

ENGINEERING STANDARD
FOR
WATER POLLUTION CONTROL

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0. INTRODUCTION

The increasing energy demand over the last decades has resulted in a corresponding growth and expansion in the refining and processing of crude petroleum. The proliferation of refineries and petrochemical plants, combined with the increasingly stringent quality requirements for effluents discharged from these facilities, has underscored the need for perfecting existing pollution control technology and developing improved approaches for minimizing the pollution potential in this sector.

Industries and Municipalities account for the largest portion of waste discharges that occur. Industries discharge an enormous variety of materials which include the largest volume of waste and the most toxic of pollutants. Environmental control is a very complex science. The trend is to move in the direction of pollution avoidance rather than control. This will add a tremendous cost to industrial budget.

The public has tolerated pollution until recently, but the condition has increased to the point that many may suffer or even die because of it.

In this Standard monitoring of wastewater control, equipment, and engineering techniques will be discussed.

1. SCOPE

This Standard Specification is intended to cover the safety and environmental control aspects as the Company's minimum requirements for water pollution control in OGP production plants. The scope is accomplished under following titles:

- Refinery Water Pollution Standard and Control.
- Petrochemical and Fertilizer Industry Water Pollution Sources, Standard and Control.
- Organic Chemical Manufacturing.
- The National Standard of Environmental Protection Agency.
- Monitoring.

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 Vendor/Consultant/Contractor.

IPS (IRANIAN PETROLEUM STANDARDS)

IPS-E-PR-730 "Water Treatment Process"

3. DEFINITIONS AND TERMINOLOGY

3.1 Abstraction

The removal of water from any source, either permanently or temporarily, so that it:

- a) Ceases to be part of the resources of that area, or;
- b) is transferred to another source within the area.

3.2 Activated Carbon Treatment

A process intended for the removal of dissolved and colloidal organic substances from water and wastewater by absorption on activated carbon; for example for the amelioration of taste, odor or color.

3.3 Aerobic Bacteria; Facultative Anaerobic Bacteria

Bacteria capable of multiplying in either the presence or absence of oxygen.

3.4 Agglomeration

The coalescence of flocs or particles of suspended matter to form larger flocs or particles which settle or may be caused to float more readily.

3.5 Alpha Factor

In an activated sludge plant, the ratio of the oxygen transfer coefficient in mixed liquor to the oxygen transfer coefficient in clean water.

3.6 Ammonia Stripping

A method of removing ammoniacal compounds from water by making it alkaline, and aerating.

3.7 Aquifer

Water-bearing formation (bed or stratum) of permeable rock, sand, or gravel capable of yielding significant quantities of water.

3.8 Aeration

The introduction of air into a liquid.

3.9 Aerobic Condition

Descriptive of a condition in which dissolved oxygen is present.

3.10 Backwashing

The operation of cleaning a filter with water, or with air and water, by reversing the direction of flow.

3.11 Biodegradation

Molecular degradation of organic matter resulting from the complex actions of living organisms, ordinarily in an aqueous medium.

3.12 Biofilm (of a Sand Filter)

The film, consisting of living organisms, which forms on the surface of a slow sand filter and which is considered to provide an important part of the effective filtering zone.

3.13 Biomass

The total mass of living material in a given body of water.

3.14 Biota

The living components of an aquatic system including Flora and Fauna of a Region.

3.15 Biotic Index

A numerical value used to describe the biota of a water body, serving to indicate its biological quality.

3.16 Ballasting (Deballasting)

The act of taking on (discharging) ballast water.

3.17 BPTCA or Best Practical Technology Currently Available

BPTCA is generally defined as the equivalent of secondary treatment presently being practiced in the particular industrial subcategory. For example, this may be considered as the activated sludge process in the organic chemicals industry.

3.18 BATEA or Best Available Technology Economically Achievable

BATEA is generally defined as treatment technology that has been demonstrated on an advanced laboratory or pilot plant scale to be technically and economically feasible for a specific industrial category.

3.19 New Source Standard

New industrial facilities are separately treated under a new source Standards category.

3.20 Biochemical Oxygen Demand (BOD)

The mass concentration of dissolved oxygen consumed under specified conditions by the biological oxidation of organic and/or inorganic matter in water.

3.21 Catchment Area; Catchment Basin

The area draining naturally to a water course or to a given point.

3.22 Chemical Tracer

A chemical substance added to, or naturally present in water, to allow flow to be followed.

3.23 Connate Water

Interstitial water of the same geological age as the surrounding rock or bed, often of poor quality and unfit for normal use (for example potable purposes, industrial and agricultural use).

3.24 Cross Connection

A connection between pipes which may cause the transfer of polluted water into a potable water supply with consequent hazard to public health. This term is also used to describe a legitimate connection between different distribution systems.

3.25 Chemical Treatment

A process involving the addition of chemicals to achieve a specific result.

3.26 Drinking Water Potable Water

Water of a quality suitable for drinking purposes.

3.27 Dewatering

The process whereby wet sludge, usually conditioned by a coagulant, has its water content reduced by physical means.

3.28 Decantation

The withdrawal of the supernatant liquor after settlement of suspended solids, or after separation from a liquid of higher density.

3.29 Detritus

In a biological context, organic particulate matter. In the context of sewage treatment practice, coarse debris denser than water but capable of being transported in moving water.

3.30 Effluent

Water or waste water discharge from a containing space such as a treatment plant, industrial process or lagoon.

3.31 Ground Water

Water that fills all of the unblocked pores of material underlying the water table within the upper limit of saturation.

3.32 Industrial Water

Any water used for, or during, an industrial process.

3.33 Physico-Chemical Treatment

A combination of physical and chemical treatment to achieve a specific result.

3.34 Rain Water

Water arising from atmospheric precipitation, which has not yet collected soluble matter from the earth.

3.35 Run-On

Any rain water, leachate, or other liquid that drain on to any waste treatment area.

3.36 Run-Off

Any rain water, leachate, or other liquid that drains over land from any part of a waste treatment facility.

3.37 Storm Water; Storm Water Run-Off

Surface water draining to a watercourse as a result of heavy rainfall.

3.38 Sewage Effluent

Treated sewage discharged from a sewage treatment works.

3.39 Storm Sewage

A mixture of sewage and the surface water arising from heavy rainfall or melting snow (ice).

3.40 Stratification

The existence or formation of distinct layers in a body of water identified by thermal or salinity characteristics or by differences in oxygen or nutrient content.

3.41 Sludge

The accumulated settled solids separated from various types of water as a result of natural or artificial processes.

3.42 Surface Water

Water which flows over, or rests on, the surface of a land mass.

3.43 Supply Water

Water, which usually has been treated, that passes into a distribution network or a service reservoir.

3.44 Sedimentation

The process of settling and deposition, under the influence of gravity, of suspended matter carried by water or wastewater.

3.45 Self-Purification

The natural processes of purification in a polluted body of water.

3.46 Septic Tank

Closed sedimentation tank in which settled sludge is in immediate contact with the wastewater flowing through the tank, and the organic solids are decomposed by anaerobic bacterial action.

3.47 Softening

The removal of most of the calcium and magnesium ions from water.

3.48 Sterilization

A process which inactivates or removes all living organisms (including vegetative and spore forms) as well as viruses.

3.49 Thermocline

The layer in a thermally stratified body of water in which the temperature gradient is at a maximum.

3.50 Thickening

The process of increasing the concentration of solids in a sludge by the removal of water.

3.51 Treated Sewage

Sewage that has received partial or complete treatment for the removal and mineralization of organic and other material.

3.52 Wastewater

Water discharged after being used in, or produced by, a process, and which is of no further immediate value to that process.

3.53 VOD (Volatile Oxygen Demand)

Compounds which under favorable conditions may participate in photochemical reaction to form oxipants typically excludes methane and ethane.

4. UNITS

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

5. REFINERIES WATER POLLUTION AND CONTROL STANDARDS

5.1 Refinery Classification

A general description of main process in refineries is given in United Nation Environment Program Industry and Environment Overview Series, Environmental Management Practices in Oil Refineries and Terminals an Overview, 1987.

5.2 Wastewater Characteristics and Classifications in Oil Refinery

The water contaminant parameters determined in refinery wastewaters include Biochemical Oxygen Demand (BOD₅), Chemical Oxygen Demand (COD), oil, Total Suspended Solids (TSS), ammonia (NH₃), phenolics, Hydrogen Sulfide (H₂S), trace organics and some heavy metals. Table 1 shows the major sources of each of the contaminants. Process wastewaters contribute a portion of virtually all while other sources have more specific contaminants discharges.

5.2.1 Water free of oil and organic material

This category includes boiler blowdown, effluent from cooling water and boiler feedwater make-up units, rain water from oil free areas, and cooling water which cannot have direct contact with oil.

5.2.2 Water accidentally contaminated with oil

This category includes water streams that are normally free of oil, but may contain oil after an accident. These streams comprise rain water from tank farms, pipe alleys and oil free processing areas; once-through cooling water, etc.

5.2.3 Water continuously contaminated with oil but with soluble organic material

This category comprises rain water from oil processing areas, tank drain water, deballasting water, cooling water blow-down, flushing and cleaning water.

5.2.4 Process water

This water is in contact with process streams, originating from steam stripping, crude oil washing, some chemical oil treatment processes etc. It contains variable amounts of oil and soluble material such as ammonium sulfide, phenols, thiophenols, organic acids and inorganic salts such as sodium chloride.

5.2.5 Sanitary and domestic water

The end result of sanitation and domestic water used in the refineries is termed as wastewater. Relevant to the above mentioned facts these five categories of water may need different treatments and for this reason, water streams are often kept segregated in a modern refinery to reduce the cost of water treatment facilities.

But in refinery different process could cause pollution which should be treated. For more details see United Nation Environment Program Industry and Environment Overview Series, Environmental Management Practices in Oil Refineries and Terminals an Overview, 1987.

TABLE 1 - WASTEWATER POLLUTANTS AND SOURCES

POLLUTIONS	SOURCES
BOD ₅ , COD, Oil	Process wastewater Cooling tower blowdown (if hydrocarbons leak into cooling water system) Ballast water Tank flow drainage and run-off
Total suspended solids	Process wastewater Cooling tower blowdown Ballast water Tank flow drainage and run-off
Phenolics	Process wastewater (particularly from fluid catalytic cracking unit)
NH ₃ , H ₂ S, trace organics	Process wastewater (particularly from fluid catalytic cracking unit and coker)
Heavy metals	Process wastewater Tankage wastewater discharges cooling Tower blowdown (If chromate type cooling water treatment chemicals are used).

5.3 Effluent Limitation and Standard Performance for Refineries

5.3.1 For effluent limitation and standard performance in refineries see Manual on Disposal of Refinery Waste Volume on Liquid Waste Chapter 16 Petrochemical Waste Treatment 1972.

5.4 Water Pollution Terminals

5.4.1 Wastewater pollutant sources crude oil terminal

The onshore facilities for most crude terminals will consist of storage tanks and associated equipment for crude oil, ballast water, and sanitary water. Thus, the major environmental concern is contamination of wastewaters with oil and the treatment of the ballast and sanitary waters prior to discharge. The treating methods for oil-contaminated wastewaters include API separators, CPI separators, or other types of gravity separators. It is most beneficial to segregate the dirty and clean waters and thereby to minimize the volume of water requiring treatment. For treatment of dirty waste waters see IPS-E-PR-730.

5.4.2 Product terminal

Product terminals typically are separate from a refinery but in some cases may be associated with a refinery. The product typically handled at a terminal include gasoline, diesel, fuel oil, Liquefied Petroleum Gas (LPG), kerosene, aviation gasoline, and jet fuels.

The few environmental concerns encountered in a product terminals are similar to those in a refinery and the pollution control methods for a product terminals are similar to a refinery.

5.5 Design Procedure for Effluent Water Pollution Control

5.5.1 Examples of design and procedures which are generally beneficial are as follows:

- a) Recovery of oil spills and hydrocarbons with vacuum trucks to reduce emissions and water effluents.
- b) Separation of oily wastes, concentrated wastes, and other process wastes from general effluents for more effective treatment.
- c) Reduction of shock pollutant loads on treatment facilities through the periodic flushing of process sewers to prevent contaminant build-up and by the use of flow and load equalization prior to treatment.
- d) A specialized program for handling oily wastes, sludges, wash waters and other effluents.
- e) Maximization of air fan cooling and employ cooling water only for those services in which low process temperatures make air fan cooling impractical or uneconomic.
- f) Limiting the amount of water used for process unit washdowns.
- g) Converting foul water strippers to reboiler strippers to reduce foul water and recover condensate.
- h) Using caustic injection into desalted crude to reduce NH_3 needed to control corrosion in the crude unit overhead system.

5.6 Spill Prevention and Control

Prevention of spills of oil and related petroleum products should be one of the prime objectives, both in the design and the operation of the proposed facility, and should include, but not be limited to siting and design criteria for all facilities, operating procedures and their periodic review, inspection and monitoring of facilities, personnel training, revision of operating procedures (where required), and redesign of facilities (if necessary).

Among specific design parameters are impervious dikes around tankage (feedstock and product), containment of storm water from the process area(s), ability to treat contaminated storm water in the wastewater treatment facility, leak-detection systems capable of detecting small volume or slow rates of leakage from the pipeline system and appropriate use of valves to minimize potential spill volumes.

5.6.1 Spill prevention techniques

Prevention of spills is the first line of defense in protecting life, property, and the environment. Experience has shown that operational or human error and equipment failures are the principal causes of spills. Both can be reduced through the involvement and commitment of all staff to spill prevention.

Proper design, inspection, and maintenance of general facilities are of principle importance. Operator capacity is also extremely important and must be periodically tested and upgraded.

Given good equipment, good operators, and good procedures, spills will be reduced. They will not, however, be eliminated. The difference between a minor event and a catastrophic event depends almost entirely on planning. Such planning includes plant design with spill containment features, and alarms, a workable and efficient contingency plan, trained spill control personnel, and adequate spill control equipment.

5.6.2 Bulk storage

Oil storage tank construction and material should be compatible with the oil stored and the storage conditions such as pressure, temperature etc.

Impervious secondary containment should be provided for the capacity of the largest single tank plus a sufficient allowance for precipitation and free board.

New metallic tanks buried underground should be protected from corrosion by coatings, cathodic protection, or other effective methods compatible with local soil conditions. The use of nonmetallic tanks, if available and practical, should be given consideration.

Above-ground tanks should be subjected to appropriate integrity testing. Appropriate procedures might include hydrostatic testing, visual inspections, or inspection by a system of non-destructive shell thickness gaging.

Plant effluents which are discharged into a watercourse should have disposal facilities observed frequently enough to detect any possible system upset that could cause an oil discharge.

5.6.3 Facility drainage

Appropriate containment or diversionary structures should be provided to prevent oil from leaving the property uncontrolled.

5.7 Groundwater Pollution Control

5.7.1 Basic sources

Two basic sources of spilled liquid petroleum products are equipment failure and operator error. Equipment failure includes corrosion and leaking of both above and below-ground piping and tanks, valves failure, refinery unit upsets and sewer and drain leaks. Many of these failures may be avoided through proper inspection and maintenance procedures. Operator error includes overfilling tanks and improper alignment of valves and piping. These and other operator errors can best be corrected through developing proven operating procedures, regular training and testing of personnel, and systematic follow-up to assure that procedures are followed.

5.7.2 Preventive measures

5.7.2.1 The preventive measures to be installed during the construction of a permanent structure must consider the following:

- a)** The type of construction (refinery, storage tank, pipeline etc.).
- b)** The volume and the nature of the oil likely to pollute the site.
- c)** The geology and hydrogeological environment; nature of the terrain, depth, activity and quality of the aquifer.
- d)** The economic environment; proximity to and capacity of water wells and intakes for domestic purposes, risk of pollution of a river, etc.
- e)** The preventive system involves four areas: corrosion protection, surface preventive measures, subsurface preventive measures, and monitoring devices to detect and warn of unsuspected pollution not visible from the surface or of a dangerous change in groundwater levels.

5.7.2.2 Other methods of preventing spilled product from entering the ground and controlling its direction are:

- a)** Rendering the soil impermeable where required by means of a concrete paving, a clay or bitumen layer, plastic sheets (PVC sheets covered with gravel, fiberglass reinforced epoxy), and chemical to be mixed with the soil.
- b)** A surface drain system in the plant area carrying all oil and oil-contaminated water to a dirty water sewer, and then to an interceptor or separator, by means of a pipe system with manholes (cast iron, steel, epoxy), and gutters.

5.7.3 Types of devices

5.7.3.1 Trench

This system of protection, which is used as a barrier to prevent the horizontal movement of the oil, can only be carried out on a practical scale if the water table is situated at a depth of less than about 3-8 meters depending on soil conditions. Spread of oil on the groundwater surface is intercepted by digging the trench to about one meter below the piezometric level. Oil flows onto the water surface where it can be recovered.

5.7.3.2 Wall

The aim of a wall is to provide a barrier, extending to below the water table, through which oil or contaminated water cannot move.

5.7.3.3 Hydrodynamic protection

The principle of oil spill control using hydrodynamic methods is to effect a change in the groundwater flow pattern such that the free oil or the contaminated water, as the case may be, can be drawn to a specific control point or points. This can be achieved by discharging or recharging the aquifer, or a combination of both. The success of the method depends on maintaining an artificial gradient in the groundwater surface.

5.7.3.4 Monitoring

Groundwater monitoring devices are typically installed to detect and warn of unsuspected contamination not visible from the surface or of a dangerous change in groundwater levels. These devices are installed around petroleum storage areas, waste treatment/disposal facilities (including lagoons, land farms, and landfills), or an entire facility depending on the potential for contamination.

Care should be taken in choosing monitoring devices to maximize accuracy and reliability of the system. Also, monitoring should be conducted to differentiate between previous and new spills.

5.7.3.5 Mitigation measures

After a spill or any contamination is detected, remedial measures such as determination of the extent or contamination (boundaries) and a hydrogeological assessment of the contamination area to determine the corrective action necessary must be conducted. When an appropriate action is determined, steps including recovery of the oil and oily water and restoration of the site may be instituted.

5.7.4 Recovery measures

The principal factor to be considered when recovering free oil from the groundwater surface is to employ the natural water gradient or by inducing one or by increasing an existing gradient by artificial means. By good use and operation of recovery equipment, free oil can be concentrated at a relatively limited number of selected sites and removed. Wells and trenches are typically used for recovering oil and water.

5.8 Wastewater Pollution Control in Crude Oil Terminal

The largest source of contaminated wastewater at a crude terminal is the ballast water from tankers. The quantity of ballast water requiring treatment depends upon the ship design, operation, and regulations governing the discharge of ballast waters. The ship-design parameters include the amount of segregated ballast, the tank dimension, and the use of onboard oil/water separators. The operating parameters include the type of previous cargo, weather conditions, and tank-cleaning procedures. Optimizing the design and operation of a tanker can reduce the amount of water requiring treatment.

Ballast water treatment has consisted of settling the ballast in shoreside tankage for periods of 10 to 24 hours, skimming off oil and discharging the water. This simple gravity separation may still be acceptable in some circumstances. For a better quality effluent physical, chemical, and/or biological methods are necessary.

In some locations where shore space is at a premium off-shore, deballasting facilities in the form of converted redundant tankers are utilized. One method to eliminate contaminated ballast water in tankers is the use of segregated ballast.

5.8.1 Simple gravity separation

These treatment systems rely on gravity difference to separate the oil and water. They are capable of removing the bulk of non-dissolved and nonemulsified oil. Examples include: storage and settlement, once through storage with skimming, API separator, corrugated plate interceptors (CPI) and holding basins.

5.8.2 Combination of simple gravity separation systems

Various combinations of the above individual treatment steps are used and such combinations may consist of storage and settlement plus API separators or Corrugated Plate Interceptors (CPI); storage and settlement plus holding basin; or storage and settlement plus API or CPI plus holding basin.

There are several reasons why a combination of steps is often the best choice of treatment process. First, storage and settlement ahead of a CPI or API will remove crude oil and prevent temporary overloading of the downstream separator. Second, rather than sizing the CPI or API separator to handle the maximum hourly flow rate, costs can be reduced by having a combination of a settling tank and CPI or API separator, with the tank designed for the maximum flow rate and the separator design to deal with the average flow rate. Third, a CPI or API plus holding basin serves as a guard chamber to finally trap any inadvertent discharge of oil from the settling tank.

5.8.3 Residual suspended matter

If it is necessary to reduce the non-dissolved oil content of the effluent below 25 mg/l, there are several processes available which can be added after the chosen simple gravity system.

Such methods will also reduce suspended solids to below approximately 30 mg/l. BOD can also be reduced because of the oil and solids removed. These processes have little effect on soluble oil content.

The physical methods include dissolved air flotation, filtration (using gravity or pressure filters), physical separation plus use of chemicals such as inorganic flocculants, and/or demulsifiers or polyelectrolytes, flocculation/sedimentation, flocculation-dissolved air flotation and induced air flotation.

5.8.4 Biological treatment

Biological treatment may in some cases be appropriate for removing dissolved biodegradable materials, which are often in low concentrations in normal ballast water. Typical devices used for biological treatment include activated sludge, trickling filters, rotating discs, and lagoons (aerated or not).

5.8.5 Spills

A major environmental concern with terminal operations is oil being spilled and the effects on birds and marine life. Depending upon the type of terminal (offshore or onshore) and the characteristics of the water (such as currents and proximity to open water), the effects of a spill can vary from insignificant to extremely damaging. For example, an enclosed area such as an inlet from the sea, which has been described as the most productive marine environment, may experience accumulation of oil to unacceptable levels over time.

The oil that is spilled offshore will have less impact on the marine environment than an equivalent oil spill within an inlet from the sea (estuary) for three reasons:

- 1) There will be fewer organisms offshore to be affected;
- 2) the concentration of toxic compounds within the water column is expected to be less because more dilution water is available in offshore and;
- 3) the contact time with the marine life will generally be shorter for an offshore spill due to the restricted flushing of the inlet from the sea.

In addition to spilled oil, the treated ballast water can also affect the marine life in an "enclosed" area. Thus, it may sometimes be best to pipe the treated water to another location where good mixing may occur, thereby, protecting the "enclosed" area and minimizing the effects on the marine environment.

Spill contaminant is an important feature of a terminal. The most common types of barrier systems used for floating booms and sorbent ropes. Two less frequently used alternatives are the air-bubble barrier systems and an enclosed berth.

5.9 Siting and Design

In previous sections, the sources of pollution and control methods were discussed. In the following pages the general outline of pollutant specific for management in the siting and design of a refinery or terminal will be discussed.

A major design requirement for a refinery or terminal is to minimize or eliminate the emission of pollutants to the environment. The methods necessary to implement this depend on the types of crude oil processed, the types of products, the availability of water fuel and other utilities and the agreed pollution parameters.

Safety requirements must also be considered at this stage to ensure that the surrounding population and plant personnel are protected from hazards such as fire, explosion and toxic chemicals.

The items of concern in siting and design of a facility are briefly reviewed. They are meant only to point out potential environmental effects.

5.9.1 Aquatic ecosystems

A refinery or terminal siting should take into account potential impacts to aquatic ecosystems. The characterization of aquatic systems in a siting should include: the location of spawning areas, feeding zones, commercial fishing areas, and sport fishing areas, a description of the benthic populations, and an estimate of primary productivity and its limiting factors.

Design considerations should include the facility's water supply requirements. While water use is usually nonconsumptive, attention should be given to the intake and discharge zones.

At refineries or terminals there is always the potential for a release of oil or petroleum products. All facilities should have a spill contingency plan and the basic pieces of equipment necessary to cleanup a spill. All tankage should be properly diked.

5.9.2 Terrestrial ecosystems

Impacts to terrestrial ecosystems from the siting of a refinery or terminal include a reduction or loss in total available habitat, destruction, or modification of food webs, and changes in populations. Another concern in the siting should be the sensitivity of plants and animals to pollutants.

5.9.3 Wetland ecosystems

Where the water table is at, near, or above the land surface for a significant part of most years, the hydrologic regime is such that aquatic or hydrophytic vegetation is usually established, although tidal flats may be non-vegetated. Because wetlands are water systems, any alteration affecting the movement or quality of water in a small area is transmitted to other areas magnifying potential impacts.

Wetlands may be altered directly by filling, dredging, draining, or creating impoundments. Indirectly, alteration of waterflow patterns at the locations and changes in adjacent land use can change the functions and values of wetland areas. In addition to facility construction, the laying of pipelines associated with these facilities can have impacts on wetlands.

5.9.4 Land use

Part of the siting for a refinery or terminal should consider the existing land use and compatibility with local and regional land use plans.

5.9.5 Water pollution control

The siting and design guidelines for water pollution control are as follows:

5.9.5.1 Siting

The most important aspect of water pollution control in the siting of a refinery is the effect of the wastewater effluent on the receiving water. Several factors which should be assessed in the siting investigation are: heat load, total dissolved solids, heavy metal concentrations, and the effects of organics in the effluent.

5.9.5.2 Design

The design of a water pollution control depends on the degree of cleanup required to permit discharge of the wastewaters to either a body of water or public wastewater treatment plant and by the characteristics of the refinery. The following design practices are directed primarily toward segregation of process and non-process wastewaters and the recycling and reuse of raw and treated wastewaters:

- a)** Refinery wastewaters should be segregated and treated based on oil content and potential for reuse. Four common divisions are oil-free wastewaters, oily cooling water, process water, and sanity wastewaters.
- b)** Raw and treated wastewater streams should be recycled to reduce the effluent volume and thereby the make-up water required. Specific practices include:
 - use of catalytic cracker accumulator wastewaters rich in H₂S (sour waters) for make-up to crude desalters after stripping;
 - use of blowdown condensate from high-pressure boilers for make-up to low-pressure boilers;
 - reuse of waters that have been treated for closed cooling systems, fire mains, and everyday washing operations;
 - stormwater use for routine water applications;
 - use of blowdown waters from cooling towers for water seals on high-temperature pumps;
 - recycling of steam condensate;
 - recycling of cooling waters;
 - pipestill overhead waters can be sent directly to the desalter.

c) Water conservation practices should be employed to reduce the volume of waste water requiring treatment. Among the most common practices are:

- recycle and reuse of refinery wastewaters;
- increase the use of air cooling;
- replacement of barometric condensers with surface condensers and vacuum pumps;
- process modifications that have reduced water requirements;
- use of closed pump gland cooling water systems.

d) Where possible, treat highly contaminated streams at their source.

e) Eliminate waste products in the process operations before they become associated with waste streams.

f) Segregate wastewaters for treatment according to the degree required for reuse, recycle, or discharge.

g) Design sample connections to eliminate prolonged purging.

h) Design facilities to avoid all spills.

Design the treated wastewater effluent outfall to minimize any environmental damage. For example, discharge of effluent into a saltmarsh may cause severe damage; therefore, the discharge should be piped to an offshore location.

5.9.6 Siting and design of groundwater pollution control

The design practices are directed towards prevention of spills and leaks and containment of any spills or leaks. The following are the most common design practices for minimizing groundwater contamination.

a) Render the soil impermeable where required.

b) Use of curbing, gutters, ditches, dikes, fire walls, or earthen barriers around tanks, processes, and product handling areas to contain any spills for cleanup.

c) Tank farm, process, and product handling areas should be sloped and graded toward sumps or sewers to permit quick removal and collection of spills.

d) Check valves and storage tanks should be installed at ends of pipelines specifically for spill prevention and control.

e) Seals should be installed on normally closed valves.

f) Cathodic protection systems should be installed for underground pipelines and tanks or apply a continuous coating around the pipeline to prevent direct contact between the pipe and the soil.

g) Where feasible, all pipelines should be located above ground to facilitate inspection and identification of leaks.

h) Concrete ditches, leading to either a chemical waste system or a wastewater system should be installed under pipelines.

5.9.7 Treatment of wastewater stream

For treatment of wastewater stream see IPS-E-PR-730.

6. SOURCE OF EFFLUENT IN PETROCHEMICAL INDUSTRY

6.1 Petrochemical

6.1.1 Water pollution

6.1.1.1 Water balance

In chemical plants, water formed by chemical reaction is generally less than the water evaporated into atmosphere, so that the water discharged tends to be less than the water intake. However, most part of the intake water is discharged. Also, rain water is fouled while flowing through contaminated areas of a plant and is discharged as part of the wastewater.

6.1.1.2 Cooling water

Most industrial water is used as cooling water. For example, there are the rapid cooling required for naphtha thermal cracking in making ethylene and EDC (Ethylene DI. Chloride) thermal cracking in the manufacture of vinyl chloride; removal of reaction heat in polymerization and oxidation; and cooling of fractionator condensers. Cooling water is not fouled since the indirect cooling method is generally adopted. However, there are instances of liquid leaking from the tubes of a cooler due to corrosion attack, resulting in contamination of cooling water.

6.1.1.3 Washing water and process water

Considering the properties of fouled water, washing water is identical to process water, so the former is frequently called "process water".

Water is used in washing because it dissolves various substances. For example, carbon dioxide, hydrogen sulfide, hydrochloric acid, etc., in gas are dissolved in dilute alkali water.

The amounts of washing water and process water being used in petrochemical plants are small compared with those of cooling water. These wastewaters contain a considerable amount of organic substances and dissolved oils. But the COD and BOD values are insufficient to indicate the amounts of organic substance contained in the wastewater from the petrochemical processes. It is necessary that the organic matter in wastewater from petrochemical plants be indicated using TOC (Total Organic Carbon) and TOD (Total Oxygen Demand) but the TOC and TOD indications themselves are not always considered useful as criteria for the detection of toxic substances in the wastewater or for the selection of wastewater treating methods. As organic compounds discharged from petrochemical processes have a variety of chemical properties depending on the processes, it is necessary to pursue the emission sources.

TABLE 2 - TYPE OF WATER POLLUTION

POLLUTION	PLANT OPERATION	EXAMPLES OF POLLUTION
Water Pollution (Wastewater, Waste Liquid)	Cooling Water	<ul style="list-style-type: none"> ◦ Direct cooling or quenching of decomposed gas-Waste-water contains tar dust, hydrogen sulfide and cyanide ◦ Breakage of indirect cooler tubes-Contamination of cooling water due to liquid inside the tubes ◦ Cooling water of pumps, etc.-Water is contaminated by oil, etc.
	Boiler Feed Water	<ul style="list-style-type: none"> ◦ Steam ejector-Steam condensate from ejector contains volatile hydrocarbon
	Washing Water	<ul style="list-style-type: none"> ◦ Water containing hydrogen sulfide and hydrochloric acid, etc. is discharged from the washing of gas ◦ Water containing hydrochloric acid, etc. is discharged from the washing of liquid ◦ Dust is contained in discharged water from dust collector
	Process Water, Feed Water (Chemical Reaction, Electrolysis)	<ul style="list-style-type: none"> ◦ Solvent for suspension and emulsion polymerization Contain catalysts, emulsifier, plastic monomer, etc. ◦ Steam condensate from steam stripping-Dissolve hydrocarbons ◦ Steam condensate originating from dilution steam for naphtha thermal cracking-Contain carbon, phenol and light oil
	Leakage (Loss)	<ul style="list-style-type: none"> ◦ Leakage from pump and agitator shafts, valve stems, and flanges, and due to operational error

6.1.1.4 Typical pollutants of petrochemical industry

Aqueous effluents originating from the petrochemical industry are essentially characterized by the presence of the following substances:

- Organic substances that are not biodegradable, or only slightly so.
- Nitrogen compounds.
- Heavy metals.

6.1.1.5 Petrochemical waste treatment

Petrochemicals have been defined as bulk chemicals derived principally from natural gas, petroleum, or both. 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. The following methods should be considered:

- a) Recycling and reuse of waste streams.
- b) Quenching with oil or chemicals other than water that 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 wastewaters leaving the plant.

The extensive use of automated controls, alarms, and checks by the operators to prevent loss of chemicals is also important. It is essential that adequate facilities be installed to prevent uncontrolled release of chemicals and wastes to sewers or receiving waters. A very effective means of quality control is the use of large lagoons capable of holding several days' production of wastewater; this allows the water to be checked before being released to receiving waters.

6.1.2 Treatment process

For treatment refer to IPS-E-PR-730.

6.2 Fertilizer

6.2.1 General appraisal

The liquid effluents arising from a fertilizer factory originate from a variety of sources, and may be summarized as follows:

- a) Ammonia-bearing wastes from ammonia plants.
- b) Ammonia and urea wastes from urea manufacturing plant.
- c) Ammonium salts such as ammonium nitrate, ammonium sulphate and ammonium phosphate.
- d) Phosphates and fluoride wastes from phosphate and super phosphate plants.
- e) Acidic spillages from sulphuric acid, nitric acid and phosphoric acid plants.
- f) Spent solutions from the regeneration of ion exchange units-acid from cation exchange units and alkali from regeneration of anion exchange units.
- g) Phosphate, chromate, copper sulphate and zinc wastes from cooling tower blowdown.
- h) Salt of metals such as iron, copper, manganese, molybdenum and cobalt.
- i) Sludge discharged from clarifiers and backwash water from sand filters.
- j) Carbon slurry from partial oxidation units.
- k) Scrubber wastes from gas purification processes containing contaminants such as:
 - Mono and DI-Ethanol Amines (MEA and DEA).
 - Arsenic as As_2O_3 .
 - Potassium carbonate.
 - Caustic soda.

The effluents from fertilizer manufacturing are generated from a wide range of unit operations, and considerable variation between waste waters from different factories may be noted. The age, state of repair, operational management and degree of sophistication of each manufacturing unit will play an important role in determining the degree of in-plant materials loss, and the important factors leading to excessive losses (and subsequent pollution) may be summarized as follows: (see UN Report, 1974):

- Outdated basic manufacturing plant with low efficiency and poor process control.
- Improper maintenance and repair, with particular emphasis on servicing of control equipment.
- Variations in feedstock, and difficulties in adjusting process plant to cope with these variations effectively.
- Lack of consideration for pollution abatement and the prevention of materials loss at the original plant design stage.

The overall water requirement for fertilizer manufacturing plants may be high, due to process cooling requirements. The total volume of effluent discharged is dependent to a considerable extent on the degree of in-plant recirculation, and in the case of total recycle, the raw water is used primarily for make-up purposes. Plants designed on a once-through process cooling system generally give rise to high volumes of effluent, from $1000 \text{ m}^3 \text{ h}^{-1}$ to volumes in excess of $10000 \text{ m}^3 \text{ h}^{-1}$, consisting primarily of cooling water discharge.

6.2.2 Nitrogenous fertilizers

A complex nitrogenous fertilizer plant based on the production of ammonium nitrate and urea products, may give rise to pollutants such as ammonium nitrate, nitric acid, ammonia, urea, sulphuric acid, caustic soda, chromate, oil, grease, and boiler feed additives, contained within the overall effluent stream. The individual effluents from the ammonia and urea plants could be categorized as follows:

a) Ammonia plant

- HCN stripper outlet
- Catalyst reduction
- Shift process condensate

b) Urea plant

- Concentrate liquor
- Cooling water blowdown

Additional pollutant discharges may arise from oily water and sanitary sewage effluents.

6.2.3 Phosphate fertilizers

The examples of the sources of liquid effluents from phosphatic fertilizer manufacture are as follows:

Plant 1: Raw Water Intake

Effluent sources:

- Superphosphate plant
- Sulphuric acid plant
- Water treatment plant
- Cooling tower
- Other sources

Plant 2: Raw Water Intake

Sea water (once-through cooling)

Effluent sources:

- Ammonia plant
- Phosphoric acid plant
- Sulphuric acid plant
- Utilities plant:
- Cooling water make-up
- Boiler blowdown, Washings from ion exchange units and floor washing

6.2.4 Compound NPK (nitrogen/phosphorus/potassium) fertilizers

A major component of the NPK effluent source is the direct loss of fertilizer compounds from the granulation units. Examples of the effluents from compound fertilizer manufacture are as follows:

Plant 1: Raw Water Intake

Effluent sources:

- Ammonia plant
- Urea plant
- Phosphoric acid and NPK plants
- Water treatment plant
- Cooling tower
- Boiler plant

Plant 2: Raw Water Intake

Effluent sources:

- Ammonia plant
- Urea plant
- Phosphoric acid and NPK plants
- Sulphuric and nitric acid plants
- Water treatment and steam generation plant
- Methanol plant

6.2.5 Effect of pollution

6.2.5.1 Wastes may be sub-categorized into major and minor elements, but it should be noted that in specific instances particular minor waste components may exercise significant polluting effects.

6.2.5.2 Major pollutants

General water pollution effects from fertilizer manufacturing wastes are dependent primarily on the elements nitrogen and phosphorus, in their varying chemical forms.

6.2.5.3 Nitrogen

Ammoniacal nitrogen and urea

These two compounds are grouped together since urea may be hydrolysed to ammoniacal nitrogen. The pollution problems which may be attributable to ammoniacal nitrogen include toxicity, oxygen demand and eutrophication. Ammonia can be toxic to fish and other aquatic life forms at relatively low concentrations, and urea itself may be toxic to some aquatic life.

Ammoniacal nitrogen and urea may both be oxidized biologically. As such, their presence must be considered a potential oxygen demand in a receiving water. In addition, ammoniacal nitrogen may act in its role as a fertilizer in an aquatic environment, leading to excess growth of algae and aquatic macrophytes and contributing towards accelerated eutrophication. The presence of high ammoniacal levels may also cause problems if the receiving water is used for water supply purposes, due to chemical interference with chlorination (i.e. formation of chloramine intermediates) and resultant increase in chlorine demand.

6.2.5.4 Nitrate

The water pollution problems resulting from high nitrate levels may be categorized into eutrophication and public health effects. High levels of nitrate can give rise to increased eutrophication, leading to the promotion of growth of algae and

macrophytes, adversely affecting water quality and amenity value. Health hazards related to nitrate in water used for supply purposes are considered to be infant methaemoglobinaemia and carcinogenic potential.

6.2.5.5 Phosphate

The presence of significant levels of phosphate has important effects on eutrophication. In terms of inorganic nutrient enrichment of receiving waters, phosphate may in many instances be more important than nitrogenous compounds, due to the fact that some forms of aquatic plant life may fix atmospheric nitrogen, so removing the absolute requirement for soluble forms of nitrogen to promote growth.

Under these circumstances, phosphate becomes the growth-limiting agent, and programmes to control eutrophication have generally sought to reduce available phosphate limits, to prevent excessive algal and macrophyte growth, with subsequent increase in nutrient retention.

6.2.5.6 Minor constituents

In addition to pollution arising from the discharge of nitrogenous or phosphatic elements in liquid waste streams, pollution can be caused by a number of secondary waste components. The most important of these may be listed as follows:

- a) Oil and grease
- b) Hexavalent chromium
- c) Arsenic
- d) Fluoride

In specific instances, one or more of these individual pollutants may give rise to detrimental effects in a receiving water, due primarily to toxicity, or can cause inhibition of nitrification. In addition, oil and grease may adversely affect the oxygen transfer characteristics of a watercourse.

6.2.5.7 Liquid effluents standard

Series of specific sub categories has been established for the fertilizer industry. For more details see Hardam Singh Azad, Industrial Wastewater Management Handbook 1976.

7. THE NATIONAL STANDARD OF ENVIRONMENTAL PROTECTION AGENCY FOR INDUSTRIAL WASTE

7.1 All industrial complex which produce waste in higher quantity above the National Standard of Environmental Protection Agency of Islamic Republic of Iran should have waste treatment facilities before final release to environment. The dilution of treated wastewater to the Standard level is not permitted.

The use of pond for untreated wastewater is allowed only by permission of National Environmental Protection Agency. Monitoring system in final stage of treatment should be provided.

For final effluent Standard see standard tables issued by National Environmental Protection Agency of Iran. Any new changes that occurred concerning Table 3 by National Environmental Protection Agency of Iran should be considered as part of this Standard..

TABLE 3 - NATIONAL EFFLUENT STANDARD FOR INDUSTRIAL WASTE

EFFLUENT CHARACTERISTIC	SURFACE WATER mg/ml	SOAKED AWAY WELL mg/ml	AGRICULTURE AND IRRIGATION mg/ml
Al	5	5	5
Ba	5	1	1
Be	0.1	1	0.5
B	2	1	1
Cd	0.2	0.2	0.2
Ca	75	-	-
Cr ⁺⁶	0.5	1	1
Cr ⁺³	2	2	2
Co	1	1	0.05
Cu	1	1	2.5
Li	2.5	2.5	2.5
Mg	100	100	100
Mn	1	1	1
Hg	Trace	Trace	Trace
Mo	0.01	0.01	0.01
Ni	2	2	2
Pb	3	3	3
Pb	1	1	1
Se	1	0.1	0.1
Ag	1	0.1	0.1
Zn	2	2	2
V	0.1	0.1	0.1
Radioactive	0	0	0
As	0.1	0.1	0.1
Cl	1	1	0.2
Cl ⁻	(Note 1) 60	(Note 6) 600	600
F	2.5	2	2
P	1	1	-
Cn	0.5	0.1	0.1
C ₆ H ₅ OH	1	Trace	1
CH ₂ O	1	1	1
NH ₃	2.5	1	-
NO ₂	10	10	-
NO ₃	50	10	-
SO ₄	(Note 2) 400	(Note 6) 400	500
SO ₃	1	1	1
T.S.S	(60 impulsive) 40	-	100
Settleable	(Note 3) 0	(Note 6) -	-
Sulfide	3	3	3
T.D.S	(Note 3)	(Note 6)	-
Oil and Grease	10	10	10
B.O.D	(Note 4) 50	(Note 4) 50	100
C.O.D	(Note 4) 100	(Note 4) 100	200
D.O	2	-	2
A.B.S	1.5	0.5	0.5
Turbidity	50	-	50
Color	Color Unit 75	Color Unit 75	75
T.	Note 5	-	-
	6.5-8.5		8.5
Ph	6.5-8.5	5-9	8.5
-	400/100 ml	400/100 ml	ml
M.P.N	1000/100 ml	1000/100 ml	ml

* Average daily sample.

Notes:

- 1) Not more than 600 if mixed with potable water.
- 2) Not increase more than 10% of sulfate content of receiving water to 200 meter.
- 3) Not increase more than 10% of total dissolved solid content of receiving water to 200 meter.
- 4) Decrease of BOD and COD effluent in comparison to 24 hr. inlet sample should not be less than 90%
- 5) Increase of temperature should not be more than 3°C and 200 meter from inlet.
- 6) Not more than 10% of potable water.

TABLE 4 - MAXIMUM EFFLUENT STANDARD FOR MUNICIPAL WASTE (DAILY AVERAGE)

EFFLUENT CHARACTERISTIC	UNIT	MAXIMUM CONCENTRATION	NOTE
BOD ₅	mg/l	30	Note 1
COD	mg/l	60	Note 2
Cl	mg/l	1	—
Chloroform	MPN	100/100 ml	—
Color	Color Unit	16	—
Detergents	mg/l	1.5	Equivalent to A.B.S
Dissolved Oxygen	mg/l	2	—
F	mg/l	2.5	—
Heavy Metals	—	—	Refer to industrial Effluent standard
Ammonia (as N)	mg/l	2.5	—
Nitrite (as N)	mg/l	50	—
Nitrate (as N)	mg/l	10	—
Oil and Grease	mg/l	10	—
Ph	—	6.5-8.5	—
Phosphate	mg/l	1	—
Settleable solid	mg/l	0.1	—
Suspended Solid	mg/l	40	Note 3
Sulfite	mg/l	400	Note 4
Sulfite	mg/l	1	—
Turbidity	N.T.U* (Previously J.T.U.)	50	—

*Nephelometric turbidity unit.

Notes:

- 1) BOD₅ should not increase to more than 50 mg/l.
- 2) COD should not increase to more than 120 mg/l.
- 3) S.S should not increase to more than 60 mg/l.
- 4) Should not increase the sulfate content of supply water more than 10%.

8. WATER MONITORING

8.1 Monitoring may be necessary for a number of reasons, such as:

- a) To measure water problems (what, where, why, when).
- b) To measure waste parameters for use in calculation of waste treatment charges for municipal or regional treatment system.
- c) To measure waste parameters to allow detection and triggering of emergency actions in case of spills or process upsets.
- d) To measure the effect of a wastewater discharge on the quality of a receiving body of water.
- e) To measure the quantity and quality of all process wastes as well as influent liquid raw materials
- f) To gather enough information on water used and contamination to allow design of pretreatment and/or reclamation systems.

LOGP Industries discharging to municipal or regional treatment systems shall be required to monitor their wastewater discharges or allow monitoring by others.

8.2 Design Considerations for a Water Monitoring System

8.2.1 The following for questions when preparing to establish a water monitoring program should be answered:

- a) What must be or should be monitored?
- b) When should samples be collected and monitoring equipment located?
- c) When should samples be collected and monitoring equipment located?
- d) How should monitoring be done? (Collection of samples, storage, analysis).

These four questions cannot always be completely answered in the sequence shown; usually information is gathered and tabulated and several questions are answered simultaneously. Conflicts may arise with selection of a monitoring station at a hazardous location because the proper type of explosionproof equipment necessary for the area is not available or is prohibitively expensive. In this case the "where" and "how" are not compatible and a compromise must be made. In general the parameters and the equipment which should be monitored, are covered in IPS-G-SF-880.