ENGINEERING STANDARD

FOR

SANITARY SEWAGE TREATMENT

CONTENTS :

PAGE No.

1. SCOPE

In this Engineering Standard, the characteristics and chemistry of sewage and its treatment methods in general are prescribed and guidances are given in particular for design of small sanitary sewage treatment, plants at Oil Industries' residential areas. Also guidances are given for the disposal of final effluents discharged from sewage treatment works.

2. REFERENCES

In this Standard the following standards are referred to and to the extent specified, form a part of this Standard:

BSI (BRITISH STANDARDS INSTITUTION)

BS 6297: 1983	"Design and Installation of Small Sewage Treatment Works and Cesspools"
BS 8007: 1987	"Design of Concrete Structures for Retaining Aqueous Liquids"
BS 1438: 1971(1983)	"Media for Biological Percolating Filters"

IPS (IRANIAN PETROLEUM STANDARDS)

E-CE-380	"Sewerage & Surface Water Drainage System"
E-CE-390	"Rain & Foul Water Drainage of Buildings"
M-CE-345	"Water Supply and Sewerage Equipment"
E-PI-240	"Plant Piping Systems"
E-PR-730	"Process Design of Plant Waste Water Treatment and Recovery Systems"
E-PR-735	"Process Design of Plant Solid-Waste Treatment and Disposal Systems"
E-SF-880	"Water Polution Control"

3. DEFINITIONS AND TERMINOLOGY

For definitions related to this Standard refer to Clause 3 of BS 6297: 1983, together with definitions set out in IPS-E-CE-380.

4. UNITS

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

5. STANDARDS OF SEWAGE EFFLUENTS

For the protection of aquatic environment and the maintenance of water quality in lakes, reservoirs, streams, rivers, estuaries and the sea, sewage-treatment works should be designed to reduce the strength of sewage to a figure which may be expected to ensure complete avoidance of nuisance in the circumstances in which the sewage is discharged.

5.1 Receiving-Water Standards

The setting of receiving-water standards comes under the jurisdiction of "Environmental Protection Organization of Iran". Hence the maximum concentrations of the contaminants for domestic and industrial wastewaters included in their latest issued booklet should be respected with the stipulation that no discharge shall create conditions that would violate them. For the standards of the above mentioned organization extracted from their latest booklet of 1371 refer to IPS-E-SF-880 "Water Pollution Control".

5.2 IPS Standards for Final Effluents of Domestic Wastewater Plants

Apart from setting of maximum permissible concentrations in respect to BOD_5 and suspended solids, which are the most important factors, it should be obvious that oil, grease, and floating solids should be removed from wastes before discharge to receiving waters. As regards the (BOD_5) and (SS), the final effluent i.e. the end product of sewage treatment plants is considered satisfactory if it contains not more than 30 part per million of suspended solids and does not absorb more than 20 ppm* of dissolved oxygen in five days.

A final effluent of this strength and turbidity when discharged into rivers is being assumed that the minimum flow of the river will further dilute the effluent by at least eight volumes of river water to one of effluent. Where this degree of dilution in discharging final effluents of base mentioned effluent standards into water courses is not available, a higher degree of purification may be advisable. On the other hand where the dilution is great, as in tidal estuaries, less stringent standards might be permitted. However, in certain instances of inland discharges, the standard of 30 ppm suspended solids and 20 ppm BOD_5 might be acceptable without further dilution of at least eight times, mentioned above, providing there are no water intakes downstream of the effluent outfall within a safe distance of 50 km. For the acceptable limits of complementary chemical and biological contaminants of final effluents, the Tables B/1 and B/2 of "Environmental Protection Organization of Iran" should be referred.

6. METHODS OF SEWAGE TREATMENT-GENERAL

The primary aim of sewage treatment is to retain the sewage in circumstances in which it is in contact with the air and acted upon by aerobic organisms for a sufficient time to oxidize the organic contents to a sufficient degree for the effluent to be safely passed to the natural waters without any fear of causing a nuisance.

The contaminants in wastewater are removed by physical, chemical, and biological means. The operations involved are classified as physical unit operations, chemical unit processes and biological unit processes.

6.1 Conventional Methods

The conventional methods of treatment, apart from treatment by dilution, fall under three heads. Treatment on land through septic tank, treatment in biological "filters," and treatment by the activated sludge processes.

7. CHOICE OF SYSTEM-GENERAL

The type of sewage treatment plants to be adopted in any particular instance depends on:

- **a)** The system which will involve the minimum of running costs and annual repayments of cost of construction.
- **b)** The extent to which minor nuisance due to flies or sewage works odor matter in the location concerned.
- **c)** The area of land available and the suitability of the land for each of the methods of treatment.
- **d)** The degree of treatment required.
- **e)** The available fall from incoming sewer at battery limit of the plant to point of outfall.

These together form a common sense economic problem to which there should be only one correct answer in any particular instance. In fact, however, decisions as to type of works too often depend on the preferences of individual engineers and on what may be considered fashionable at the time.

*** ppm = mg/L = g/m³ of liquid**

8. DESIGN OF SEWAGE TREATMENT PLANTS-GENERAL GUIDANCES

Sewage treatment works are designed on the quantity of sewage to be treated and the strength of the sewage i.e. the degree of organic pollution. Were sewages generally more constant in consistency than they are, it would be quite possible to design accurately in terms of head of population to be served, but sewages vary considerably according to the amount of water used per head of population, the degree of infiltration of subsoil water, and the quantity and nature of trade waste. In the case of purely or almost purely domestic sewage from a normal town, where waterclosets are generally installed, the size of the aeration unit of the sewage works (land, percolating filter or aeration tank) can be and sometimes is, determined according to the population to be served. But in most other cases, the aeration unit is sized according to the strength of the sewage as determined by analysis, and the average dry-weather flow.

In this Engineering Standard general guidance is given on adequate design only. Particular requirements should be determined by local conditions. Hence, the given recommendations can be supplemented as required by skilled engineering advice, if any, based on a knowledge of sewage works practice.

9. DESIGN OF SMALL SEWAGE TREATMENT PLANTS

The design guidances and criteria given under this clause deal with engineering of sewage treatment works suitable for the domestic discharge from domestic and industrial communities ranging from single households up to about 1000 population equivalent and with the storage of sewage by means of a cesspool, the contents of which are periodically removed for disposal or treatment. For design details refer to BS 6297, Clause 8. Domestic discharges are taken to include those from schools, hotels, restaurants, etc. but excluding the treatment of trade effluents, or the effluent from chemical closets.

Note:

Provision of cesspools if possible should be avoided and instead, at least, septic tanks should be provided. In Tehran, disposal of raw sewage in deep wells of around 40 meter depth is still practiced and permitted by the municipality, for which refer to IPS-E-SF-880.

9.1 Collection of Information

For designing small sewage treatment plants the following main items of basic data should be obtained and considered.

a) Any requirements of the local municipality over and above the permissible effluent standards of this Standard and that of the Iran's "Environment Protection Organization".

b) Minimum and maximum number of persons (resident and non-resident) to be served.

c) Average 24 h water consumption, and any special conditions affecting the composition of sewage and peak rates of flow; data are obtainable from the local water authorities in many instances.

d) Existence of infiltration water.

e) Particulars of site:

1) distance from nearest habitable building;
2) prevailing winds;
3) levels;
4) information as to the nature of the ground including the level and variations of the water table;
5) access for vehicles and plant.

f) Particulars of outfall, e.g. tidal or inland waters, rivers, streams, ditches or soakage; also the proximity, highest known flood level and minimum flow of any stream or other watercourse to which discharge of the effluent is possible.

g) Conditions under which the works will normally operate and be maintained;

h) Possibility of the need for future extensions of the works or of their elimination by a comprehensive scheme;

i) Availability of electric power and mains water;

j) Facilities for eventual disposal of sludge and screenings.

9.2 Design Guidances

9.2.1 Climatic considerations

The engineering guidances and design factors given in this Standard are for temperate conditions only. Hence, specialist advice should be sought where appropriate and whenever climatic considerations demand special methods of treatment. The performance of treatment units varies with changes in temperature, exposure and altitude. Prevailing weather also affects the operation of the works e.g. the dislodging of tanks may have to be done more frequently in hot conditions. Similarly, during periods of frost, trickling filters and mechanical plant may be affected by freezing.

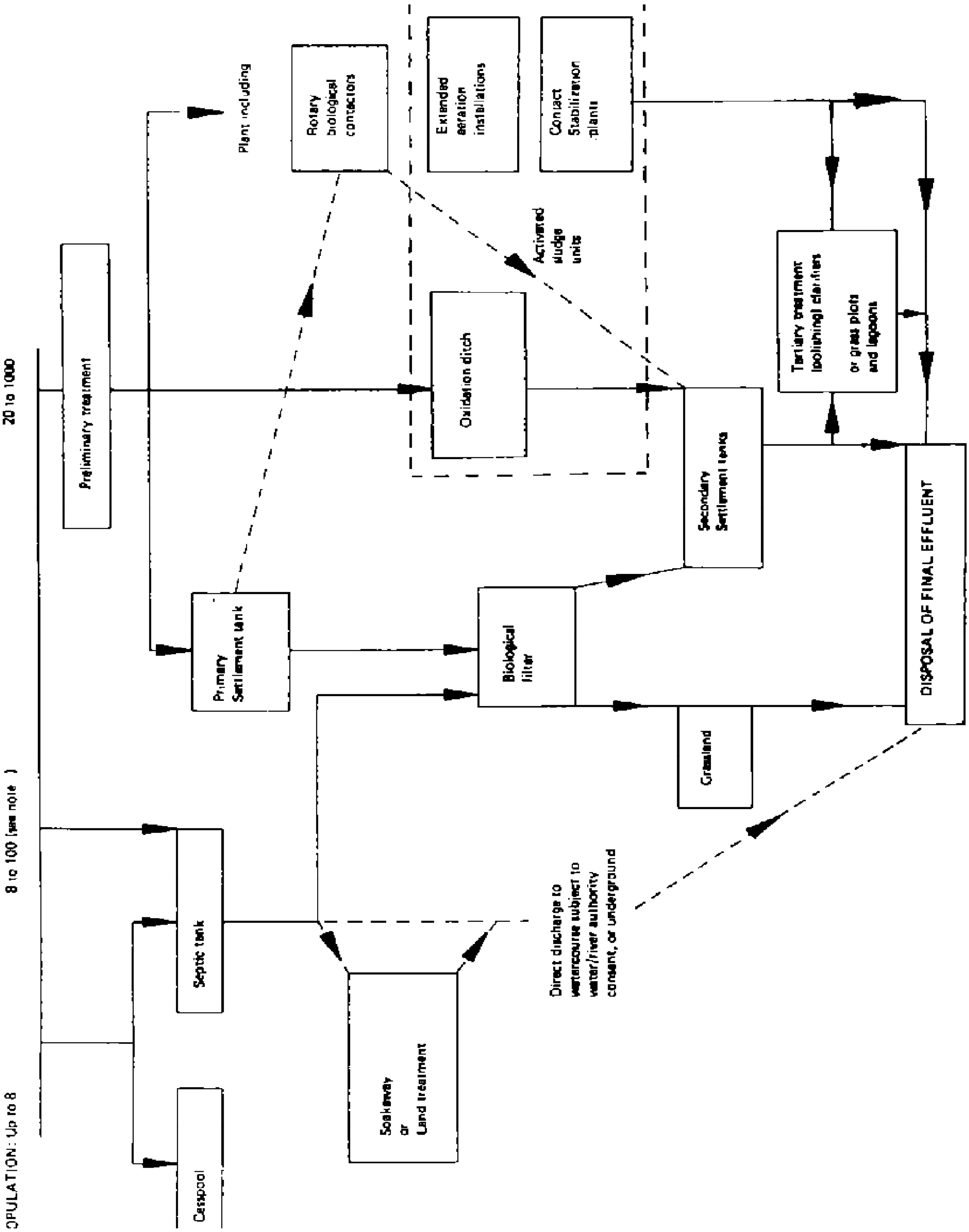
9.2.2 Types of treatment plants

Broad options of treatment works for small communities with ranges of population up to 8 to 100 and 20 to 1000 are shown graphically in flow chart pattern in Fig. 1. Before any process or combination of processes is adopted, the latest demanded standard of final effluent should be obtained from the responsible authorities. The normal requirements are 30 mg/L max. suspended solids and 20 mg/L max. BOD, usually referred to as "30:20".

9.2.3 Location and safety

9.2.3.1 Siting

Sewage treatment works should be as far from habitable buildings as is economically practicable. The direction of the prevailing wind should be considered in relation to any properties when siting the works. A small treatment works serving more than one premise incorporating conventional biological treatment should be a minimum of 25 m from any dwelling and this should be progressively increased for larger treatment works. Treatment units should not be located in an area subject to flooding or where the water table can rise to such levels as to cause flow into the treatment units.



SEWAGE TREATMENT: BROAD OPTIONS FOR SMALL COMMUNITIES

Fig. 1

Note:

The population ranges are not mutually exclusive.

9.2.3.2 Safety

Full consideration should be given to the safety requirements in the design of sewage treatment works. They should be adequately fenced against unauthorized interference to prevent potential accidents.

For safety requirements of stairs, ladders and platforms see IPS-E-SF-400 and for requirements of gas masks, respirators and personal protective clothing see IPS-G-SF-140 and IPS-M-SF-325 respectively.

9.3 Septic Tanks

9.3.1 General design considerations

The designer should make adequate provision, where appropriate, for unusual pollution loads. These may arise from establishments such as hospitals, hotels etc. Domestic use of detergents and disinfectants is not detrimental but excessive use may have a harmful effect on the performance of the works.

Excessive quantities of grease and oil may cause malfunction of a small sewage works. In such cases, arrangements should be made where practicable for grease and oil to be removed at source or for them to be excluded from the sewerage system.

A septic tank installation provides only partial treatment of sewage but is permissible without undue risk of pollution in some locations. Biological treatment to follow primary settlement may be necessary and in some cases, a further polishing stage is required.(see Clause 14 of BS 6297).

9.3.2 Requirements for tanks

It is essential that tanks constructed to hold or treat sewage. e.g. cesspools, septic tanks, primary and secondary settlement tanks and chambers, should be of watertight construction so that they permit neither ingress of ground water nor egress of sewage to the ground.

Engineering bricks, concrete bricks, in situ concrete and large precast concrete pipes are all used for the construction of tanks. Brickwork should normally be in cement mortar and of not less than 229 mm nominal thickness. In situ concrete for walls, floors and surrounds should be not less than 150 mm thick.

A roof should be provided to a septic tank, in which case it may be wholly or partially removable and be of concrete. If fixed, the roof should have adequate access openings, with covers, including those necessary for inspection and cleansing of the inlet and outlet arrangements. Where it is not roofed a septic tank should be provided with a protective fence to prevent unauthorized access. Materials should be adequately protected against corrosion and electrolytic attack where appropriate.

Cesspools and septic tanks should be adequately ventilated and access to rod the horizontal inlet pipe should be provided. An integral inspection chamber can be provided.

9.3.3 Sizing of tanks

For sizing of tanks designed and constructed to hold or treat sewage for small communities, the following design criteria should be adopted:

9.3.3.1 Capacity

Calculation of the total capacity of septic tanks for the populations covered by this Standard should be made on the basis of the number of persons to be served, and the following formula is recommended for general use, where dislodging is carried out at not more than 12 monthly intervals:

C = (180 P + 2000)

Where:

C is the capacity of the tank (in L) with a minimum value of 2720 L; and
P* is the design population with a minimum value of 4.

This formula allows for proportionately larger retention at the lower populations in order to cover the surges in flow which are experienced in small systems.

For schools, similar premises and hotels, capacity requirements can be evaluated separately or included in the general formula using population equivalent ** figures for P after taking into account factors such as part-time occupancy and shared cooking facilities:

Where multi-compartment tanks are used, the inlet (settlement) zone should have a capacity of not less than 2/3 C and the subsequent zones should have a combined capacity of not less than 1/3 C.

The calculated capacity C is recommended as a minimum for all types of septic tanks and the Figure of 180 in the formula may be regarded as made up as follows:

SLUDGE STORAGE CAPACITY	L	
Blance to cover		90
a) 12 h storage of average domestic water usage of 120 L per head per day assumed as passing to drains.	60	90
b) Higher consumptions and/or infiltration etc.	30	
Total	180	

Capacities may, however, be increased to take account of particular circumstances (use of high consumption fittings, projected growth in water usage, reliable information on infiltration, etc.).

9.3.3.2 Arrangement

The design of septic tanks should be such that the discharge of solids in the tank effluent is kept to a minimum. This is best achieved by the use of tanks in series, either by constructing two separate tanks or by dividing a single tank into two by a partitiones, In either case the compartments should be not less than 1200 mm deep below TWL for up to 10 persons and not less than 1500 mm deep below TWL for larger populations. The first compartment should have a length of not less than twice its width. In the larger installations serving over 30 persons, a baffle should be provided at the inlet and a scumboard at the outlet.

In order to facilitate dislodging operations, the floor of the first compartment should have a fall of 1:4 towards the inlet end.

Tanks should be provided with a valve-controlled sludge pipe not less than 100 mm in diameter at their lower end, arranged so as to discharge to a sludge drying bed or beds. Positioning the sludge pipe slightly above the floor level of the tank will facilitate the retention of a proportion of the sludge for reseeding purposes.

*** Design population means the minimum and maximum number of persons (resident and non-resident) to be served.**

**** Population Equivalent = The equivalent, in terms of fixed population, e.g. of a hospital or resturant, based upon a figure of 0.06 kg BOD per head/day, or 120 L per head/day.**

9.3.3.3 Inlets and outlets

The design of septic tank inlets and outlets should be such as to introduce the crude sewage and to remove the clarified liquid with the least possible disturbance of the settled sludge or the surface scum.

A satisfactory form of inlet for rectangular tanks not more than 1200 mm wide is a T-shaped dip pipe of cast iron or other suitable material not less than the nominal bore of the incoming drain, fixed inside the tank, with the top limb rising above scum level and the bottom limb extending about 450 mm below TWL.

For tanks in excess of 1200 mm in width, two submerged inlets having inverts at the same level are preferable.

For duplicate tanks each of which is in excess of 1200 mm in width and the flow divided equally by forming a crested weir see Clause 9.3 of BS 6297.

The final outlet for tanks which are less than 1200 mm wide should be by a 100 mm nominal bore dip pipe of cast iron or other suitable material fixed inside the tank in a similar manner to the inlet dip pipe and 25 mm below it. For wider tanks it is necessary to use a weir outlet extending the full width of the tank and protected by a scumboard, e.g. of suitable protected timber, plastics or asbestos cement fixed 150 mm from the weir and extending 150 mm above and 450 mm below TWL. It is important that the top edge of the weir be 'true' and set level 50 mm below the inlet drain.

A deflector should be formed either in the structure of the end (outlet) wall or by a purpose-made deflector to prevent rising particles from reaching the outlet weir. This deflector should be located 150 mm below the base of the scumboard and protrude 150 mm into the tank

Consideration should be given to the provision of access to the outlet pipe for rodding.

Where two or more tanks are served by a common incoming drain or sewer it is important that the invert of the outlet dip pipes serving tanks up to 1200 mm wide and of the weirs serving tanks more than 1200 mm wide are set at precisely the same level.

For general arrangement of Septic Tanks see Std. Drwg. No. IPS-D-CE-402.

9.3.3.4 Further treatment of septic tank effluent

When required, further treatment of septic tank effluent should be carried out by the use of a biological filter or disc.

Where this is not practicable, the tank effluent may be given treatment on land. This latter method is unlikely to produce an effluent satisfying a 30:20 standard. There are two ways by which this can be carried out, but the dangers arising from pollution of local water supplies, from airborne and fly-borne contamination of food and from rat infestation, should be carefully considered.

9.4 Preliminary Treatment

Rags and floating debris will inevitably form part of the flow reaching the works and to reduce blockages and fouling of plant, particularly with larger installations, one of the following methods may be adopted:

a) The placing of a small metal screen with 30 mm to 75 mm clear spacing between the vertical bars in the inlet channel. Provision should be made for overflow or by-pass of the screen in the event of blockage. Provision should also be made for the regular and safe disposal of screenings.

b) The provision of a macerator in the inlet channel of pipe to chop up all the debris before it enters the plant.

c) If the sewage has to be pumped at any stage before treatment, a pump incorporating a cutting edge or a separate macerator unit.

9.5 Primary and Secondary Settlement Tanks

The efficiency of a settlement tank is dependent on the velocity of the flow, which is determined by the tank dimensions. In small sewage treatment works in particular, the considerable variations in flow which occur can reduce settlement efficiency.

Settlement tanks may be of the horizontal flow or upward flow type. The latter type is generally more expensive to construct than a horizontal flow tank, but it has distinctive advantages.

Facilities should be provided for the regular removal of sludge, which is crucial to the performance of all settlement tanks. In normal operation, tanks should be desludged at least once each week.

Unless otherwise specified, scum retention boards and removal facilities should be provided for settlement tanks, since small sewage treatment works are more likely to receive relatively high proportions of oils, fats and grease than are large works.

9.5.1 Primary settlement tanks

Primary settlement tanks are used to settle out solids prior to biological treatment and thus reduce the BOD load on following units. They should not normally be used for populations of fewer than about 100.

9.5.1 Capacities of primary settlement tanks

a) Upward flow tanks

The arrangement of an upward flow settlement tank should be such that the nominal upward flow velocity through it is less than the settling velocity of the material to be removed. A figure of 0.9 m/h at maximum flow rate is recommended. Where the maximum flow rate is unknown, the surface area of the tank may be calculated from the formula:

$$\mathbf{A = \frac{1}{10} P^{0.85}}$$

Where:

A is the minimum area (in m²) of the tank at the top of the hopper; and
P is the design population (see * in Clause 9.3.3.1).

This formula allows for increased variability of flow rates which occurs as populations decrease. It is based on a dry weather flow of 180 L per head per day but should be adjusted pro rata for other values of the dry weather flow. The dimensions and capacity of the hopper can be determined from a knowledge of its volume and surface area.

b) Primary horizontal flow tanks

The calculation of the capacity of a horizontal flow tank should be based on the number of persons to be served and the dry weather flow. The detention period should not exceed 12 h at dry weather flow and the following formula is recommended:

$$\mathbf{C = 180\ P^{0.85}}$$

Where:

C is the gross capacity of the tank (in L); and
P is the design population (see * Clause 9.3.3.1).

This formula allows for the increased variability in flow rates which occurs as populations decrease. It is based on a dry weather flow of 180 L per head per day but should be adjusted pro rata for other values of the dry weather flow.

9.5.2 Secondary settlement tanks

Secondary settlement tanks, usually known as humus tanks when used in conjunction with biological filters, are essential components of secondary sewage treatment where a 30:20 or better quality effluent is required. They are installed immediately following biological treatment, either as independent units or as integral parts of packaged systems.

The design principles for secondary settlement tanks are similar to those for primary tanks. For design, constructional and operational convenience it may be desirable to make secondary settlement tanks of equal size to primary tanks. Otherwise, the formulae in 9.5.2.1 (a) & (b) for determining capacities are recommended.

9.5.2.1 Capacities of secondary settlement tanks

a) Upward flow tanks

The surface area should be not less than:

$$A = \frac{3}{40} P^{0.85}$$

Where:

A is the minimum area (in m²) of the tank at the top of the hopper; and
P is the design population (see * Clause 9.3.3.1).

This formula is based on a dry weather flow of 180 L per head per day and allows for increased variability of flow rates at small populations. It may be adjusted pro rata for other values of dry weather flow.

b) Secondary horizontal flow tanks

The calculation of the capacity of a horizontal flow tank should be based on the number of persons to be served and the dry weather flow. The following formula is recommended:

$$C = 135\ P^{0.85}$$

Where:

C is the gross capacity of the tank (in L); and
P is the design population (see * Clause 9.3.3.1).

This formula is based on a dry weather flow of 180 L per head per day and allows for increased variability of flow rates at small populations. It may be adjusted pro rata for other values of dry weather flow. Use of the formula will give gross detention periods of less than 9 h at dry weather flow for all values of dry weather flow and a population in excess of 100.

It is also recommended that the surface area of the tanks be not less than that determined by means of the formula given in 9.5.2.1 (a).

9.6 Biological Filters

In a conventional biological filter, the effluent from a septic tank or a primary settlement tank is brought into contact with a suitable medium, the surface of which becomes coated with a biological film. The film assimilates and oxidizes much of the polluting matter through the agency of micro-organisms. The biological filter requires ample ventilation and an efficient system of underdrains leading to an outlet.

9.6.1 Distribution

The effluent should be distributed evenly over the surface of the biological filter, through which it percolates to the floor. Biological filters are usually either rectangular or circular in plan, and various methods of distribution may be used. the most suitable for use in small installations being a series of fixed channels or a rotating-arm distributor.

9.6.2 Volume of filter

It is essential that the volume of filter medium provided is sufficient to allow for surge flows which occur with small installations, such variations being more pronounced the smaller the number of persons served. The volume of mineral medium required can be calculated by the formula:

$$V = 1.5\ P^{0.83}$$

Where:

V is the volume of medium (in m^3); and
P is the design population.

In Table 1, the volumes of medium required for representative numbers of users are given; intermediate values may be interpolated on a linear basis. The volume of medium per user is also given and it can be seen that surge flows are allowed for.

TABLE 1 - FILTER MEDIUM CAPACITY

P	4	6	8	10	15	20	25	30	40	50
V	4.7	6.6	8.4	10.1	14.2	18.0	21.7	25.2	32.0	38.6
V/P	1.18	1.11	1.05	1.01	0.95	0.90	0.87	0.84	0.80	0.77
P	100	200	300	400	500	600	700	800	900	1000
V	69	122	171	217	261	303	345	385	425	464
V/P	0.69	0.61	0.57	0.54	0.52	0.51	0.49	0.48	0.47	0.46

9.6.3 Mineral filter media

Mineral filter media should comply with the requirements of BS 1438 and be chosen with regard to the following considerations.

a) It should be strong enough to resist crushing under its own weight or when walked on.

b) It should be obtained washed and dust-free.

c) It should not contain any toxic substances or other undesirable matter likely to be dissolved into the sewage flow.

d) It should be capable of resisting breakdown due to the flow of the sewage or under frost action.

e) The general shape of the individual pieces should be roughly cubical rather than very elongated or flat.

f) The surface of the pieces should preferably be rough and pitted.

g) Local availability, having regard to suitability.

Several mineral materials are suitable for this purpose, the most usual being hardburnt clinker, blastfurnace slag, hard broken stones and hard crushed gravel. Efficiency is dependent on careful grading; a suitable grading for mineral media is 100 mm to 150 mm at the bottom for a depth of about 150 mm, the remainder being 50 mm nominal maximum size which requires, in accordance with BS 1438, the grading limits given in Table 2.

TABLE 2 - GRADING LIMITS FOR 5 mm FILTER MEDIUM

BS 410 TEST SIEVES	PROPORTION BY MASS PASSING
mm	%
63	100
50	85 to 100
37.5	0 to 30
28	0 to 5

For general information about design and ventilation of biological filters refer to Clause 12 of BS 6297.

9.7 Activated Sludge Units

For the purposes of this Standard, installations operating on activated sludge principles are those providing for the aeration of crude unsettled sewage with activated sludge. An important feature of these installations is that a long period of aeration should be provided at some stage in the process in order to bring about oxidation of sludge, thus reducing the rate of production of surplus sludge and the frequency with which this sludge should be removed. In all activated sludge systems there is a need regularly to remove quantities of surplus sludge. For location, general requirements, types of installation and settlement of activated sludge refer to Clause 13 of BS 6297.

9.8 Tertiary Treatment (Polishing) Processes

Conventional biological treatment can produce an effluent of 30:20 standard (SS:BOD), or better, after separation of solids, but for reliable production of higher quality effluents a tertiary or ’polishing’ stage of treatment is necessary before final disposal. Polishing processes rely mainly on flocculation, sedimentation or filteration of residual suspended solids, directed toward further reduction in ammonia and organic nitrogen, phosphorus, refractory organics and dissolved solids.

The BOD associated with the solids is removed and some methods also provide further biological purification. Polishing is suitable only for dealing with good quality secondary effluents and, in general, will operate efficiently only at works where biological treatment is adequate. If a suitably chosen polishing process is applied to a good quality secondary effluent it should normally be possible to achieve at least 10:10 standard. Several methods are now available.
These include slow sand filteration, rapid sand filteration, microstraining and retention in lagoons. In small sewage treatment works the following methods are more common:

a) Treatment over grass plots.
b) Upward-flow clarifiers (not normally used with activated sludge plants).

For general description of the above mentioned sewage treatment methods refer to Clause 14.2 and 14.3 of BS 6297.

9.9 Disposal of Final Effluent

After treatment, the disposal of final effluent should be by one of the following methods:

a) Despposal to inland or tidal water;
b) Disposal to underground strata;
c) Disposal on land;
d) Drying and disposal of sluge.

For general description of Paragraphs (a) through (d) refer to Clauses 15.2 through 15.5 of BS 6297.

10. ADVANCED WASTEWATER TREATMENT

With due reference to Clause 9.8, many of the substances found in wastewater are not affected, or are little affected by conventional treatment operations and processes. These substances range from relatively simple inorganic ions, such as calcium, potassium, sulfate, nitrate, and phosphate, to an ever-increasing number of highly complex synthetic organic compounds. As the effects of these substances on the environment become more clearly understood, it is anticipated that treatment requirements will become more stringent in terms of the allowable concentration of many of these substances in the effluent from wastewater treatment plants. In turn, this will require advanced wastewater treatment facilities, which nowadays are not used extensively.

10.1 Effects of Chemical Constituents in Wastewater

The typical composition of domestic wastewater is shown in Table 3. Most domestic wastewaters also contain a wide variety of trace compounds and elements, although they are not measured routinely. If industrial wastewater is discharged to domestic sewers, the distribution of the constituents will vary considerably from that reported in Table 3. Some of the substances found in wastewater and the concentrations that may cause problems when discharged to the environment are shown in Table 4. This list highlights the fact that a wide variety of substances must be considered and that they will vary with each treatment application.

TABLE 3 - TYPICAL COMPOSITION OF UNTREATED DOMESTIC WASTEWATER (ALL VALUES EXCEPT SETTLEABLE SOLIDS ARE EXPRESSED IN mg/l)[a)]

CONSTITUENT	CONCENTRATION		
	Strong	**Medium**	**Weak**
Soilds, total	1200	720	350
Dissolved, total	850	500	250
Fixed	525	300	145
Volatile	325	200	105
Suspended, total	350	220	100
Fixed	75	55	20
Volatile	275	165	80
Settleable solids, mL/L	20	10	5
Biochemical oxygen demand, 5-day 20°C (BOD_5, 20°C)	400	220	110
Total Organic Carbon (TOC)	290	160	80
Chemical Oxygen Demand (COD)	1000	500	250
Nitrogen (total as N)	85	40	20
Organic	35	15	8
Free Ammonia	50	25	17
Nitrites	0	0	0
Nitrates	0	0	0
Phosphorus (total as P)	15	8	4
Organic	5	3	1
Inorganic	10	5	3
Chlorides[b)]	100	50	30
Alkalinity (as $CaCO_3$)[b)]	200	100	50
Grease	150	100	50

Notes:

a) mg/L = g/m³.

b) Values should be increased by amount in domestic water supply.

TABLE 4 - TYPICAL CHEMICAL CONSTITUENTS THAT MAY BE FOUND IN WASTEWATER AND THEIR EFFECTS

CONSTITUENT	EFFECT	CRITICAL CONCENTRATION mg/L
Inorganic Ammonia	Increases chlorine demand; toxic to fish; can be converted to nitrates and, in the process, can deplete oxygen resources; with phosphorus, can lead to the development of undesirable aquatic growths	Any amount variable[a)] Any amount
Calcium and Magnesium	Increase hardness and total dissolved solids	250
Chloride	Imparts salty taste; interferes with agricultural and industrial processes	75-200
Mercury	Toxic to humans and aquatic life	0.00005
Nitrate	Stimulates algal and aquatic growth can cause	0.3[b)]
	Methemoglobinemia in infants (blue babies)	10[c)]
Phosphate	Stimulates algal and aquatic growth; interferes with	0.015[b)]
	Coagulation; interferes with	0.2-0.4
	Lime-soda softening	0.3
Sulfate	Cathartic action	600-1000
Organic		
DDT	Toxic to fish and other aquatic life	0.001
Hexachloride	May be related to the development of cancer; also	0.02
Petrochemicals	May cause taste and odor problems in water	0.005-0.1
Phenolic compounds		0.0005-0.001
Surfactants	Cause foaming and may interfere with coagulation	1.0-3.0

Notes:

a) Depends on pH and temperature.
b) For quiescent lakes.
c) U.S Environmental Protection Agency.

10.2 Advanced Wastewater-Treatment Operations and Processes

Unit operations and processes that have been applied to the further treatment of wastewater can be classified as physical, chemical, and biological.

Although the final effluent requirement of "Iran's Environmental Protection Organizations" (IEPO) for domestic sewage treatment (Clause 6.2 and IPS-E-SF-880) are such that usually do not necessitate use of advanced wastewater treatment methods, however the brief description of the physical, chemical, and biological processes involved are given in Table 5.

TABLE 5 - ADVANCED WASTEWATER-TREATMENT OPERATIONS AND PROCESSES

Description	Type of waste-water treated[a]	Principal or major use	Waste for ultimate disposal
Physical unit operations			
Air stripping or ammonia	EST	Removal of ammonia nitrogen	None
Filtration.			
multimedian	EST	Removal of suspended solids	Liquid and sludge
Diatomite bed	EST	Removal of suspended solids	Sludge
Microstrainers	EBT	Removal of suspended solids	Sludge
Distillation	EST nitrified + filtration	Removal of dissolved solids	Liquid
Electrodialysis	EST + filtration - carbon adsorption	Removal of dissolved solids	Liquid
Flotation	EPT. EST	Removal of suspended solids	Sludge
Foam fractionation	EST	Removal of refractory organics, surfactants, and metals	Liquid
Freezing	EST + filtration	Removal of dissolved solids	Liquid
Gas-phase separation	EST	Removal of ammonia nitrogen	None
Land application	EPT. EST	Nitrification. denitrification. removal of ammonia nitrogen and phosphorus	None
Reverse osmosis	EST + filtration	Removal of dissolved solids	Liquid
Sorption	EBT	DDIS	Liquid and sludge
Chemical unit processes			
Breakpoint chorination	EST (filtration)	Removal of ammonia nitrogen	Liquid
Carbon adsorption	EPT. EST (filtration)[b]	Removal of dissolved organics, heavy metals, and chlorine	Liquid
Chemical precipitation	EBT	Phosphorus precipitation, removal of heavy metals, removal of colloidal solids	Sludge
Chemical precipitation in activated sludge	EPT	Removal of phosphorus	Sludge
Ion exchange	EST + filtration	Removal of ammonia and nitrate nitrogen	Liquid
Electrochemical treatment	Untreated	Removal of dissolved solids	Liquid and sludge
Oxidation	EST	Removal of refractory organics	None
Biological unit processes			
Bacterial assimilation	EPT	Removal of ammonia nitrogen	Sludge
Denitrification	Agricultural return water	Nitrate reduction	None
Harvesting of algae	EBT	Removal of ammonia nitrogen	Algae
Nitrification	EPT. EBT	Ammonia oxidation	
Nitrification-denitrification	EPT. EBT	Total nitrogen removal	Sludge

Note:

a) EPT = Effluent from Primary Treatment;
EBT = Effluent from Biological Treatment;
EST = Effluent after Secondary Treatment.

b) Optional.

11. EFFLUENT DISPOSAL AND REUSE

The sanitary engineer can design a treatment plant to accomplish as much removal of pollutants as may be required. Ultimate disposal of wastewater effluents will be by dilution in receiving waters; by discharge on land; or, in some cases in desert areas, by evaporation into the atmosphere as well as seepage into the ground. Disposal by dilution (after secondary treatment) in larger bodies of water, such as lakes, rivers, estuaries, or oceans, is by far the most common method. The proportion of the self-purification capacity, sometimes called the assimilative capacity of the receiving waters, should not be exceeded.

11.1 Direct and Indirect Reuse of Wastewater

It is generally impossible to reuse a wastewater completely or indefinitely. The reuse of treated effluent by direct or indirect means is a method of disposal that complements the other disposal methods.

The amount of effluent that can be reused is affected by the availability and cost of fresh water, transportation and treatment costs, water-quality standards, and the reclamation potential of the wastewater. Water reuse may be classified according to use as:

1) municipal,
2) industrial,
3) agricultural,
4) recreational, and
5) groundwater recharge.

Direct and indirect reuse applications for these uses are shown in Table 6.

11.1.1 Municipal reuse

Direct reuse of treated wastewater as drinking water, after dilution in natural waters to the maximum possible extent varies only in degree from the situation existing on many rivers that are used for both water supply and waste disposal.

TABLE 6 - POTENTIAL USES OF RENOVATED WATER

USE	DIRECT	INDIRECT
Municipal	Park or golf course watering; lawn watering with separate distribution system; potential source for municipal water supply	Ground water recharge to reduce aquifer, aquifer overdrafts
Industrial	Cooling tower water; boiler feed water; process water	Replenish groundwater supply for industrial use
Agricultural	Irrigation of certain agricultural lands, crops, orchards, pastures, and forests; leaching of soils.	Replenish groundwater supply for agricultural overdrafts
Recreational	Forming artificial lakes for botaing, swimming, etc.; swimming pools.	Develop fish and waterfowl areas
Other	Groundwater recharge to control saltwater intrusion; saltbalance control in groundwater; wetting agent-solid waste compaction	Groundwater recharge to control land subsidence problems; soil compaction. Oil well repressurizing

Advanced methods of wastewater and water treatment, such as demineralization and desalination, are capable of almost complete removal of impurities, and water treated by such methods, after chlorination, is safe to drink. These methods are very expensive and, where they are found to be necessary due to inadequate water supplies, may be economically feasible only if a dual supply system is adopted. In such cases, adequately treated and disinfected waste-water effluents could be reused for flushing toilets, yard watering, and other direct applications.

11.1.2 Industrial reuse

Industry is probably the single greatest user of water in the world, and the largest of the industrial water demands is for process cooling water. However reuse of final effluents of wastewater treatment plants within the petrochemical plants to replace a portion of the need of industrial water is not recommended.

11.1.3 Agricultural reuse

The types of crops that can be irrigated with reclaimed wastewater depend on the quality of the effluent, the amount of effluent used, and the health regulations concerning the use of treated and untreated wastewater on crops. Health considerations prohibit the use of untreated wastewater.

However, the final effluents meeting the secondary treatment requirements can be used for irrigation of certain field crops such as cotton with the permission of "IEPO".

11.1.4 Recreational reuse

Golf-course and park watering, establishment of ponds for boating and recreation, and maintenance of fish or wildlife ponds are methods for the recreational reuse of water. Today's technology allows the production of an excellent effluent that is well suited for the purposes described. The use of treated effluent for park watering has been practiced for many years in western countries.

11.1.5 Groundwater recharge

Ground water recharge is one of the most common methods for combining water reuse and effluent disposal. Recharge has been used to replenish groundwater supplies in many areas of the United States. Another possible effluent use is in the recharging of oil-bearing strata. Oil companies have conducted much research on flooding techniques to increase the yield of oil-bearing strata.