chlorides	Acidity	Alkalinity	Susp. Solid
Crude Oil and Product Storage	XX	X	XXX	--	--	XXX	XX	0	0	0		0		XX
Crude Oil Desalting	XX	XX	XX	X	XXX	X	XXX	X	XXX	XX	XXX	0	X	XXX
Crude Oil Distillation	XXX	X	X	XX	XXX	XX	XXX	X	XX	XXX	X	0	X	X
Thermal Cracking	X	X	X	X	X	X	--	XX	XX	X	X	0	XX	X
atalytic Cracking	XXX	XX	XX	XXX	XXX	X	X	XXX	XX	XXX	X	0	XXX	X
ydrocracking	X	--	--	--	XX	--	--	--	XX	--	--	--	--	--
eforming	X	0	0	X	X	X	0	0	X	X	0	0	0	0
olymerization	X	X	X	0	X	X	0	X	X	X	X	X	0	X
lkylation	XX	X	X	0	XX	X	0	XX	X	X	XX	XX	0	XX
somerization	X	--	--	--	--	--	--	--	--	--	--	--	--	--
olvent Refining	X	--	X	X	0	--	X	X	0	--		0	X	
ewaxing	X	XXX	XXX	X	0	X	0	--	--	--	--	--	--	--
ydrotreating	X	X	X	--	XX		0	XX	--	0	0	0	X	0
rying and Sweetening	XXX	XXX	X	XX	0	0	X	XX	0	X	0	X	X	XX

XXX - Major Contribution
XX - Moderate Contribution
X - Minor Contribution
0 - No Problem
-- - No Data

APPENDIX F

EFFLUENT SEGREGATION (TYPICAL FOR A REFINERY)



EFFLUENT SEGREGATION (TYPICAL FOR A REFINERY)

Fig. F.1