



ENVIRONMENTAL PROTECTION AGENCY

An Ghníomhaireacht um Chaomhnú Comhshaoil

**WASTEWATER
TREATMENT MANUALS
PRELIMINARY
TREATMENT**

This document
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WASTE WATER TREATMENT MANUALS

PRELIMINARY TREATMENT

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WASTEWATER TREATMENT MANUALS

PRELIMINARY TREATMENT

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The Environmental Protection Agency was established in 1993 to licence, regulate and control activities for the purposes of environmental protection. In Section 60 of the Environmental Protection Agency Act, 1992, it is stated that *"the Agency may, and shall if so directed by the Minister, specify and publish criteria and procedures, which in the opinion of the Agency are reasonable and desirable for the purposes of environmental protection, in relation to the management, maintenance, supervision, operation or use of all or specified classes of plant, sewers or drainage pipes vested in or controlled or used by a sanitary authority for the.....disposal of any sewage or other effluent to any waters"*. Criteria and procedures in relation to the treatment and disposal of wastewater are being published by the Agency in a number of manuals under the general heading: 'Wastewater Treatment Manuals'. Where criteria and procedures are published by the Agency, a sanitary authority shall, in the performance of its functions, have regard to them.

This manual on Preliminary Treatment sets out the general principles and practices which should be followed by those involved in the treatment of wastewater. It provides criteria and procedures for the proper management, maintenance, supervision, operation and use of the processes and equipment required in the preliminary treatment of wastewater. The Agency hopes that it will provide practical guidance to those involved in plant operation, use, management, maintenance and supervision. Further manuals are planned for secondary and tertiary treatment of wastewater. Where reference is made in the document to proprietary equipment, this is intended as indicating equipment type and is not to be interpreted as endorsing or excluding any particular manufacturer or system.

The Agency welcomes any suggestions which users of the manual wish to make. These should be returned to the Environmental Management and Planning Division at the Agency headquarters on the enclosed User Comment Form.

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ABBREVIATIONS

DOE	Department of the Environment
WRc	Water Research Centre, U.K.
EPA	Environmental Protection Agency
BOD	Biochemical Oxygen Demand
COD	Chemical Oxygen Demand
DWF	Dry Weather Flow
CCTV	Closed Circuit Television
EEC	European Economic Community
RBC	Rotating Biological Contactor
UV	Ultra Violet
p.e.	Population Equivalent
PLC	Programmable Logic Controller
HMSO	Her Majesty's Stationary Office
S.I.	Statutory Instrument
HMIP	Her Majesty's Inspectorate of Pollution
RBI	Rotating Bar Interceptor
rpm	revolutions per minute

Pretreatment of Wastewater

1.1 PRELIMINARY TREATMENT

Section 60 of the **Environmental Protection Agency Act, 1992** permits the agency (EPA) to specify and publish criteria and procedures, which in the opinion of the Agency are reasonable and desirable for the purposes of environmental protection, in relation to the management, maintenance, supervision, operation or use of all or specified classes of plant vested in or controlled or used by a sanitary authority for the treatment or disposal of sewage or effluent to any waters. This document is prepared in accordance with the foregoing, in respect of **wastewater preliminary treatment**. Its objective, therefore, is to provide criteria and procedures to properly manage, maintain, supervise, operate or use the processes and equipment required in the preliminary treatment of wastewater.

In interpreting these requirements, it is considered appropriate that criteria be evolved in relation to the following topics:

- **management:** criteria for the establishment of preliminary treatment including siting, design, process and equipment selection and organisational management to meet performance objectives;
- **maintenance:** criteria for servicing and upkeep of equipment, approach channels and accommodation works, renewal of consumable items, servicing and repair;
- **supervision:** superintendence of the works, maintenance of detailed performance records and monitoring to check compliance with service objectives, avoidance of nuisance and assessment of operating costs;
- **operation or use:** criteria for optimised operational performance and efficiency of plant including disposal of by-products in an environmentally safe manner, minimisation of nuisance from odours, flies, aerosols or other social impacts either at the plant or disposal site.

These criteria are considered from the point of view of the purpose, functioning and load

conditions which apply. Therefore, the criteria for selection of process and equipment are reviewed, together with the issues which arise in day to day operation.

In considering these issues, regard must be had to the variations in wastewater flow and other characteristics. Foul flows are subject to variation with daytime peaks and night-time low flows. The effects of rainfall can increase flows substantially and result in greater loads of grit and screenings brought into the sewers through gullies. Preliminary treatment processes must, therefore, cater for a range of flow conditions between minimum and maximum.

1.2 NATURE OF WASTEWATER

Municipal foul sewage is derived from domestic, commercial and industrial waste streams together with stormwater run-off. Apart from faecal matter, sewage contains a variety of suspended and floating debris including grit and other inert solids washed in from pavement and roof surfaces, paper, plastics, rags and other debris.

Other constituents of sewage are derived from process water from industry or commercial undertakings. These can give rise to the following constituents:

- slaughter house and butcher wastes can include animal hair, bone fragments, blood and offal;
- creameries result in milk and milk fat wastes which constitute a high carbohydrate load which can result in operational problems in activated sludge plants;
- food processing and catering establishment wastes can include grease, heated effluents and organic solids with a high biological load;
- filling stations, garages and other service centres can result in discharge of used oil and other hydrocarbon products in sewage;
- industries involved in metal plating, computers and related areas can have elevated levels of heavy metals which can be toxic to critical organism species in activated sludge.

They may also restrict the disposal options for the sludge; and

in general, many industries use detergents, dyes and solvents which may give rise to operational problems, foaming, high nutrient loadings and other problems affecting the treatment process and final effluent.

These characteristics of sewage must be taken into account in the design, management and operation of sewage treatment works. The monitoring of incoming sewage should be sufficient to identify the characteristics which would affect the operation and performance efficiency of the plant. In relation to pretreatment processes, significant issues include:

the amount of floating and suspended matter will influence the amount of screenings and grit to be removed, the nature of these materials and the potential for odour nuisance and disposal difficulties associated with them;

similarly, grease, oils and fat in the sewage stream will require removal if the levels constitute a problem for the downstream treatment process; and

high organic loading, for example milk or blood wastes, require more stringent standards in relation to stormwater overflows to protect receiving waters.

In accordance with the Urban Wastewater Directive, and arising from the application of the "Polluter Pays" principle, there is increased emphasis on treatment of industrial wastewater at source. The practical application of Schedule 4 of the Directive will be that many industrial/commercial facilities will be obliged to install/upgrade their wastewater treatment facilities before discharge to the municipal sewer to *"ensure that the operation of a wastewater treatment plant and the treatment of sludge are not impeded"*.

Where pretreatment of industrial wastewaters is discussed, it is not intended to advocate such treatment at the municipal plant. On the contrary, appropriate pre-treatment should be provided prior to discharge to the local authority sewer. Nevertheless, the municipal treatment plant operator should be aware of the nature of such effluent streams and their implications for his works, in the event of treatment failures at the

source plant due to break-down or overloading. In particular circumstances, the Local Authority may provide for treatment of industrial effluents on behalf of the industry, by agreement.

1.3 STORMWATER IN SEWAGE

All sewerage systems receive some level of stormwater inflow. The three types of sewer network are as follows:

combined systems: the traditional system where all foul and storm flows discharge to a common pipe network. In this system, sewage flows can increase dramatically following rainfall with peak flows of up to 30 times the average flow (**DWF**);

partially separate: used during the 1960's and early 1970's, the partially separate system involved draining the storm run-off from the backs of houses and the rear footpaths to the foul system with a separate storm drainage network in the roads to take road and front of house run-off; and

separate system: in this system, a dedicated foul sewer is provided for foul flows only, with all storm run-off directed to the separate storm sewers. In all systems, a degree of misconnection occurs and some storm run-off inevitably discharges to the foul system. Typically, 5-10m² per house is connected to the foul sewer, even in nominally separate systems, producing peak flows of 4-5 times DWF.

Increased storm flows can have a flushing effect upon the sewerage system bringing a quantity of stale sewage and debris to the treatment works in the early period of a storm. This is known as the **"first foul flush"** and can give rise to very strong sewage with very high loading on the treatment plant and a substantially increased level of grit and other debris resulting from the flushing of gully pots and the resuspension of bed sediment in sewers. One effect is an increased level of grit and screenings content.

As the storm continues, the strength of the sewage reduces significantly and can result in a relatively dilute sewage inflow for longer storms, typically during winter rainfall. It follows that overflows to receiving waters should be prevented, as far as practicable, during the first foul flush stage.

The major effect of rainfall, therefore, is increased flow to the works which, if allowed pass to the treatment process, will result in hydraulic overloading. In activated sludge plants, it will cause flushing out of the activated sludge biomass giving rise to plant upset and possible failure, if a large percentage of the biomass is washed out. Carryover of biomass to the sedimentation tanks will also have an immediate negative impact on effluent quality. Loss of biomass in the process reactor can lead to long-term plant failure until such time as the biomass grows back. Excess flows might also result in flooding of the works depending on pipe capacity between the different elements.

For this reason, it is necessary to restrict the forward flow to the treatment plant. This requires overflowing of excess storm flows. In order to prevent pollution of the receiving streams from the effects of these overflows, arrangements are required to limit the frequency and volume of overflow spill by the use of storage and to prevent carryover of solids by effective use of baffles and screens. This aspect is discussed in detail in Chapter 2.

It is particularly important that overflows should not occur during the period of first flush. If the screenings removal equipment is under designed or inadequately maintained, "blinding" of the screens may occur from the extra screenings load carried down the sewer, resulting in premature overflows. Such overflows could have potentially very serious pollution consequences due to very high concentrations of BOD, ammonia and the potential for hydrogen sulphide which is extremely toxic to aquatic life.

In this document, flows to the treatment plant are expressed in terms of multiples of dry weather flow (**DWF**). This is the total volume of sewage during a day which follows 7 days without rain and may also be described as an average daily flow in dry weather.

1.4 TYPICAL SEWAGE LOADS

1.4.1 HYDRAULIC LOADING

As already stated, the flow of sewage to the works is usually expressed in terms of dry weather flow (**DWF**). Peak flow is then described as a multiple of dry weather flow (e.g. 3 times **DWF**). Dry weather flow will vary according to the nature of the contributing catchment and will include the following elements:

- * **domestic sewage** which is typically in the range 180-200 l/head. This is based on normal per capita water consumption of 150 l/day, plus some leakage and sewer infiltration. Frequently, the domestic flow is taken to include normal commercial discharges from premises such as public houses, restaurants and similar establishments and a total figure of the order of 225 l/hd per day may be appropriate based on major flow surveys carried out in Ireland. Actual flows should be verified in each case, however;
- * **industrial effluent** flows are normally the subject of effluent licence conditions which include a requirement for metering. Accordingly, these flows can be metered, providing details of average and peak values. Flows from institutions such as hospitals, schools or from hotels can be estimated from resident population or from direct measurement. Such site measurements are always necessary prior to the design stage of a new wastewater treatment plant; and
- * **infiltration** results from leakage into the sewers and will tend to be at a maximum in winter time when the groundwater table is at its highest. Infiltration is a function of the condition of the sewer system and can be significant in older systems involving masonry culverts or in newer systems where poor construction practices are employed resulting in leaks at joints and at manholes. The quantity of infiltration can only be established from flow measurement, particularly base night flow measurement. CCTV surveys can also assist in identification of infiltration.

1.4.2 ORGANIC LOADING

Urban wastewater is characterised in the Urban Wastewater Directive (91/271/EEC) as having 60 g of BOD per population equivalent (p.e.) per day. Field investigations may give somewhat lower values, in practise. This value may be used to estimate the pollution load from the domestic population of a catchment. Surveys are usually required to establish the load from commercial or institutional development.

1.4.3 LOAD VARIATION

A further complication arises from seasonal variations. For example, tourism can result in a major increase in foul flows in seaside towns resulting in markedly increased flows to the treatment plant. This can present serious treatment difficulties and may require mobilisation of standby equipment to meet the seasonal peak flows. Therefore, peak conditions must be catered for in the design and operation of a plant.

Where permanent measurement facilities are not available, inflows should be monitored over the full cycle, by fitting of a suitable flow measurement device. This can be combined with flow proportional sampling to establish the organic load of the plant.

1.5 OVERVIEW OF WASTEWATER TREATMENT

Wastewater treatment processes can involve physical, chemical and biological processes depending on the required effluent standards, the nature of the wastewater and the scale of the works (**Fig. 1.1**). Among the processes which may arise in wastewater treatment are the following:

preliminary processes: physical processes ahead of the treatment stage as described in Section 1.6;

primary sedimentation: nowadays generally confined to larger plants of at least 5000 population equivalent (p.e.);

biological treatment: in fixed or suspended media reactors using biofiltration, activated sludge or extended aeration or variants on these. Other biological processes include rotating biological contactors (RBC) and the use of constructed wetlands for full treatment or final polishing of wastewater. Nitrification/Denitification may be provided for to reduce the nitrate concentrations where the effluent is discharged to a sensitive marine environment;

chemical treatment: may be used to adjust the parameters of wastewater prior to biological treatment (e.g. pH adjustment, reduction in heavy metals or nutrient adjustment). It may also be used in

conjunction with biological treatment for phosphate removal;

final sedimentation: used to separate the sludge solids from the final effluent. Typically, this is carried out in radial flow sedimentation tanks, though horizontal flow rectangular tanks are used in older works;

tertiary systems: sand or microfiltration systems may be employed to enhance the quality of final effluents, where necessary. Other tertiary treatment processes may include disinfection using UV radiation or ozone treatment; and

sludge treatment: as discussed below.

Further handling and treatment processes are generally employed to deal with the surplus sludge generated within the treatment works. These processes may include the following elements:

sludge draw-off, flow balancing and pumping;

gravity thickening of sludge in circular tanks usually assisted by a rotating picket fence and scraper mechanism. Mechanical thickening is also an option, increasingly used in Europe;

stabilisation treatment of sludge may include aerobic or anaerobic digestion treatment;

volume reduction of sludge is achieved by mechanical dewatering in belt press or centrifuge system; and

inter-stage transfer of sludge is achieved using positive displacement pumps, screw and belt conveyors.

1.6 PRELIMINARY TREATMENT PROCESSES - OVERVIEW

The purpose of preliminary treatment is to ensure a satisfactory quality of final effluent and final sludge product and to protect the treatment process from malfunction associated with accumulation of screenings, debris, inorganic grit, excessive scum formation or loss of efficiency associated with grease or oil films or fat accumulations.

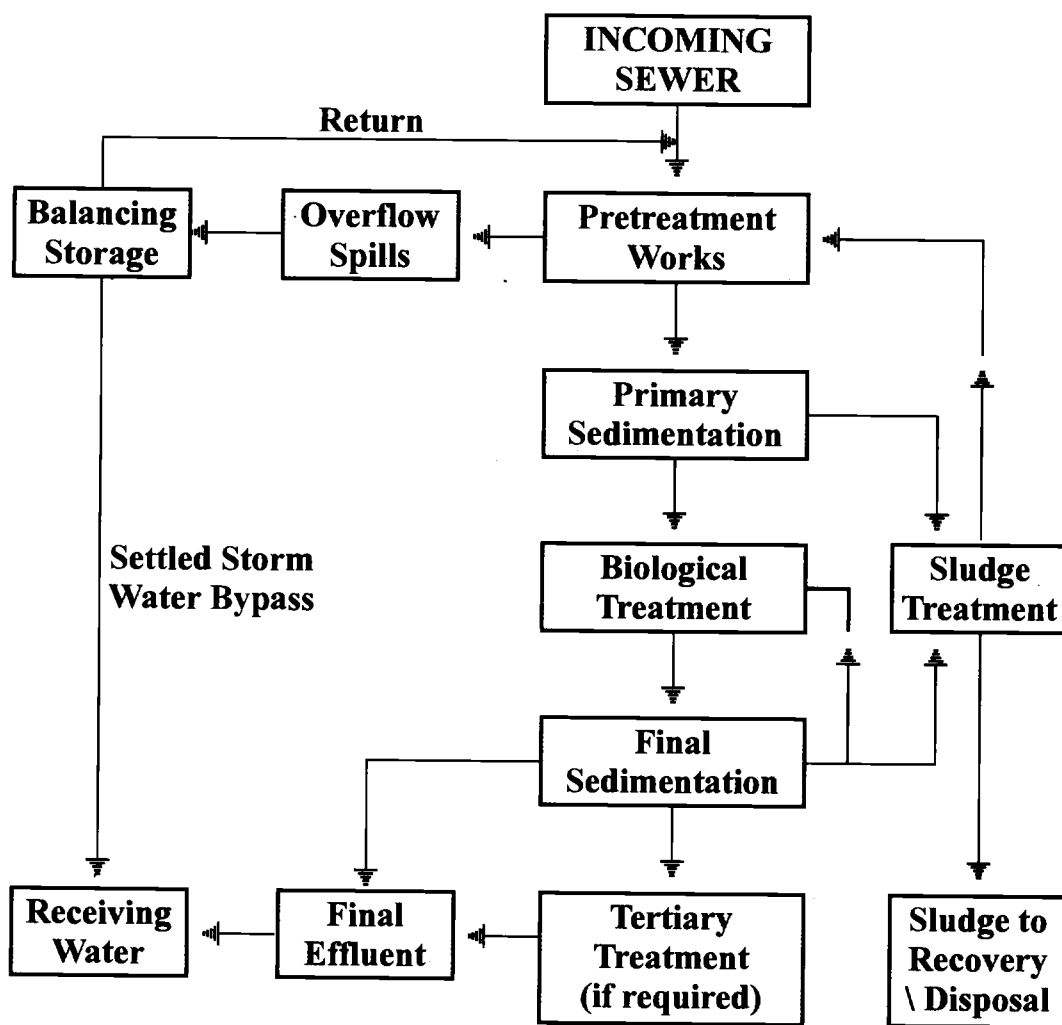


FIGURE 1.1: WASTEWATER TREATMENT PROCESS

Wastewater preliminary treatment processes essentially comprise physical processes required to ensure that the treatment plant can cater satisfactorily for the “pass-through” flows. Their satisfactory operation enables the plant to produce the required final quality of effluent and a treated sludge suitable for recovery or for the specified disposal objectives (e.g., disposal to agricultural land).

The principal preliminary treatment processes employed at a wastewater treatment works, therefore, may be described as follows (**Fig. 1.2**):

storm overflows: involve an in-line control device to regulate the maximum forward flow to treatment with facilities for accommodation of excess flows using either on-line storage, off-line storage or overflow spill pipe;

screening: may include coarse and fine screening, usually mechanically operated, to intercept floating and suspended debris with ancillary equipment to remove the screenings, flush organic matter back to the sewage flow and compact the final screenings residue for disposal off site;

grit removal: to intercept and separate out inorganic grit particles including grit washing and storage facilities. Removal of grit prevents its downstream accumulation in process units and the potential for excessive wear in pumps, sludge dewatering plant and other machinery;

oil, grease and fat: facilities for flotation and removal by skimming of oil, grease and fat are necessary where these are significant constituents of the wastewater inflow. This is desirable to prevent blockages and scum formation and the accumulation of fat on conveyors and other elements of the works resulting in reduced efficiency and excessive maintenance requirement. Fat/grease removal is best achieved on the contaminated stream rather than on the total flow, if practicable, for efficient performance and correct selection of the plant required;

flow measurement: required to quantify the hydraulic load to treatment normally including facilities for proportional sampling for analysis of organic, nutrient or other parameters. It is also highly desirable to assist in control of sludge flows and the addition of chemicals;

odour nuisance: odours arise at the pretreatment works primarily associated with the removal of material from the sewage stream and the storage of residues. This gives rise to the production of noxious gases. Treatment of odour may require containment and extraction of malodorous air for treatment. Treatment processes can include chemical treatment using ozone, dry or wet scrubbers and adsorption filters. Biological treatment of odours can be achieved using peat or compost beds. Odour masking chemicals have occasionally been used as a short-term strategy for dealing with odours;

monitoring and control system: the plant monitoring and control facilities may provide for monitoring of such parameters as inlet flows, equipment status, wastewater level,

overflow duration and frequency, combined with control of return flows from storm balancing storage; and

hazard zoning: where pretreatment processes are enclosed in buildings, it is necessary to monitor for hydrogen sulphide, methane, hydrocarbon concentration and oxygen deficiency, and to give consideration to hazard zoning of the various compartments and equipment contained therein.

In the following chapters, pretreatment processes are considered from the point of view of purpose, design criteria, control and supervision, types of equipment and specification, nature and disposal of residues.

1.7 ROLE OF PLANT OPERATOR

Individual sections of this manual will outline the role of the plant operator in the management, maintenance and general operation of each process. In general, duties can be summarised as follows:

record keeping: requires recording of all significant operational information including weather conditions, changes in quantity or characteristics of the wastewater, details of screenings, grit or other residues indicating time/date, method of removal, estimated volume and end disposal option;

routine maintenance: in accordance with detailed plant manuals, recording of maintenance schedules, breakdowns and repairs carried out on the plant;

maintaining the works in a clean condition: by regular washing down of screens, walls, storage areas, etc. Controlling rodents, scavengers and similar pests within plants;

prevention of solids accumulation: in channels or tanks including flushing out of sediment accumulations in the balancing storage following a storm event;

maintaining safe working conditions: including maintenance of gas monitoring equipment and alarms, maintaining equipment guards and following safe working practices. This would involve implementing an occupational Health & Safety plan devised for the scheme by the authority responsible for it; and

effluent quality: ensuring that the works produces a final effluent treated to the required standard.

To summarise, the plant operator is responsible for carrying out regular and routine maintenance to ensure continued efficient operation of the equipment, maintenance of the plant in a clean and safe condition to achieve performance objectives, minimising hazards and nuisance to operators, visitors or the public, and maintenance of detailed operational records by

means of which performance and plant loadings can be verified. For detailed advice on the operation and maintenance of plants, reference should be made to the Local Authority National Training Group or Sanitary Services Sewage Treatment Trainers Manual. Operatives should follow the detailed requirements in that manual for equipment maintenance and operation, reporting, safe working and hygiene practices recommended therein.

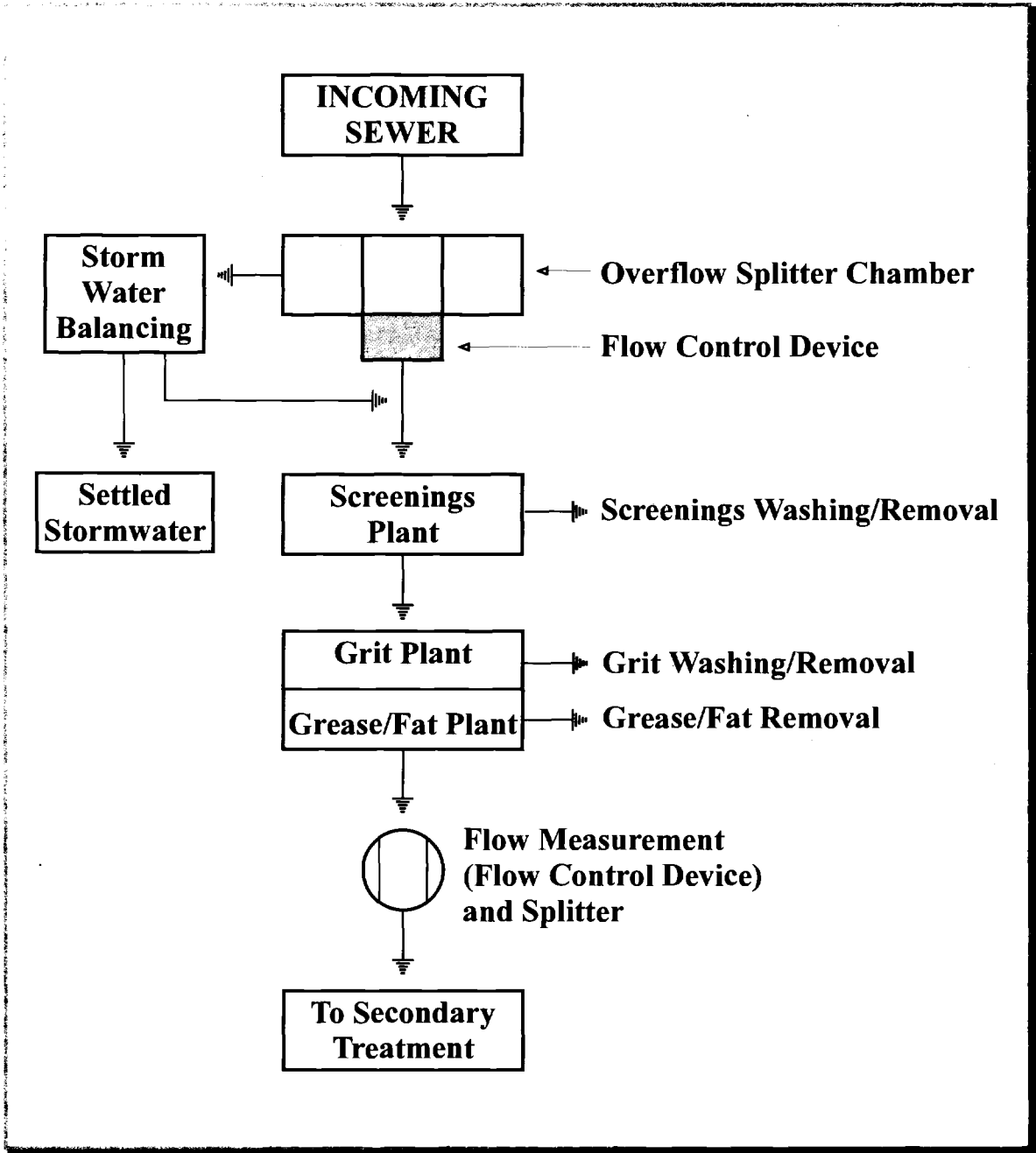


FIGURE 1.2: TYPICAL WASTEWATER PRELIMINARY TREATMENT PROCESSES

2.1 TREATMENT PLANT FLOWS

2.1.1 FLOW TO TREATMENT

A critical consideration in the design of a wastewater treatment plant is the determination of peak hydraulic loading or maximum flow to be accommodated through the works. This maximum flow determines the sizing of pipework and the head losses to be provided between each stage of the works. Therefore, it influences the process selection and sizing, including the volume of process units and the surface area of sedimentation tanks. As such, the selection of peak design flow has a substantial bearing on the size of a works and therefore on its cost.

For large treatment plants, it is common to design the plant for a peak flow of **3 times DWF**. In smaller plants, the scale of works and cost implications of a higher design coefficient are less significant and the figure normally taken is **6 times DWF**, where the sewerage system is combined or partially separate. This approach is applied to all plants up to 2000 p.e. and may well be desirable up to at least 5000 p.e. Any additional costs for smaller plants are likely to be offset by savings in the omission of storm flow balancing at the works inlet. Ultimately, peak design flow should be determined by optimisation of the total system comprising the collection network and treatment plant.

2.1.2 FLOW CONTROLS AND OVERFLOWS

Flow control requires that a flow control device be incorporated at the inlet works to restrict the forward flow to treatment. Where inlet flows are pumped, the pump capacity determines the flow regime. Flow balancing in conjunction with variable speed drives and PLC controllers can reduce hydraulic loading on the treatment works. The key elements of flow control and overflow works are:

- a flow control device such as a measuring flume or other appropriate control (e.g. hydrobrake type orifice). The use of orifice

- plates or penstocks gives rise to ragging which can cause variations in the flows passed. They can be used downstream of screens, where appropriate. **Table 2.1** lists characteristics of flow control options, with advantages and disadvantages;

- a storm overflow structure designed to satisfy the WRC guidelines (reference ER 304E) to ensure efficient hydraulic control and solids separation/retention. The device must ensure that maximum inflows can be accommodated with minimum increase in the permitted through-flow, while at the same time avoiding overflows until the design through-flow is achieved;

- the overflow should have effective debris containment and be amenable to safe access for maintenance and inspection. The objective should be retention of screenings in the flow rather than removal at this stage; and

- on larger works or where the receiving waterway is sensitive to spills, a level monitor should be incorporated to provide a record of overflow frequency and duration.

Details and dimensions of the overflow structure should be determined in accordance with the U.K. Water Research Centre (WRC) guidelines (Ref. 17) in order to achieve relatively quiescent conditions, to minimise carryover of debris. However, it is imperative that a dry weather channel be provided in the invert of the overflow structure with an appropriate profile and gradient to achieve self cleansing conditions during normal flows. The plant operator should ensure that this channel and benching are maintained clean and free from ragging and sludge deposition. A typical overflow weir application (high side weir overflow) is shown in **Fig. 2.1**. This may require flushing after a storm event.

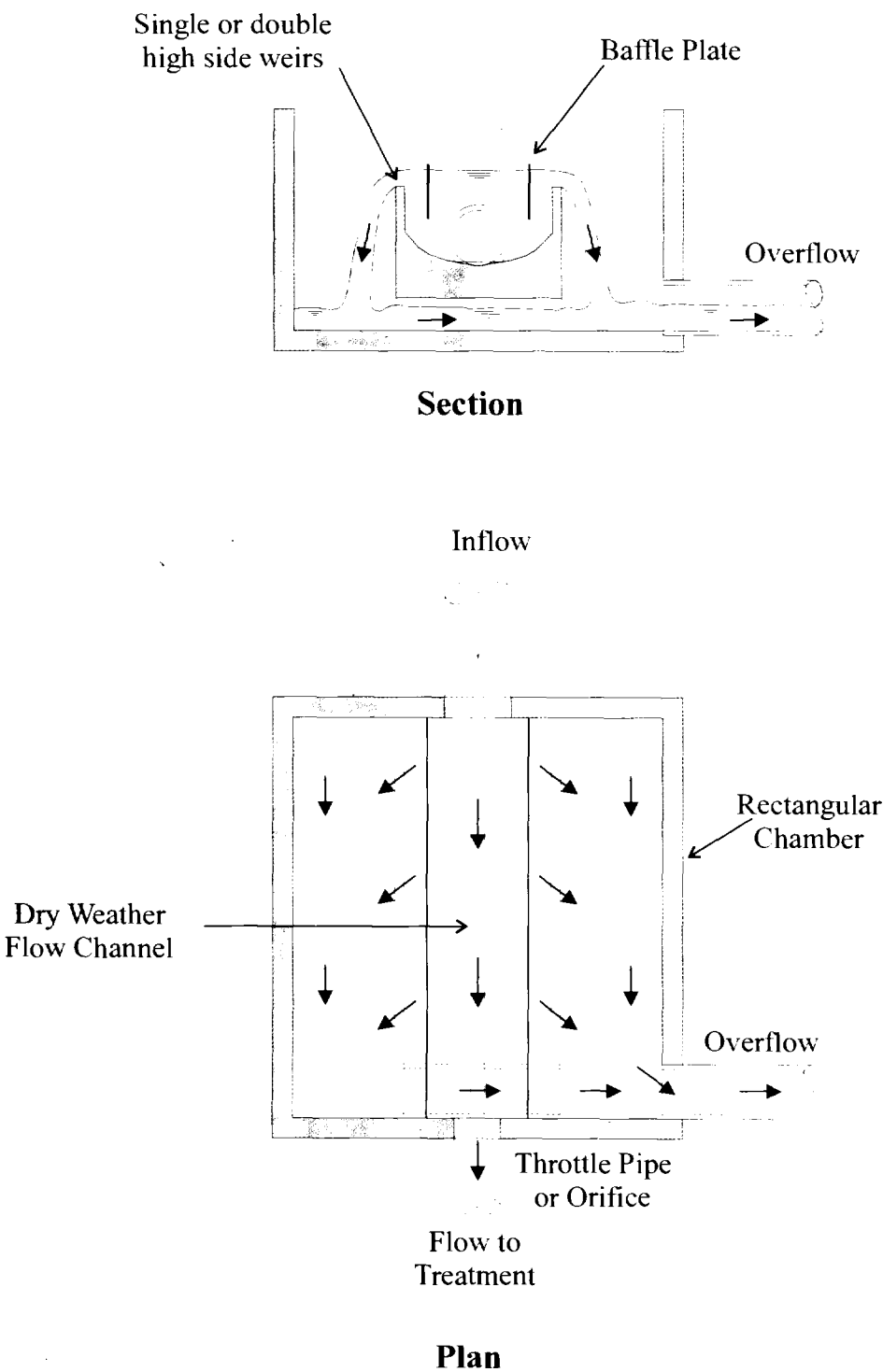
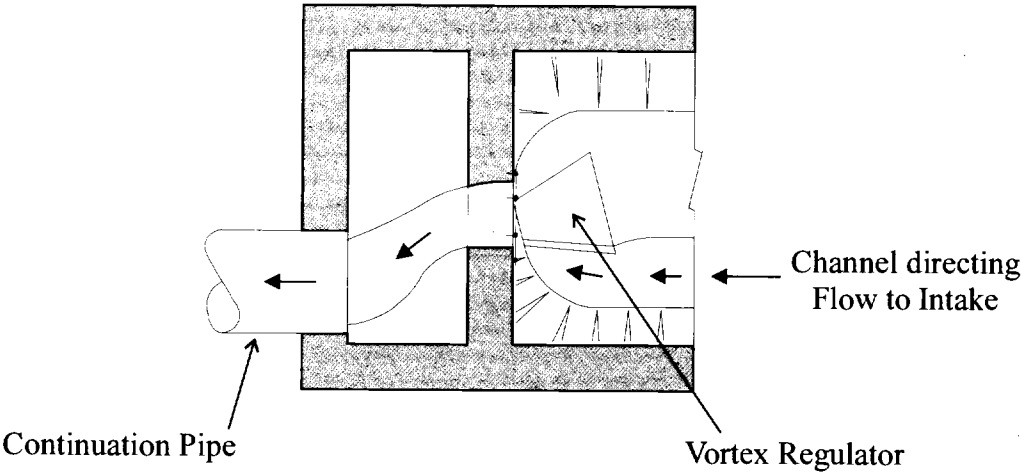
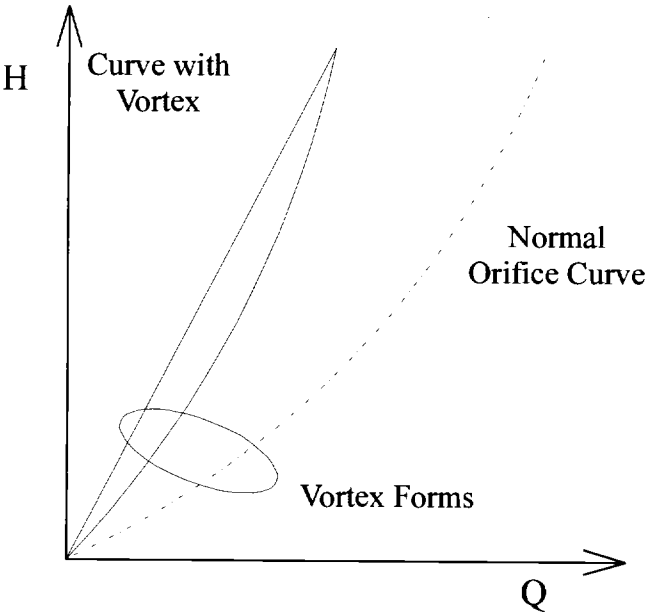


FIGURE 2.1: HIGH SIDE WEIR OVERFLOW



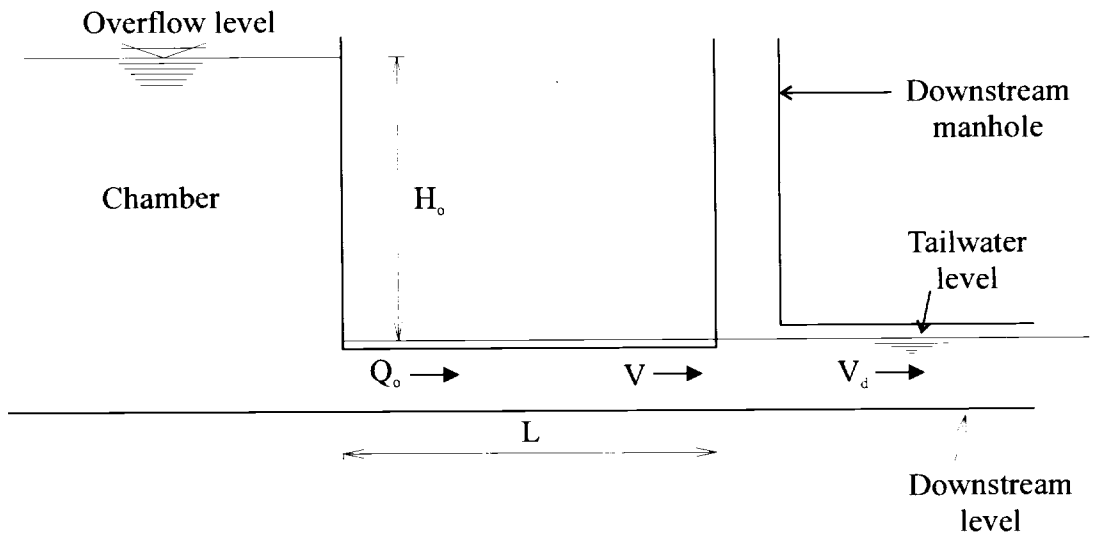
a) Vortex Regulator Throttle (Plan View)



b) Head Discharge Curve

Where H is Head, Q is Flow

FIGURE 2.2: VORTEX REGULATOR THROTTLE DEVICE (REF. WRC 304E)



$$H_o = 1.5V^2/2g + V_d(V_d - V)/g + S_f L$$

Where H_o = Head Loss (m)

V = Throttle Pipe Velocity (m/s)

V_d = Downstream Velocity (m/s)

S_f = Friction Gradient

L = Throttle Pipe Length (m)

Q_o = Continuation Flow (m/s)

FIGURE 2.3: THROTTLE PIPE DESIGN (REF. WRC 304E)

TABLE 2.1: FLOW CONTROL DEVICES AT STORMWATER OVERFLOWS - OPTIONS

TYPE	PROPERTIES	ADVANTAGES	DISADVANTAGES
Flume	Critical depth flume $Q = C B H^{3/2}$ (C approx. 1.805)	• Accurate measurement • Combines control with flow measurement • Good reliability • Low head loss • Facilitates proportional sampling	• Requires long approach channel (10 * W) • Head may not suit the minimum weir height, requiring separate overflow control.
Orifice	Orifice Plate to required diameter $Q = C_d A (2g (h_1 - h_2))^{0.5}$ Dia. > 200mm	• Accurate H/Q • Inexpensive and easy to install	• Prone to ragging and obstruction • Small head increment gives large flow increase • Needs approach length of 10 x dia. • Large obstruction and Head Loss
Weir	Rectangular : $Q = 1.744 B H^{1.5}$ "V" Notch (90 deg.) $Q = 1.42 H^{2.5}$	• Accurate H/Q • Suitable for small flows • Easy to install	• Cause backup, siltation and ragging • Unsuitable for permanent use
Vortex Regulator (e.g. Hydrobrake) Fig. 2.2	Vortex generated allowing air core and high peripheral velocity. (Ref. Manufacturer's Catalogues).	• Relatively constant discharge rate • Accommodates gross solids • Accommodated in confined space	• Expensive, for smaller works • No measurement of flow
Throttle Pipe Fig. 2.3	Pipe, 200mm dia. or bigger, minimum length: Slope = 0.002, L = 16D = 0.004, L = 25D = 0.006, L = 35D $H = \frac{1.5V^2}{2g} + \frac{V_d}{g}(V_d - V) + S_f L$	• Low maintenance • Simple installation • Optimum for overflows in network	• Less accurate • Potential for blockage • Length may not be available at works
Penstock (Adjustable)	Used in conjunction with flow measurement - possible automatic operation.	• Can control downstream flow to optimise storage (real-time control)	• High Maintenance • Requires automatic control system

Note: Q = Flow (m³/s); B = Width (m);
 h₁ - h₂ (Head difference (m));

H = Head (m); C or Cd = Coefficient,
L = Length (m)

2.2 COMBINED SEWER OVERFLOW - DISCHARGE CRITERIA

The excess flows spilled at the overflow may have the potential to cause pollution of receiving waters if discharged without restriction. This requires consideration of the following issues:

- the water quality criteria and objectives for the receiving water;
- the nature of the spill, its characteristics, frequency and volume;
- the location of the storm overflow pipe outfall and the aesthetic and general amenity impacts of discharge;
- the bacteriological effect of discharges on receiving waters if located in designated bathing areas;
- the potential nutrient load (nitrates and phosphates) in the spill flow; and
- the balancing storage provided.

The general criteria for wastewater effluent discharges derive from the urban wastewater treatment directive (91/271/EEC) and the national regulations S.I. 419, 1994. The Directive contains no specific criteria for storm sewage overflows. Appropriate criteria have been interpreted in the light of the directive in a Department of the Environment memorandum entitled "Procedures and Criteria in Relation to Stormwater Overflow". This document provides guidelines in determining an appropriate design for combined sewer overflows.

2.2.1 STORM WATER OVERFLOW SETTING

The minimum overflow setting, above which overflows might be permitted, is defined as that given by "Formula A", following the report of the Technical Committee on Storm Overflows and the Disposal of Storm Sewage (HMSO 1970) (Ref. 19). This is defined as follows:

$$\text{Formula A} = \text{DWF} + 1.36\text{P} + 2\text{E m}^3/\text{day},$$

$$\text{where DWF} = \text{PG} + \text{I} + \text{E}$$

Where "P" is the population served and "G" is the average per capita water consumption ($\text{m}^3/\text{hd-d}$), "E" is the industrial effluent flow and

"I" is the rate of infiltration. The factor of 2E should be reconsidered where the industrial effluent is a high strength waste with potentially toxic impacts or where it constitutes a significant proportion of the total flow. In these circumstances, a higher factor would be appropriate. This flow should be regarded as a minimum setting and reference should be made to the D.O.E. guidelines in determining the appropriate setting for each site (Ref. 18).

In general, the following criteria also require to be satisfied:

overflows to minor watercourses should be avoided, where possible;

as already stated, the storm overflow structures should satisfy the criteria in WRc publication ER304E (Ref. 17) with overflow structures confined to high side weir, stilling basin or vortex chamber overflows;

the outlet control at the overflow should maximise the retained flow at a near constant rate within the system capacity and overflow spilling should not occur until the minimum settings have been exceeded. Chamfered or bevelled outlets should be used to minimise ragging;

such an overflow should be designed for effective containment of detritus and floating debris, oil and grease. It should be fitted with adequate baffle plates with adequate freeboard and depth of immersion;

overflow discharge points should be discreetly located and coastal outfalls should be taken, where practical, to below low water level;

a preliminary assessment should be carried out to establish containment of "first foul flush" flows having regard to the nature of the catchment runoff (time of concentration, extent of sediment in sewers, etc); and

specific performance objectives in terms of spill frequency are required for discharges to coastal waters, including bathing waters and recreational amenity waters (3 and 7 spills respectively per bathing season) (Ref. 18). Similarly, spill frequency and volume limitations may apply to other receiving waters having regard to available dilutions and water quality objectives. Frequencies of

16, 8 or 4 times per year on average might be set, depending on available dilutions.

It follows, therefore, that the sewer flows above which discharges to watercourses or other receiving waters may be permitted will generally exceed the maximum flow permitted to the treatment plant. This requires the provision of storage on the overflow to intercept the spilled flows for return to the inlet works, when storm conditions have abated.

2.3 STORM OVERFLOW STRUCTURES

As already stated, the WRc reviewed the design criteria for storm sewage overflows and provided detailed guidelines for appropriate structures in its report on "A Guide to the Design of Storm Overflow Structures", (Ref. 17).

In arriving at recommendations for future practice, the WRc study identified the following difficulties with traditional designs:

- outlet obstructions are common where diameters are less than 200mm or where gradients are slack, or where they are inaccessible for maintenance;
- forward flows can exceed the safe limit in structures with restricted spill capacities or variable head such as leaping weir or "hole in the wall" types;
- poor solids separation is common. Traditional low side weir overflows can give rise to solids being carried out in the overflow due to longitudinal currents in the main channel. The scumboards have little effect in such situations; and
- such overflows (low side weir, leaping weir, etc.,) commence overflowing before the full forward flow is reached;

Recommended overflow structures include "High Side Weir", "Stilling Pond" and "Vortex" overflows. Detailed design recommendations are given for each type to achieve the objectives of:

- controlled forward flow at near constant value;
- deferral of spilling until forward flow is reached; and

efficient solids and screenings retention.

Details of each type of overflow are shown diagrammatically (Figs. 2.4 to 2.6), giving key dimensions for correct sizing. The characteristics of each type are listed in Table 2.2.

Arising from the foregoing selection criteria, it might be concluded that the high side weir or stilling pond option would normally suffice where storage is provided. The storage would be expected to make up for any loss of settlement efficiency. However, where storage is not provided and the receiving water is particularly sensitive, for example, where it supports a high level of visual or general amenity, the vortex separator should be considered.

2.4 OPERATIONS AND MAINTENANCE OF OVERFLOWS

Proper operation and maintenance of overflows is essential to satisfactory performance. This requires attention to the following aspects:

- access for easy inspection and maintenance at inlet and outlet;
- good ventilation is necessary and lighting should be considered, if overflow is covered;
- inverts should minimise risk of solids deposition and be self cleansing;
- high pressure washing facilities are desirable; and
- on large overflows, a bypass is desirable, with penstock control, to allow maintenance of chamber and throttle device.

Overflows should be regularly checked to ensure that outlets are clear and free from ragging.

2.5 STORM FLOW BALANCING

Historically, storm flow balancing was frequently provided for storage of that proportion of flow in excess of the through flow to treatment up to the permitted flow level at which spills might be permitted. For example, a weir would be provided to allow diversion to storage at **3 DWF** with a second weir spilling to overflow at **6 DWF** setting.

TABLE 2.2: RECOMMENDED STORM OVERFLOW STRUCTURES

Type	Characteristics	Advantages	Disadvantages
High Side Weir (Fig. 2.4)	Stilling Zone, Overflow Zone, double weirs of specified height and length and storage zone. Include DWF Channel for 1m/s at 2 * DWF	• Low gradient • Accommodates to existing inverts • Minimum surcharge of u/s sewers • Easy maintenance	• Large structure (> 15D) • Moderate separation efficiency • Limited overflow screening options.
Stilling Pond (Fig. 2.5)	Extended Stilling pond chamber, surcharge of inlet sewer and transverse weir overflow.	• Higher separation efficiency • Shorter structure	• Surcharge of inlet sewer • Greater gradient requirement • Outlet must not impede weir
Vortex Overflow (Fig. 2.6)	Secondary currents in a forced vortex used to separate solids.	• High separation efficiency • Works with high inlet velocity • Circular tank suited to deep sites or poor ground	• Significant drop in invert level required. • May surcharge upstream sewer. • Normally requires Hydrobrake type outlet control

However, many storms are of short duration with concentrated discharges which would give rise to spills of moderate volume but high frequency (with short duration intensity exceeding **6 times DWF**). Such spills are potentially unsatisfactory, particularly during summer conditions, when receiving waters are most vulnerable. If fully diverted to storage, many such overflows would be contained without discharge and could be returned back to the treatment works when the storm has abated. Even where discharge is necessary due to the severity of a storm, the beneficial effects of settlement in the tank can be considerable.

Therefore, the objective of storm balancing storage should be to intercept all flows which exceed the through flow to treatment up to the capacity of the tank. Where the intensity and duration of the storm results in spill discharges which exceed the tank capacity, the excess flows are then permitted to be discharged to the receiving waters subject to effective containment of floating debris. Such flows have the benefit of substantial dilution and potentially significant settlement in the balancing tank.

The optimum sizing of storm balancing storage is determined from modelling of the sewerage network combined with spill settings determined

for the receiving waters. Historically, tanks were designed for up to **6 hours DWF** and this volume would generally be satisfactory. Flow balancing might also be desirable to even out the effects of pumping. A direct monitoring and control system is recommended to optimise the use of the total storage volume.

The control system may combine the following elements:

timer control with return flow commenced linked to a set time delay in smaller works;

flow proportional return based on inflow rate. For example, storm water return at **DWF** flow-rate could commence when inflow falls below **2DWF**; and

this flow proportional return can be optimised by use of variable speed pumps to optimise stormwater handling efficiency. This would also permit flow balancing to the works to even out hydraulic loading.

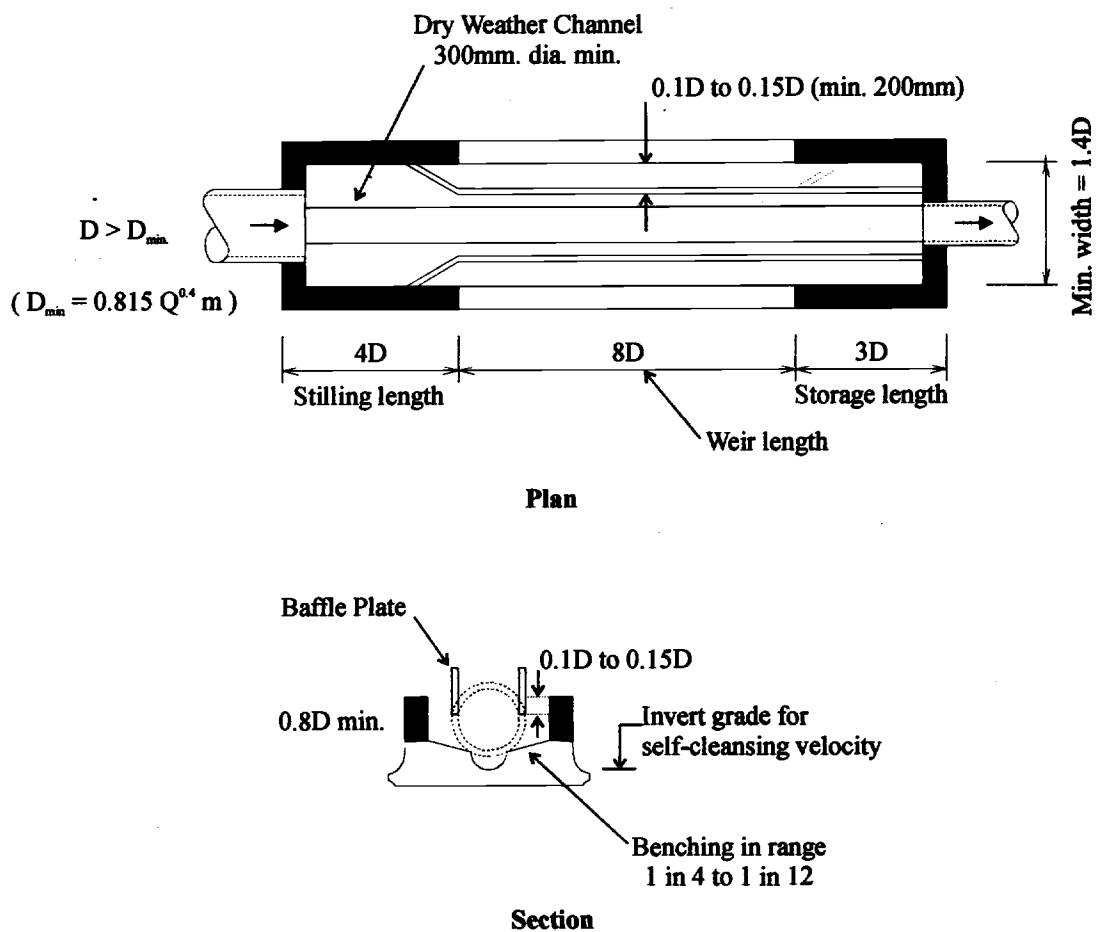


Fig. 2.4 Typical High Side Weir Criteria (Ref. WRC 304E)

FIGURE 2.4: TYPICAL HIGH SIDE WEIR CRITERIA (REF. WRC 304E)

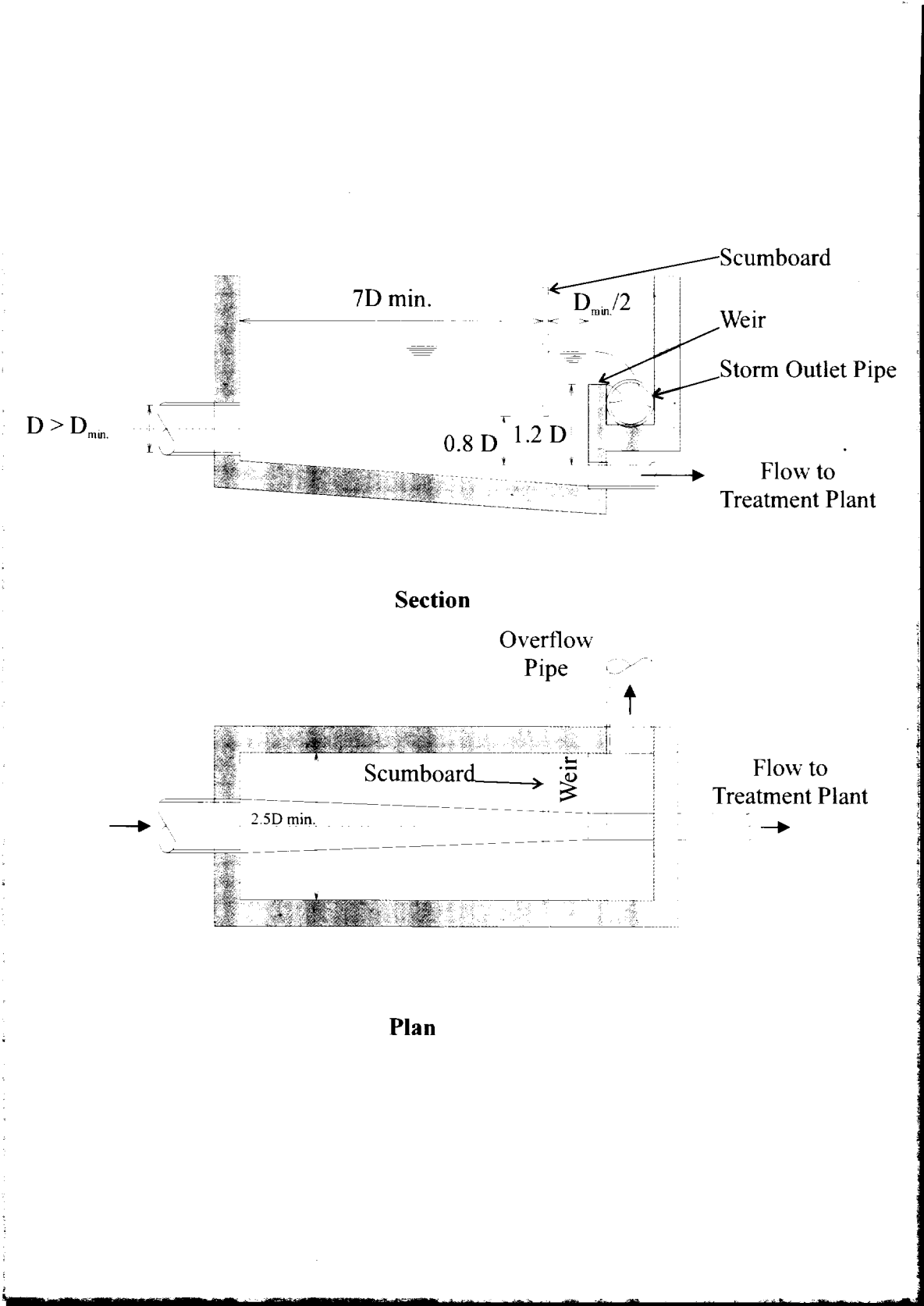
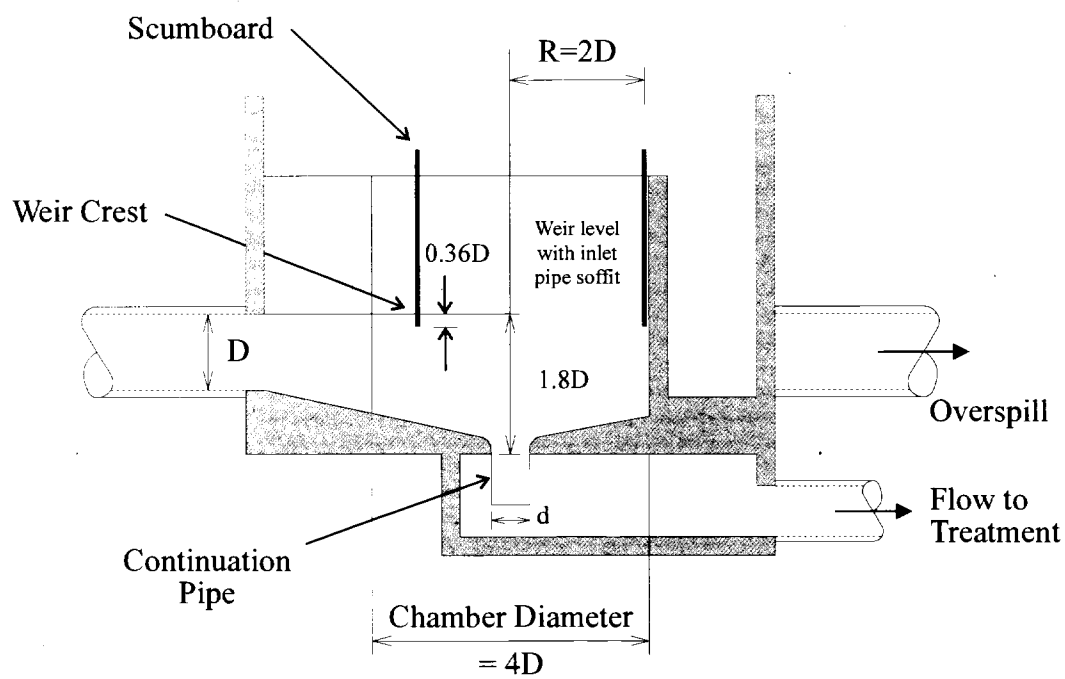
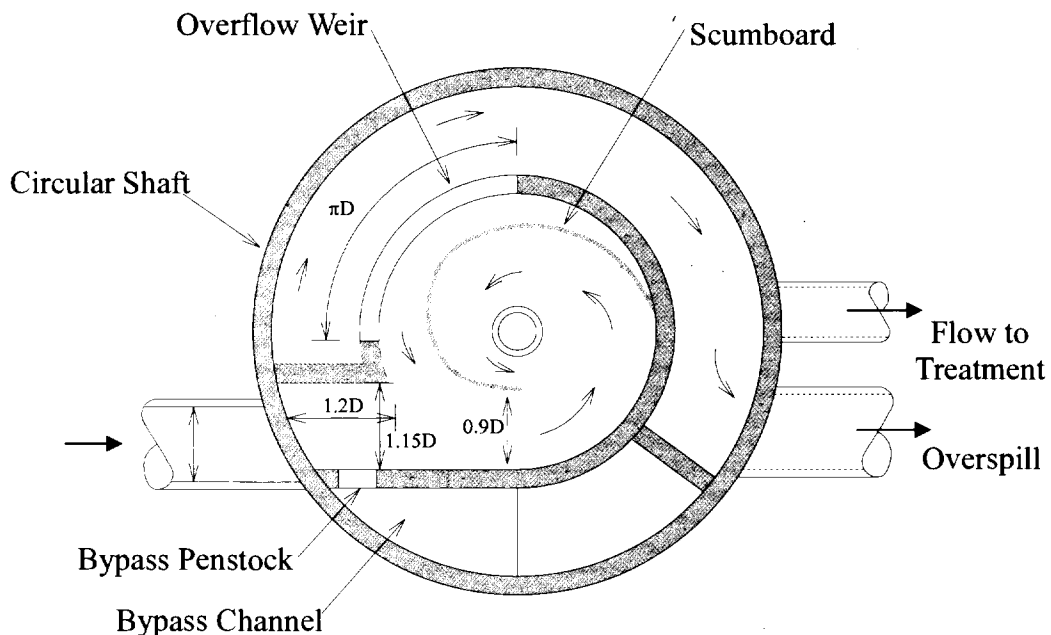


FIGURE 2.5: STILLING POND OVERFLOW CRITERIA (REF. WRC 304E)



Section



Plan

FIGURE 2.6: VORTEX CHAMBER IN CIRCULAR SHAFT (REF. WRC 304E)

Flow balancing can be achieved by a variety of methods including the following:

in-line storage upstream of the overflow by means of a tank sewer or large diameter sewer in which the flows are backed up before discharge. Such systems have the benefit of automatic operation. Even though fitted with **DWF** channels, there is a tendency for retention of settled deposits on benching when storm flows have receded, which may result in substantial maintenance;

horizontal rectangular tank with sloping floor and either pumped or gravity facilities for the return flow. Traditionally, such tanks provided for separate sludge draw off, but a modern system would ideally incorporate facilities for resuspension of sediments to avoid separate sludge handling facilities. Tanks would be subdivided into a number of cells; and

circular radial flow tank with sloping conical floor and central sump fitted with scraper mechanism (similar to primary sedimentation tank).

Where some surcharge or backing up of the trunk sewer to the treatment works is permitted, storage can be achieved within the sewer system to meet some or all of the storage requirement. This “in-line” storage is limited by the extent to which surcharging can be permitted without risk of upstream flooding. Its impact on the flow metering devices being utilised should also be considered.

Off-line tanks provide the balance of the storage requirement to meet the overflow spill objectives. **Fig. 2.7** illustrates schematically the nature of “on-line” and “off-line” storage. These tanks are commonly constructed in cells with provision for overflowing from one cell to the next. This ensures that the more contaminated overflows are collected in the initial cells with more dilute discharge in downstream cells to the point of ultimate overflow. For smaller storms, only the initial tank or cell is utilised, thereby reducing the maintenance requirement involved in desludging/cleaning.

The design objective is that storm tanks are always emptied completely each time they are used. This ensures that storage capacity is available for the next rainfall event and also prevents consolidation of sludge in the base of the tank. The whole of the contents of the tanks

should be returned to the pretreatment works to prevent malodours and avoid sludge residues in the tank. This may involve incorporating measures for resuspension of settled sludge. Alternatively, the tanks can be designed so that the supernatant water is returned for treatment and the sludge dealt with separately.

Where ground conditions are poor, relatively shallow rectangular storm settlement tanks may be most appropriate. Such tanks are particularly suitable where a gravity return of the stored flows is possible, for example adjacent to pumping stations, where flows are returned to the wet well. Such tanks should incorporate the following features:

a dry weather channel in each compartment to ensure adequate velocity for self cleansing of the channel;

facilities for resuspension of solids as the tanks are drawn down by means of pumped recycling, tank mixer unit or air/water scour pumps;

facilities for cleaning of the tank floor on draw-down of the contents, utilising “tipping bucket” flushing facilities, combined with high pressure power hoses; and

where pumped return is required, the optimum design is for a circular radial flow tank similar to the tanks required for primary sedimentation. These tanks are equipped with a central hopper and scraper system. The sludge is automatically drawn off from the conical sump at the invert of the tank, in conjunction with the returned flow.

The operational management of storm tanks within the treatment works requires that:

the tanks are drawn down by recycling of flows to the inlet works at the end of each storm event when flows have returned to a satisfactory level. For example, a plant designed for **three times DWF** could accommodate a return rate of **DWF** when the inflow rate has subsided to **twice DWF**;

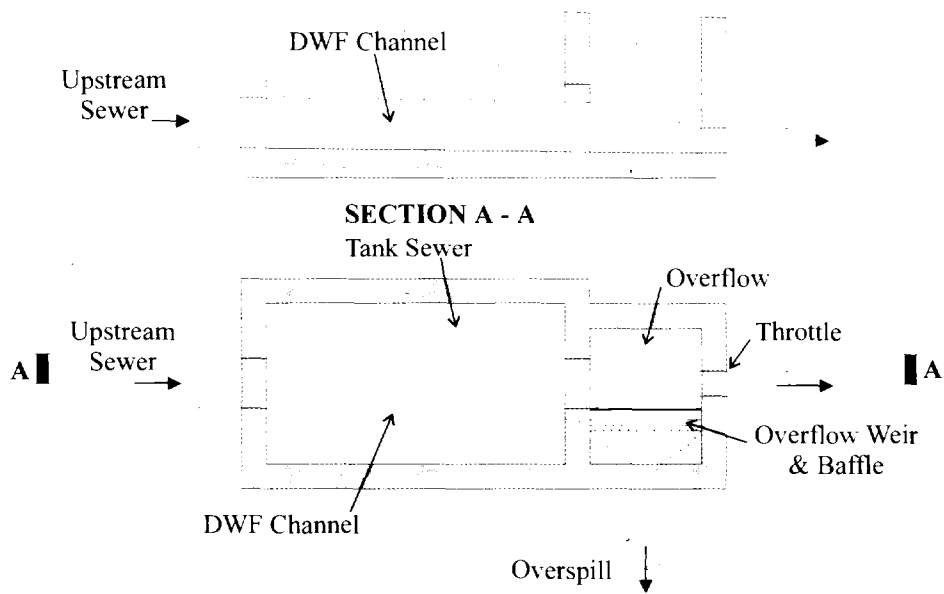
storm tanks should be fully emptied at the conclusion of each storm event; and

the operator’s duties should include thoroughly flushing out the storm tank at the

conclusion of each storm cycle. Appropriate power washing facilities should be provided to achieve this.

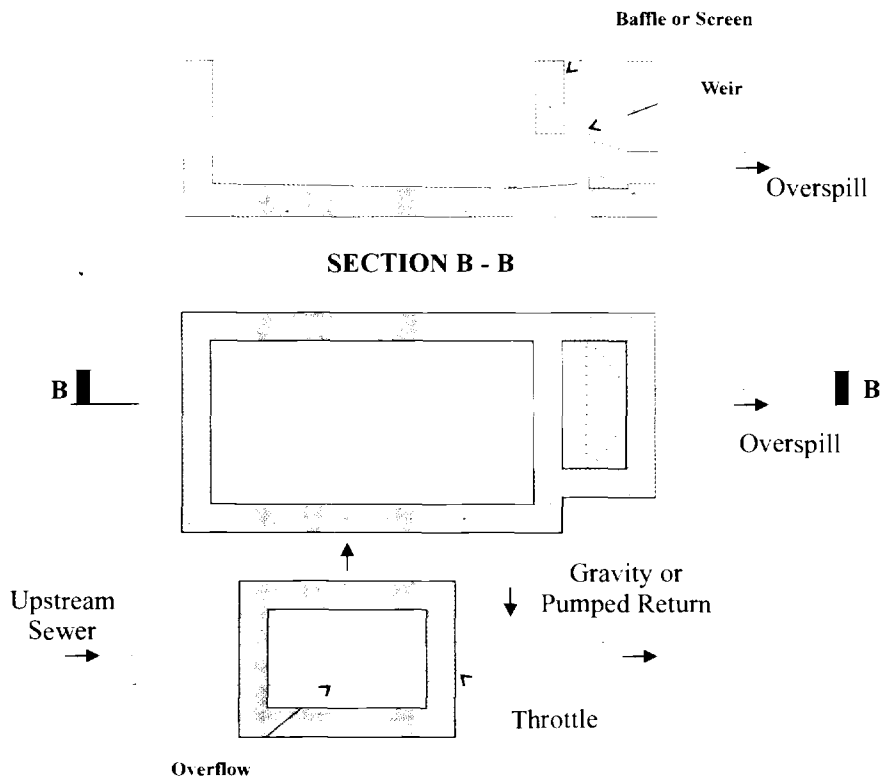
Stormwater storage at the inlet to a sewage treatment works is utilised for approximately 5% of the time. For this reason, there may be a tendency to neglect or underestimate its significance as part of the treatment works. The intermittent use of equipment may also lead to breakdown, for example, of scraper mechanisms and pumping plant. Nevertheless, the proper operation of storm balancing storage is critical to the satisfactory operation of the treatment plant and the protection of receiving waters.

Given the operational difficulties which may occur with storm balancing storage, it might be considered that treatment plants up to 5000 p.e. and possibly even of larger size (up to 10,000 p.e.) would be designed to accommodate "Formula A" flows through the treatment plant, avoiding the need for balancing tanks. This hydraulic capacity combined with well designed and well maintained overflow facilities could achieve the required objectives without off-line storage, except where higher standards are necessary for the receiving waters. However, this should always be subjected to economic and technical appraisal in order to determine the appropriate option in each case.



PLAN

a) On-line Balancing Storage



PLAN

b) Off-line Tank Overflow

FIGURE 2.7: ON-LINE AND OFF-LINE STORAGE

3.1 DEFINITION

Screenings comprise the coarse suspended and floating solids which are present in a wastewater stream and which are retained on bar racks or screens. The smaller the screen opening, the greater the quantity of screenings. In addition, the more screenings that are removed in them, the more organic putrescible content will be present.

3.2 PURPOSE OF SCREENING

The functions of screening equipment as part of the pretreatment works are:

To protect downstream mechanical plant from damage or obstruction due to large objects in the wastewater flow;

To separate and remove the larger material which might interfere with the efficient operation of wastewater treatment processes; and

To ensure the absence of unsightly floating matter at outfalls or in receiving waters.

The protection of receiving waters from aesthetic nuisance is increasingly the objective in selection of screening plant. For bathing waters, S.I. 84, 1988 entitled "European Communities (Quality of Bathing Water Regulations), 1988" gives effect to the Council Directive No. 76/160/EEC. This requires effective containment of screenings debris for discharges to bathing waters and similar standards are now generally applicable to amenity waters.

The National Strategy for Sewage Sludge Management adopted by the Department of the Environment envisages re-use of sludge as far as possible. E.C. Directive 86/278/EEC and the ensuing National Regulations (S.I. 183, 1991) set criteria for the use of sewage sludge in agriculture. The successful implementation of a re-use strategy involving land spreading requires a consistent, high quality product. This requires that the sludge be free of rags, plastics and other non-biodegradable debris, which would normally be removed by an efficient fine screening process.

In some instances, fine screening can be used to reduce the pollution load entering the wastewater

treatment plant by removing suspended solids and BOD. However, in municipal wastewater treatment, the objective should be to minimise the removal of organic matter at the preliminary treatment stage so that the screenings material for ultimate disposal is less objectionable and less likely to give rise to odour nuisance at the plant or disposal site.

3.3 SOURCES OF SCREENINGS

The main constituents of screenings are:

- rags,
- paper,
- plastics,
- timbers,
- offal, and
- leaves.

There are many additional elements of screenings which arise from the nature of the activities connected to the collection network. For example, building works tend to give rise to building debris. Other materials arise from illicit deposition of waste materials in sewers and manholes.

The amount of screenings will also vary with flow conditions in the sewer. Storm conditions will tend to increase the quantity of screenings arriving at the treatment works as additional material will be carried in via gulley traps, gratings, and resuspension of material trapped in bed sediments associated with increased sewer velocities. Therefore, screenings design must cater for the maximum hydraulic load to the works and have regard to the likely maximum screenings load associated with this flow.

The treatment works operator should maintain records of the quantities of screenings. The operator should also note any problems with screening equipment or problems associated with particularly heavy screenings loads. The occurrence of unusual or excessive quantities of screenings should prompt investigation of

potential sources both to alleviate the problem at the works and to avoid potential problems in the upstream sewer network.

Catchments with a substantial amount of storm inflow and where sewer gradients are steep can generate large debris which will damage fine screens and screenings handling equipment. Such catchments may require the provision of coarse screens upstream of fine screening to intercept boulders, timbers and similar debris.

3.4 CHARACTERISTICS OF SCREENINGS

The characteristics of screenings are extremely variable and dependent on many factors including the nature of activities within the catchment, the nature of the sewer system (combined, partially combined or separate), industrial and commercial activity and the nature of industrial effluents and their pretreatment prior to discharge.

Coarse screens with bar spacings of the order of 75-100mm are designed to intercept only the largest materials and these are generally held back in the flow to be manually removed. Such materials will generally be rocks, branches and large pieces of timber with little organic contamination.

Coarse screening of the order of 20 mm spacing have been found to have a high rag content. Such screenings will have a relatively high volatile solids content which can be up to 80% and will typically have a dry solids content in the order of 15-25%.

Fine screenings retained on screens with apertures of the order of 6mm will also have significant volatile solids contents and are likely to include 5-10% of influent suspended solids. Moisture contents are likely to be somewhat greater than for coarse screenings. They will also contain significant elements of grease and scum.

Because of the high putrescible matter content, including faecal material, screenings require careful handling and disposal. In a raw state, they are highly volatile and will quickly give rise to an odour nuisance if they are stored on site for any significant length of time. Daily disposal is therefore necessary, together with washing down of storage areas.

3.5 QUANTITY OF SCREENINGS

The quantity of screenings collected will vary depending on the type of screen used, the size of the screen opening, the type of sewer system and the geographical location. Sewer gradients and the resulting flow velocities can significantly influence the type of screenings encountered.

The predicted quantity of screenings at any given location is difficult to estimate as there are no data available for wastewater treatment plants in Ireland. However, the following textbook data provide an indicative range.

Volume of Screenings	0.01 - 0.03 m ³ /1,000 p.e.per day
Density of Screenings	600 - 950 kg/m ³ .
Moisture Content	75% - 90%.
Volatile Solids	65% - 95%.

Continental data suggest a figure of 10-15 litres of screenings per person per year for 6mm screens. Fig. 3.1 provides indicative guidelines for screenings volume for a range of screen bar spacings.

In recent years, there has been a marked increase in the amount of plastic materials arriving at the treatment plants. These plastics are difficult to remove by traditional screening methods and may be seen at various locations throughout wastewater treatment plants. They have a tendency to float longitudinally, prising through traditional bar screens.

3.6 TYPES OF SCREEN

Up to the mid 1970s, the basic type of screen used in sewage treatment in Ireland was a manually raked bar screen, having bar spacings of 20 - 25 mm. These screens have been overtaken to a large extent by the advent of economical mechanically raked screens and the need for finer screening. The screen types may be defined as follows:

Screen Type	Aperture
Coarse	> 50 mm.
Medium	15 - 50 mm.
Fine	3 - 15 mm.
Straining	< 3 mm.

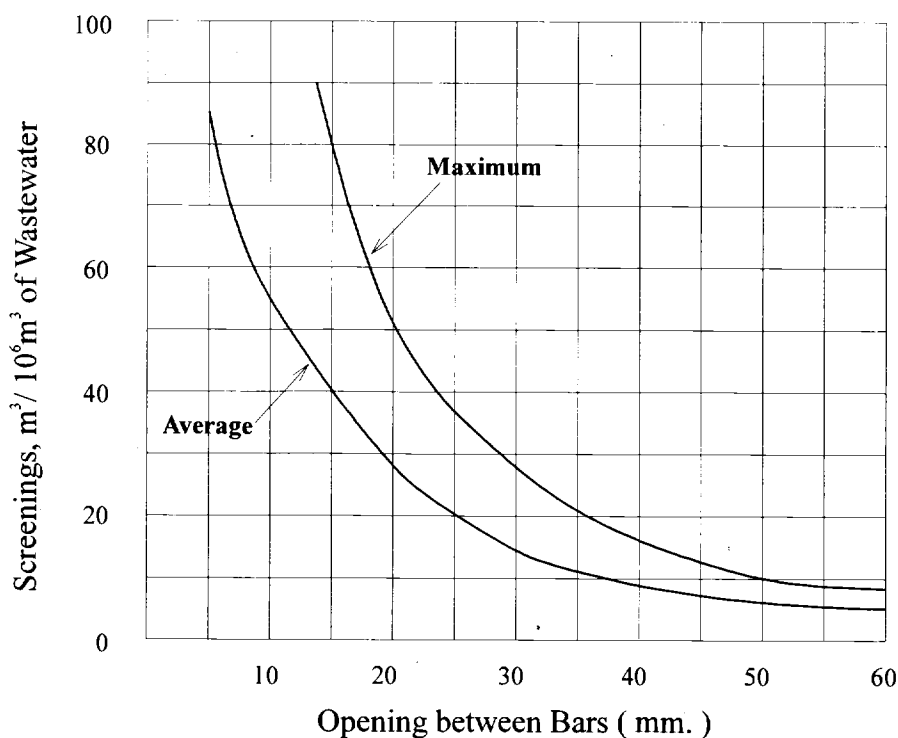


FIGURE 3.1: QUANTITIES OF SCREENINGS COLLECTED FROM MECHANICALLY CLEANED BAR RACKS
(COURTESY ENVIREX INC.)

The following table lists the types of screen available, although each type of screen has as many versions as there are manufacturers. Where reference is made to proprietary equipment, this is intended as indicating a type of screen and is not to be interpreted as endorsing or excluding any particular manufacturer or system. In addition, there are a number of new types of screen now on the market which do not come under the traditional descriptions. **Table 3.1** lists the screen types and their applications. Strainers have not been included in this list as these are a form of treatment and are not normally used in municipal wastewater pretreatment.

3.7 MANUAL BAR SCREENS

On many of the older wastewater treatment plants, the only form of screening is the manual bar screen with a bar spacing traditionally of approximately 25 mm. These bar screens are normally fixed on a guide rail inclined at 45° to 60° to the flow and are fitted with a perforated screenings trough above the water level into which the screenings are raked at irregular

intervals. These screens are quite ineffective and blind easily. They should be replaced where possible with mechanically raked screens and retained on a by-pass basis only.

3.8 COARSE SCREENS

3.8.1 TRASH RACKS

Coarse screens, such as trash racks, are normally used only in large volume stormwater drainage schemes and upstream of large pumping stations where the pumps need to be protected from large objects such as concrete blocks, logs of wood and other solid objects which could damage the mechanical equipment. Pumps on such duties would normally be unaffected by medium sized objects. These trash racks are rarely mechanically raked. They are generally aligned at an angle to the flow to minimise the risk of blinding during flood conditions.

TABLE 3.1: TYPICAL SCREEN APPLICATIONS

Screen	Type	Application
Trash Rack	Coarse	Used at inlet to large stormwater or combined flow pumping stations or before fine screens on a large wastewater treatment plant. These may be manually or mechanically raked.
Rotating Bar Interceptor (R.B.I.)	Coarse	As for trash rack, but do not need to be cleaned except to take out large objects by hand. Useful for interception of boulders, large timber segments, etc.
Manually Raked Bar	Medium	Used at inlet to small wastewater treatment plants or on by-pass to mechanical screen or disintegrator.
Curved Bar Screen	Medium	Used at inlet to small to medium size wastewater treatment plants. Intermittent raking. Shallow channels.
Vertical or Inclined Bar Screen	Fine or Medium	Used at inlet to small to large size wastewater treatment plants. Intermittent or continuous raking. Any depth of channel.
Band Screen (Stepped Screens)	Fine	Used at inlet to small to large size wastewater treatment plants. Continuous cleaning. Shallow to medium depths of channel.
Drum Screen	Fine	Used at inlet on large wastewater treatment plants. Continuous cleaning.
Cup Screens	Fine or Medium	Used at inlet to large wastewater treatment plants and sea outfalls. Continuous cleaning.
Screezer, Rotomat	Fine	These machines combine screening, screenings removal and dewatering suitable for medium to large wastewater treatment plants. Intermittent or continuous cleaning.
Discreen	Fine	For use on stormwater overflows or in combination with a disintegrator. Continuous cleaning.
Disposable Bags	Fine	Used at outlet of primary settlers, screened outlets, overflows, etc.



FIGURE 3.2: ROTATING BAR INTERCEPTOR (*JONES AND ATTWOOD*)

3.8.2 ROTATING BAR INTERCEPTORS (R.B.I.)

Rotating bar interceptors are now used in preference to static trash racks upstream of pumping stations (**Fig. 3.2**). These consist of rotating bars which, by virtue of their rotation, prevent the accumulation of debris (rags, etc.) on the bars. They do, however, retain larger objects such as concrete blocks, large timber sections, animal carcasses and similar large debris which would be likely to cause pumps blockage. In the event of jamming of the screen, the motors are reversed, reversing the direction of rotation and freeing the obstruction.

3.9 MEDIUM SCREENS

Medium screens are bar screens having a spacing of 15 - 50 mm and generally in the range 20-25 mm. These screens were initially developed as an

upgrade from the manual screen and were generally fitted with mechanical rake or brush facilities to convey screenings to a receiving trough.

The operation of the raking mechanism is normally intermittent, controlled by timer or head loss measurement. Downstream of pumps, it may be activated by pump start-up with timer controlled duration.

Automatic bar screens must be fitted with limit switches to prevent damage due to overloading or blockage. The controls also generally provide for a switch to ensure that the rake automatically stops moving at a point outside the screen area to avoid jamming at start-up.

3.9.1 CURVED BAR SCREENS

The curved bar screen is suitable for shallow inlet channels (i.e., less than 2.5 m) (**Fig. 3.3**). It is fixed in the channel sloping away from the flow. A rotating rake (normally double sided) is driven by an electric motor and follows the curvature of the screen with the tines interlocking with the screen bars. A tine cleaning device at the top of the screen sweeps the screenings into a collection trough. Curved bar screens, by virtue of their shape, are very suited to low flows.

3.9.2 VERTICAL AND INCLINED SCREENS

The vertical and inclined bar screens are variations of each other and are used for deeper inlet channels. These screens can be either front

or back raked and are generally hydraulically or chain operated. The cleaning action mimics a manual raking action. The cleaning rake is normally parked in the upper position and is actuated either by a timer or a water level signal. The cleaning rake will then travel down to the bottom of the screen with the rake in a disengaged or retracted condition. At the bottom of the travel, the rake is engaged into the screen by hydraulic or mechanical means. The rake collects the solids from the discharge chute and elevates them to the discharge chute where a hinged wiper pushes the solids into the receiving trough.

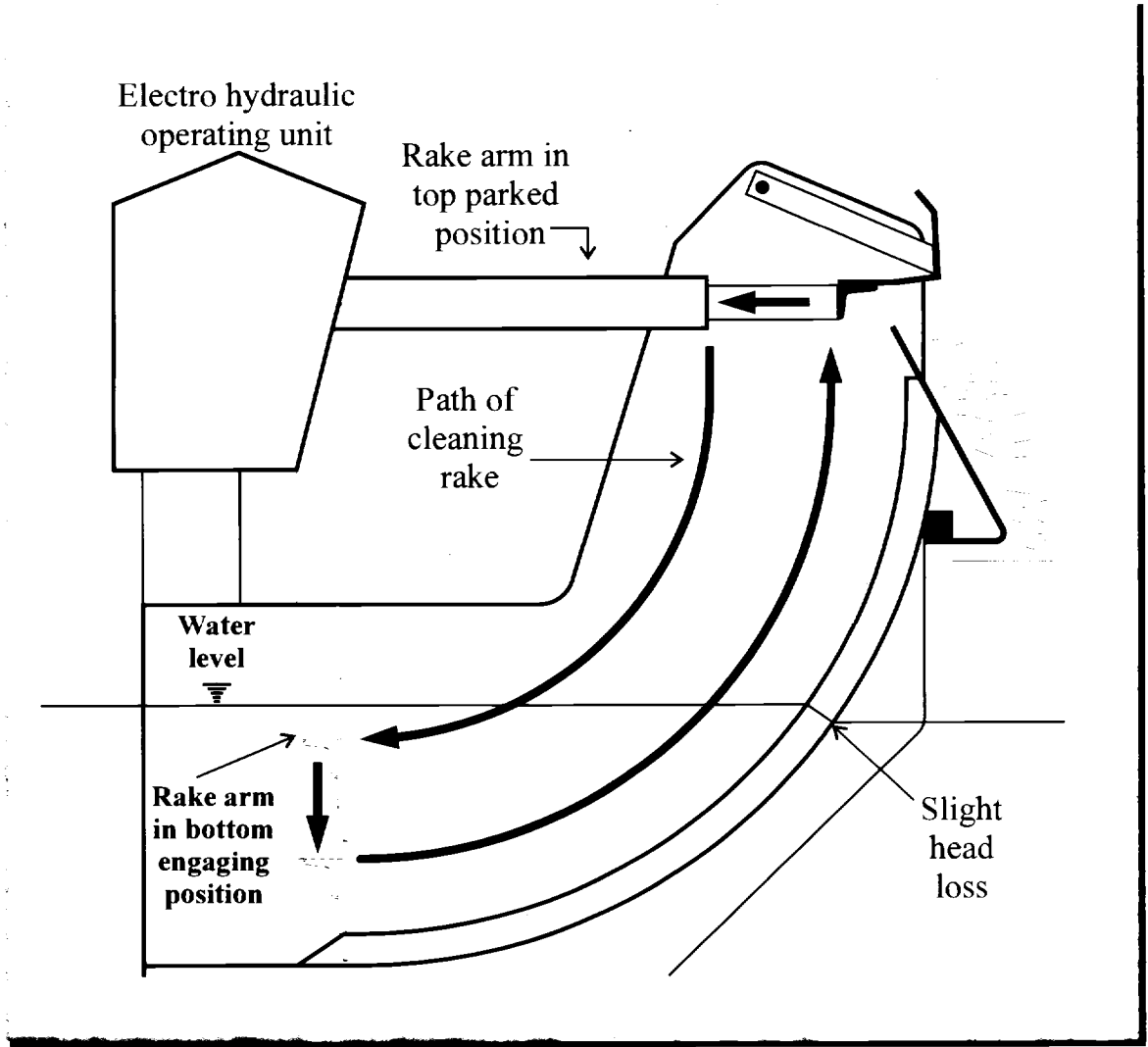


FIGURE 3.3: CURVED BAR SCREEN (JONES AND ATTWOOD)

3.10 FINE SCREENS

Fine screening (3 - 15 mm) is becoming increasingly common for the following reasons:

- advances in technology have made fine screens more reliable and more economical to manufacture;

- protection of bathing waters requires the adoption of fine screens for virtually all applications, particularly where European blue flag standards apply;

- the quality requirements for sludge re-use require effective fine screening to ensure removal of plastics and rags;

- development of improved and more economical screen washing equipment offsets the extra organic load removed by fine screens by returning it to the flow; and

- improved dewatering and compaction equipment greatly improves the handling and volume reduction of screenings, offsetting the effects of increased quantity removed.

The decision of Her Majesty's Inspectorate of Pollution (H.M.I.P.) in the U.K. to set a maximum spacing of 6 mm for outfalls has set the standard for screen manufacturers in Britain.

In general, Irish practice is likely to be similar given the common standards used and the fact that equipment is commonly sourced in Britain. The Department of the Environment criteria for storm overflows to Bathing Waters, for example, have adopted the 6mm standard.

Considerable research and development in screening is taking place in the development of fine screening, washing and dewatering as a consequence of their increased usage. Therefore, any discussion of screens is of necessity confined to the general types rather than the full range of models available or under development. The following sections discuss the main types of equipment on offer at present.

3.10.1 INCLINED BAR SCREENS

These screens are, as the name suggests, standard bar screens set at any inclined angle to the flow, having bar spacings of 5 mm upwards. Screens

are continuously front or back raked by means of cleaning tines mounted on a chain mechanism. These tines continually lift the screenings for discharge at the upper end, either by gravity or by means of a brushed cleaning device (Fig. 3.4).

3.10.2 BAND SCREENS

Band screens consist of a series of panels which continually move up through the flow on a belt drive collecting the screenings on the way. In general, these band screens are made up in either of two ways (Fig. 3.5):

- shaped plastic or stainless steel hooks, formed in rows or bands; and

- step shaped perforated plates, similarly arranged.

These are assembled to form a continuous belt which filters the effluent and, in fact, the collected screenings provide further filtration. There are a number of methods of removing the screenings from the band screen, either by means of a brush system or a backwash system.

3.10.3 DRUM SCREENS

Drum screens have been in existence for many years and basically consist of a large perforated cylinder mounted horizontally in the flow and through which the wastewater has to pass to reach the inlet to the treatment works. The flow must pass from outside to inside the drum. The screenings are maintained on the outside of the drum which rotates into the liquid and they are collected within a screenings pit from where they are removed by means of a pump or other elevator.

3.10.4 ROTOMAT, SCREEZER, CONTRA-SHEAR

There are now, however, a number of other rotating screens which fall into this general category, such as the Huber Rotomat, the Jones & Attwood Vertical Drum Screen and the Contra-Shear drum screen.

Each of these screens operates by having rotating drums immersed to some degree in the sewage flow. In the case of the Rotomat and Contra-Shear, the sewage enters the inside of the drum and flows through it to a collector channel externally. The screenings are collected on the

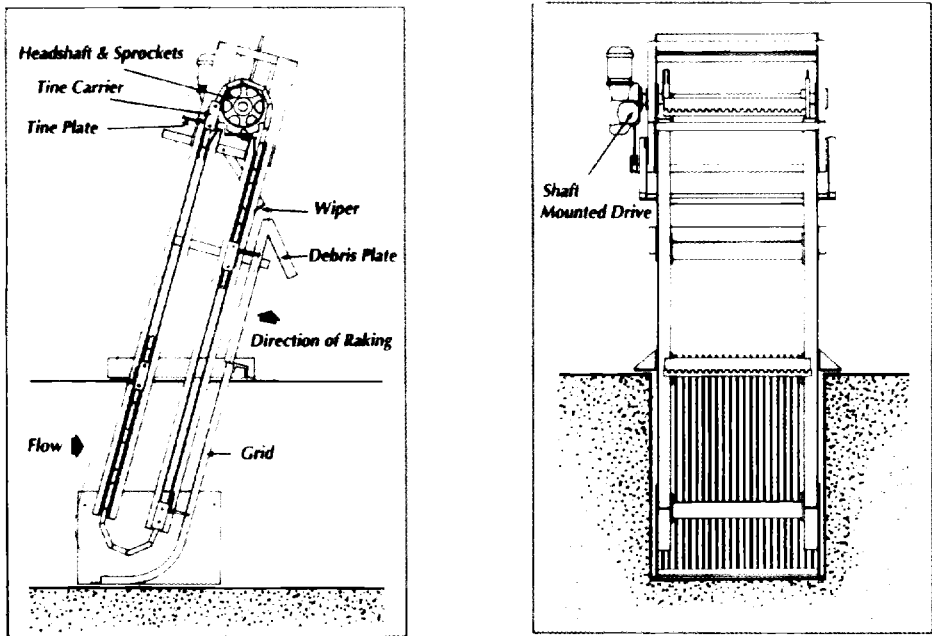


FIGURE 3.4: INCLINED MECHANICALLY RAKED BAR SCREEN

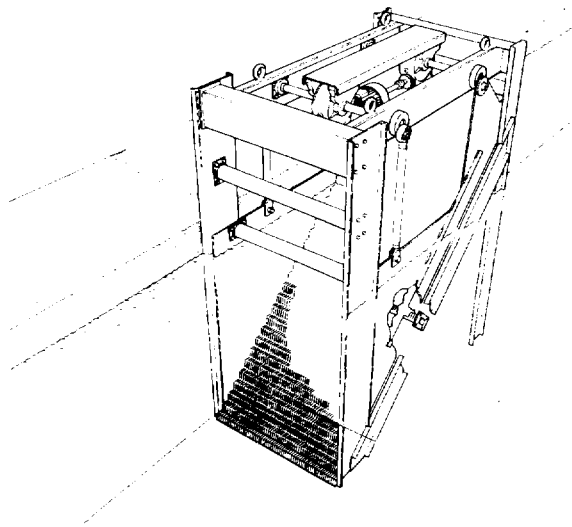


FIGURE 3.5: STEP SCREENS (INKA SYSTEMS)

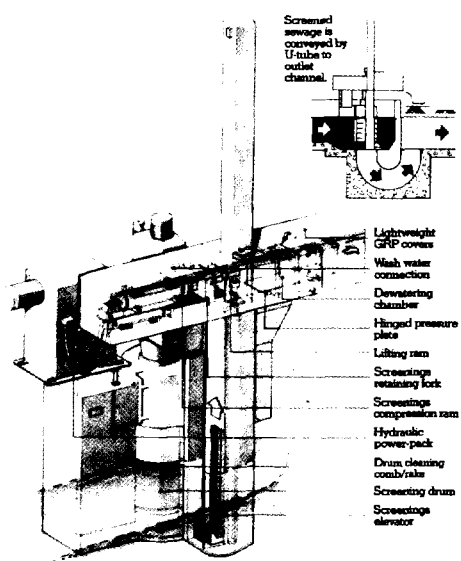


FIGURE 3.6: SCREEZER (JONES AND ATTWOOD)

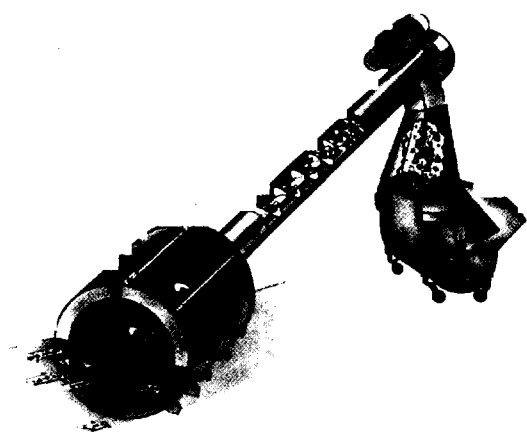


FIGURE 3.7: DRUM SCREEN - ROTAMAT TYPE (HANS HUBER GMBH)

inside of the drum and rotated upwards to be dropped out into a receiving chute in the centre.

The Jones & Attwood Vertical Drum Screen is a direct replacement for the comminutor and, in this case, the sewage flows from outside to inside of the drum, dropping down from the centre via an inverted syphon. The screenings are retained outside the drum and are lifted to the surface by a lifting tine or conveyor. The Jones & Attwood Vertical Drum Screen is ideal as an upgrade for an existing comminutor installation, where it can be readily retro-fitted.

Some of these screens, notably the Contra-shear screen, require a significant level drop which may not be available at a gravity plant or in an existing works. All of these machines are effective but are also expensive (both for the mechanical plant and in terms of civil works) with the exception of the

Rotomat which can be fitted in a standard channel.

3.10.5 DISCREEN

The Discreen is a variation on the Monomuncher disintegrator and consists of a series of vertical shafts, each fitted with overlapping discs which rotate in the same direction at different speeds accelerating towards the downstream end (**Fig. 3.8**). The screenings are continuously moved along the screen and kept in the flow, while liquid passes through. The screen does not remove the screenings but retains them in the flow. This screen is suitable for use on stormwater overflows, particularly at pumping stations and is fitted before the sump overflow pipe.

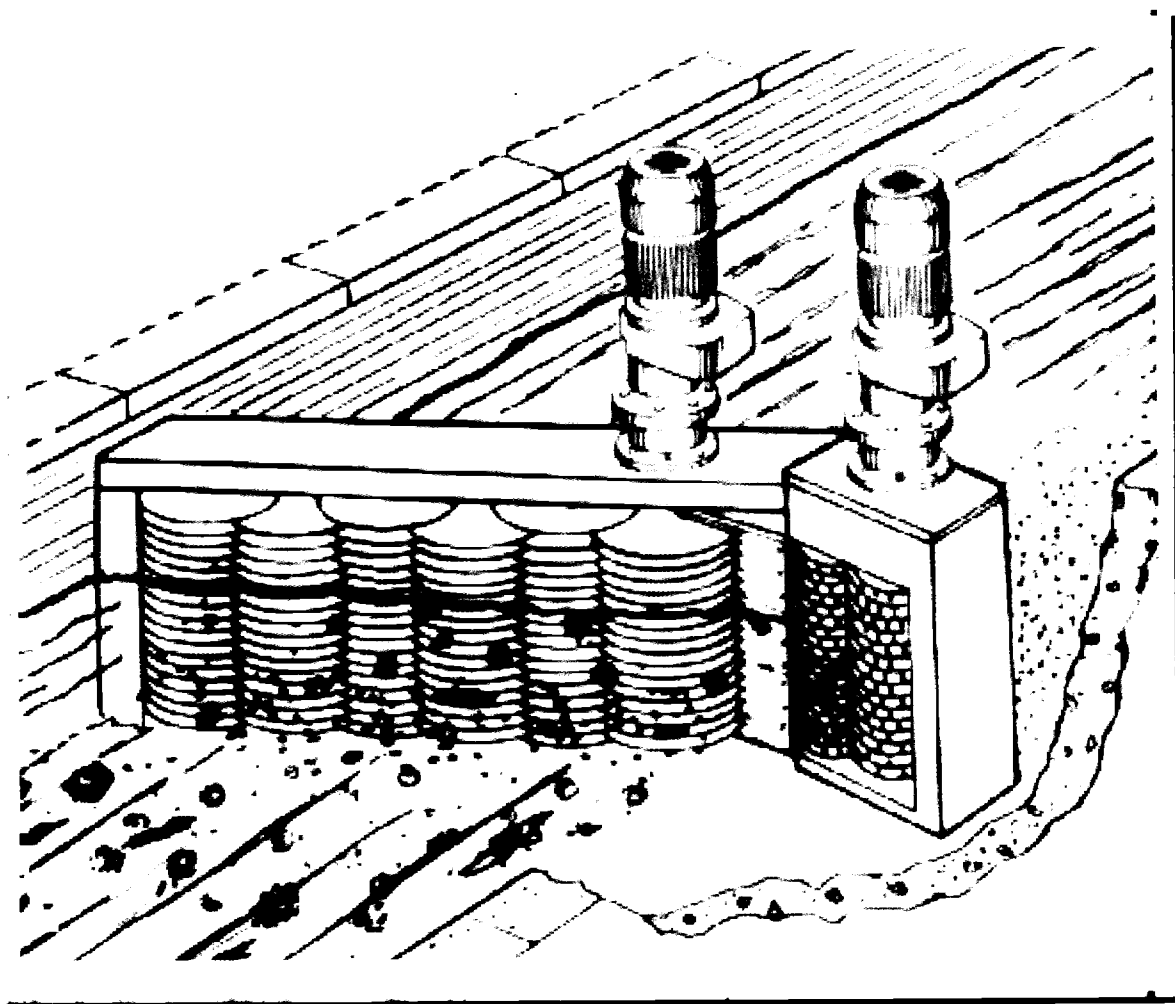


FIGURE 3.8: DISCREEN (H₂O WASTE-TEC)

3.10.6 DISPOSABLE BAGS

Disposable open mesh bag screening is a recent and cheap option which has been marketed by Copa Sacs and takes the form of disposable open mesh bags which are mounted in the flow and collect fine screenings. These screens are not suitable for inlet application, but can be retro-fitted to unsatisfactory existing installations to protect the overflow or after primary sedimentation to protect the distribution arms of percolating filters. They could also be used on the outlet from a treatment plant to ensure that no floating debris passes out. If used, the sacks need to be changed regularly.

3.11 SCREEN DESIGN

3.11.1 SELECTION

The specific screen to be selected will depend on the application. In general, the approach as set out in Table 3.2 is suggested.

In general, manually raked screens should not be installed on new plants, except in the case of very small plants which would not justify mechanically raked screens. In this case, the area of immersed bar screen must be higher than that for a mechanically raked screen to avoid blockages.

TABLE 3.2: SCREEN SELECTION

APPLICATION	APERTURE	TYPE
Large Pumphouses	50 - 15 mm.	Trash Rack. R.B.I.
Small Pumphouses	50 mm.	Liftable Cage. Bar Screen.
Small Wastewater Treatment Plants (Without Sludge Treatment)	15 - 25 mm.	Curved Bar Screen. Vertical Bar Screen. Inclined Bar Screen.
Small Wastewater Treatment Plant (With Sludge Treatment)	5 - 10 mm.	Inclined Bar Screen. Vertical Bar Screen. Band Screen.
Medium Wastewater Treatment Plant (With Sludge Treatment)	5 - 10 mm.	Inclined Bar Screen. Vertical Bar Screen. Band Screen. Screezer (V.D.S.). Rotomat. Contra-Shear.
Large Wastewater Treatment Plants (With Sludge Treatment)	15 - 50 mm. (Before Fine Screen)	Vertical Bar Screen. R.B.I.
	5 - 10 mm.	Band Screen. Drum Screen. Cup Screen. Screezer (V.D.S.). Rotomat. Contra-Shear.
Overflows (Retain Screenings in Foul Flow)	5 - 10 mm.	Discreen. J&A Weir Mount.

A standby or bypass channel should be provided for all screening facilities to avoid the possibility of flooding or discharge of unscreened and untreated sewage due to a breakdown or clogging of the inlet screen. A manually raked screen should be fitted in this bypass channel. Dual screen channels are appropriate only at large works, say 20,000 population equivalent and over, where a bypass channel should also be incorporated.

3.11.2 STANDARDS

Due to the large diversity of screen types available, there is no standard method of comparison. If comparison is desired, then a number of simple tests could be carried out. These tests are:

tracer test: a known quantity of mixed items of plastics such as plastic strips, papers, condoms, sticks, etc., can be placed in the channel a fixed distance upstream from each screen and the quantity of plastics captured measured; and

mesh test: depending on the aperture size, a series of aluminium meshes may be placed in the sewage flow both upstream and downstream of the screen and the degree of capture on each mesh compared. These mesh sizes would typically be in multiples of the design screen size.

3.11.3 DESIGN

The basic design of a bar screen should be such that the velocity through the screen would be sufficient for matter to attach itself to the screen without producing an excessive loss of head or complete clogging of the bars. At the same time, velocities in the channel upstream should be sufficient to avoid deposition of solids. In all cases, the shape of the bar should be tapered from the upstream side so that any solids which pass the upstream face of the screen cannot be jammed in the screen, thereby causing a trip out of the raking mechanism.

The following table gives the design factors for bar screens:

TABLE 3.3: SCREEN DESIGN FACTORS

Item	Manually Cleaned	Mechanically Cleaned
Bar Size: Width (mm)	5 - 15	5 - 15
Depth (mm)	25 - 80	25 - 80
Aperture (mm)	20 - 50	5 - 80
Slope to Flow (Deg)	45° - 60°	18° - 90°
Velocity Through Screen (m/s)	0.3 - 0.6	0.6 - 1.0 (Max. 1.4)

The minimum head loss which should be allowed for through a screen is 150 mm but this will vary with screen type and design. Allowable head loss will often depend on available head.

The degree of clogging of a bar screen will vary with the size of the screen and the wastewater quality. For mechanically raked bar screens, the clogging can be anywhere between 10% for surface water and 30% for wastewater with high solids content. For manually raked screens, the degree of clogging will be greater due to infrequent cleaning.

Because of the need to control flow velocities through the screen, approach velocities upstream will generally be slow, especially in the case of fine bar screens with an open area of less than 50%. This means that the channel widths will be relatively wide and channel deposition is difficult to avoid. The plant operators must flush such channels clean on a daily basis.

It is important in the design of screening installations to ensure that upstream velocities are kept sufficiently high to minimise deposition of sediments which create nuisance.

The following equations may be used for standard bar screens to calculate the width of channel required and the head loss through the screen:

$$\text{Width of Channel } W = \frac{100Q}{V * D * S} \quad (3.1)$$

Head Loss

for clean or partially clogged screens

$$H_L = 1.43 \left(\frac{V^2 - v^2}{2g} \right) \quad (3.2)$$

for clean screens

$$H_L = b \left(\frac{B}{A} \right) h_v \sin \theta \quad (3.3)$$

for fine perforated plate screens

$$H_L = \frac{1}{2g} \frac{1}{C} * \left(\frac{Q}{A} \right)^2 \quad (3.4)$$

where:

- Q = Maximum Flow (m³/s)
- V = Velocity Through Screen (m/s)
- v = Velocity in Upstream Channel (m/s)
- D = Depth of Flow (m)
- W = Width of Channel (m)
- S = % Screen Open Area.
- H_L = Head Loss Through Screen (m)
- g = 9.81 m/s² (gravity).
- h_v = Head on Screen Upstream (m)
- A = Submerged Aperture Area (mm²)
- B = Bar Width (mm)
- θ = Angle of inclination of bars.
- C = Coefficient which should be checked with the manufacturer.
- β = Bar Shape Factor. The values of bar shape factors for clean rack are summarised as follows:

Bar Type.	β
Sharp-edged rectangular.	2.42
Rectangular with semi-circular upstream face.	1.83
Circular.	1.79
Rectangular with semi-circular upstream and downstream faces.	1.67
Tear shape.	0.76

Proprietary screens, such as the Rotomat, Screezer, Contra-Shear, etc., are not covered by these formulae and head losses have to be calculated separately. Reference should be made

to manufacturer's technical data sheets for appropriate design criteria. In general, the head available (together with the performance required) will tend to dictate the type of screen to be used.

3.12 SCREENINGS DEWATERING

The disposal of screenings is made difficult by the presence of faecal matter and other undesirable materials. When medium to coarse screening of sewage was the norm at plants and the screens were manually raked, the quantities of screenings to be dealt with was reasonably small. In small sewage treatment plants, these were normally dealt with by burying on site, while on larger plants they were transported to the local landfill.

With the improvement in screening techniques and the advent of finer screens, the quantity of screenings to be dealt with has greatly increased. This increase will accelerate with the requirement under the Urban Wastewater Treatment Regulations and Directive to provide wastewater treatment facilities at many more towns, including the larger coastal conurbations. At the same time, finer screening means that more faecal matter and other undesirable objects are trapped in the screenings making them unacceptable for handling in their raw state.

Since the mid-1980's, much development has taken place in the design of screening dewatering devices. These devices come under four main headings:

- * hydraulic press,
- * screw compactor,
- * washer/dewaterer, and
- * centrifuge.

Most of these devices include some form of washing to reduce the amount of faecal matter. The success of this washing is very variable. One successful approach is to liquefy the faecal matter by means of pumping or maceration and washing in the flow prior to screening. Alternatively, equipment is available to disintegrate the screenings in the presence of water, after removal from the flow. This will liquefy the faecal matter facilitating its return to the flow, leaving relatively clean screenings.

The dryness of the screenings following dewatering is also very variable, depending on the machine used and a further consideration is the compactness of the finished product.

3.12.1 HYDRAULIC PRESS

In the hydraulic press, the screenings are deposited into the pre-pressing/wash stage via a hopper. The faecal matter is washed out by means of high pressure water jets and the hydraulic ram then forces the washed screenings into a compression chamber where a constant pressure is maintained, thereby achieving a high degree of dewatering. The washed and dewatered screenings are discharged by means of displacement by fresh screenings deposited in the press. The most common version of the hydraulic press on the Irish market is the Launder Feed Press manufactured by Jones & Attwood (Fig. 3.9). This achieves a finished product of

approximately 50% moisture and can accept screenings from multiple screens. A more expensive variation of the Launder Press is the Squeezer which is a dedicated hydraulic ram press fitted to a vertical drum screen which replaces existing comminutors, in the larger sizes (25R.M. and 36R.M.).

3.12.2 SCREW COMPACTORS

There are very many versions of the screw compactor with extremely variable performances. Basically, all screw compactors operate in the same way in that screenings are deposited onto the screw through a feed hopper where washing is carried out using water jets which may or may not be high pressure units. The screenings are conveyed from the washing area into a compaction area where more drainage occurs (Fig. 3.10).

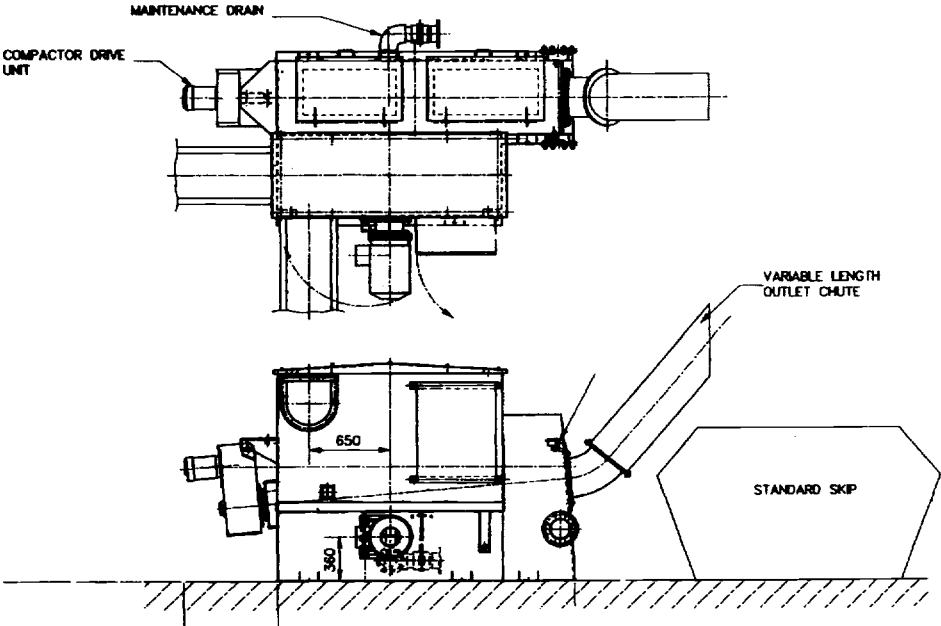


FIGURE 3.9: HYDRAULIC SCREENINGS PRESS DETAIL (JONES AND ATTWOOD)

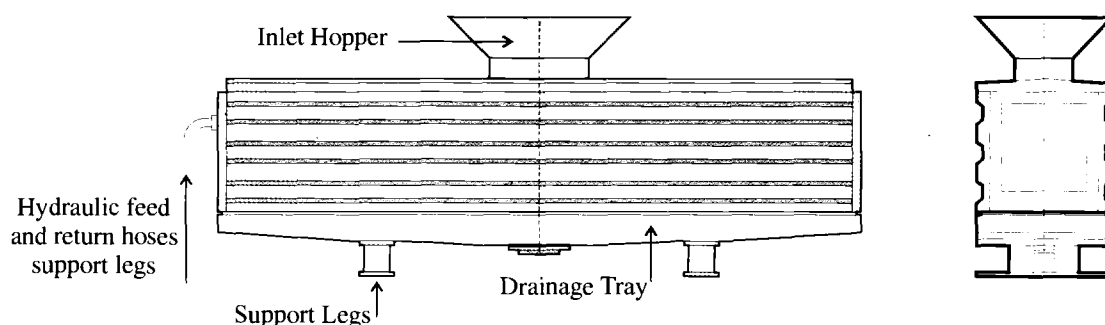


FIGURE 3.10: SOLID WASTE SCREENINGS - TOP FEED PRESS (JONES AND ATTWOOD)

Compaction can take place either by a spring loaded flap or merely by gravity on an inclined discharge chute. Some screw compactors incorporate a screw with a decreasing pitch which aids the compression of the screenings.

In general, screw compactors do not remove much of the faecal matter from the screenings and the compacted cake will have a moisture content of between 60% and 70%.

3.12.3 WASHER DEWATERERS

These machines incorporate a definite disintegrating stage which breaks down and washes out the sewage solids before the compacting stage takes place. Compaction is by means of rollers or a screw compactor. The versions of this type of machine in use in Ireland at present are the Washpactor from Jones & Attwood and the Parkwood Washer/Dewaterer. The final product is clean and inoffensive and has a moisture content of approximately 60% - 65%.

3.12.4 CENTRIFUGE

A screenings centrifuge process currently available is the Lisep Process (Haigh Engineering). Screenings are first collected to a macerating pump sump from where they are pumped with maceration to the Lisep unit. The maceration process has the effect of liquefying the faecal matter and separating it by washing from the other materials in a liquid stream. The Lisep device itself can be located either adjacent

to the screening installation or remotely in a building. The latter is advisable because the final product is dry and loose and susceptible to be wind blown.

The macerated screenings are pumped to a liquid distribution chamber from where the liquid is fed into a centrifuge where separation is effected by a stainless steel paddle rotating at 1,450 r.p.m. The paddle rotates inside a stainless steel screen containing 1.5 mm. holes. This screen is conical in shape. The separated liquid drains through the perforated mesh and returns to the treatment plant while the dry solid materials are ejected through the bottom of the device. The dewatered material is relatively innocuous and aesthetically acceptable. However, it is not compacted and is susceptible to wind scatter if not contained.

This system is compact and efficient in producing a clean product with minimum organic removal from the wastewater.

3.13 SCREENINGS DISPOSAL

Traditionally, there have been a number of methods of screening disposal:

- removal to a landfill;
- disposal by burial on site (small plants only);
- incineration (large plants only); and

co-disposal with municipal solid waste.

The first of these is by far the most common and it is envisaged that this practice will continue in the foreseeable future. It is suggested that where small quantities of screenings are involved, a bagging unit might be appropriate.

Incineration is only relevant where an incinerator already exists for the disposal of sewage sludge or other wastes. This is unlikely to be a practical disposal route in Ireland in the foreseeable future. However, when considering such a route, it should be remembered that screenings have a calorific value of approximately 15×10^6 kJ/tonne dry solids and are not autothermic. It is also important that the screenings should be incinerated at temperatures greater than 800°C to avoid malodorous emissions.

The disintegration of non-biodegradable screenings and return to the flow should be avoided where possible as this can create problems both in the end use of the sludge and in the final effluent.

3.14 DISINTEGRATION

Disintegrators are not, strictly speaking, screens but they have been widely used in the past at the inlet to wastewater treatment plants. This equipment was designed to chop up the solids for retention in the flow and removal with the sludge. The practice is no longer favoured for the following reasons:

- it results in a poor quality sludge, unsuitable for re-use;

- the chopped screenings cause operational problems at weirs, dewatering presses, etc.; and

- screenings carryover, particularly plastics, causes aesthetic nuisance at outfalls and within the works.

Disintegrators basically comprise the following machines:

- comminutors,
- macerators, and
- munchers.

3.14.1 COMMUNUTORS

The comminutor consists of a cast iron hollow drum made up of a number of sections rotating around the vertical axis. The drum is a fine screen with horizontal slots. The drum is fitted in line with flow from outside to inside and discharged from there via an inverted siphon. The solids are retained on the face of the drum and combs fixed at various locations around the drum carried the solids to fixed teeth on the comminutor casing which disintegrates the solids and allows them to pass through the screen with the flow. Problems have arisen with comminutors due to lack of maintenance, deposition in the channels and inverted syphons and the fact that floating plastics frequently pass straight through the slots.

Jones & Attwood comminutors can be directly replaced by their Vertical Drum Screen or Screezer, both of which remove the screenings from the flow. This equipment can be retro-fitted relatively easily.

3.14.2 MACERATORS

Macerators are basically high speed centrifugal pumps which incorporate rotating cutting edges which cut the solids against a fixed hardened steel shear plate. A variation on the macerating pumps is a pump which has a set of cutting knives fixed into the suction pipe separately from the pump itself.

In-line macerating may continue to have application for pumped effluents with high levels of screening, for example, hospital effluent. The equipment is useful to liquefy organic solids in screenings prior to compaction, so that the subsequent screenings removal contains a minimum of faeces.

3.14.3 MUNCHERS

The Muncher is a slow speed high torque parallel shaft grinder (**Fig. 3.11**). Each shaft is fitted with a series of interlocking cutters and spacers which counter-rotate and trap objects onto teeth crushing and grinding them. The Muncher can be installed in channels, pipelines and used on the inlets to pumphouses, sewage treatment plants, etc. One of the drawbacks of the Muncher is its high head loss. This drawback has been overcome with the advent of the Discreen which conveys screenings to the Muncher while passing the screen flow through.

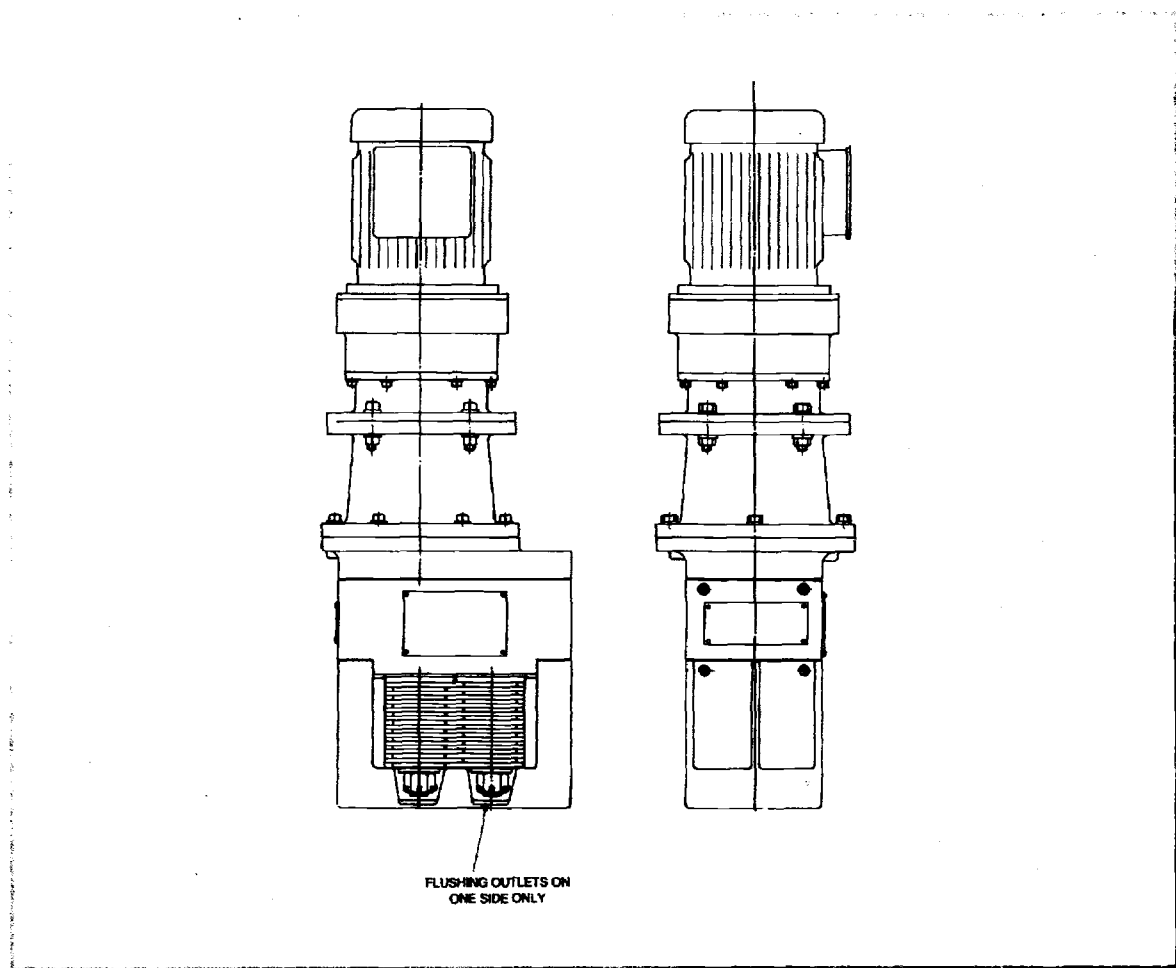


FIGURE 3.11: IN-LINE DISINTEGRATOR (MUNCHER) (H_2O WASTE-TEC)

While there are many locations in which disintegrators are suitable, it is now generally accepted that screenings should be removed where possible from the flow.

3.15 MAINTENANCE

There should be a Schedule of Maintenance for the screening facility broken down into daily, weekly, monthly, biannual or annual operations.

The daily operations should include the removal of the screenings to avoid odour and vermin nuisance. Storage of the screenings in covered containers is desirable which would be removed daily or weekly for disposal. The storage area should be regularly washed and cleaned with a chemical solution such as chlorine or hydrogen peroxide. The screen channels upstream and downstream and the by-pass channels should be cleaned daily to ensure no build-up of sediment or malodorous materials. It should be noted that the screening area is one of the few areas within a

modern wastewater treatment plant where odours are difficult to avoid.

The screen raking mechanism (raking chain, sprockets, teeth and other moving parts) should be inspected daily. Where dewatering devices have been installed, these should also be inspected daily. All moving parts should be lubricated and adjusted as recommended by the manufacturers.

Each screen and dewatering device, where relevant, should be taken out of service for maintenance on a routine basis. The unit should be cleaned down and the components checked for painting, cables, chains, teeth replacement, removal of obstructions, straightening of bent bars, etc.

3.16 COMMON OPERATING PROBLEMS

As with every section of a wastewater treatment plant, common problems arise in the screening area and a short trouble shooting guide for these is presented in **Table 3.4**.

TABLE 3.4: OPERATIONAL PROBLEMS AT SCREENS

PROBLEM	CAUSE	SOLUTION
Obnoxious odours and vermin.	Improper or prolonged storage of screenings.	Provide proper storage, increase frequency of removal and disposal.
Excessive screen clogging.	Unusual amount of debris in wastewater.	Identify the source of excessive debris and stop it.
	Low velocity through the rack. Automatic rake action not often enough.	Provide a coarser rack. Reset the timer cycle or install a level override.
Excessive grit accumulation.	Low velocities in the channel.	Remove flow irregularities. Reslope the floor. Rake the channel. Flush regularly.
Jammed raking mechanism will not reset.	Obstruction still on the screen.	Remove the obstruction.
	Moment setting too fine.	Consult manufacturer regarding setting adjustment.
Screen not being raked but motor is running.	Broken chain, cable or limit switch.	Inspect the chains, switches and rakes and replace as necessary.
Rake will not operate - no visible reason.	Defective control mechanism.	Check control circuits and motors and replace as necessary.

4.1 DEFINITION

Grit consists of sand, gravel, stones, soil, cinders, bone chips, coffee grounds, seeds, eggshells, glass fragments, metals and other materials present in wastewater which do not putrefy.

In general, grit as defined above has a specific gravity between 1.5 and 2.7 as opposed to a specific gravity for organics of approximately 1.02. In addition, grit settles as discrete particles, rather than as flocculant solids which is the case with organics.

4.2 SOURCES

Grit can originate from many sources, depending on a number of factors, but particularly on the type of collection system, i.e., separate, partially separate or combined. The following is a listing of some of the sources and types of grit:

domestic waste: *glass, coffee grounds, seeds, eggshells;*

industrial effluent: *metals, sands, clays, etc.;*

stormwater drains: *sands, pebble, road-making materials;*

new construction sites: *and, gravel, concrete blocks, stone, etc.;* and

infiltration: *leaching of soil fines into the pipe.*

The transport of these items within the sewer system will depend on the condition and gradient of the sewers.

4.3 QUANTITIES OF GRIT

The quantity of grit varies greatly, depending on a number of factors including:

- type of collection system,
- topography,
- condition and gradient of sewers,
- types of industrial wastes,

- climatic conditions,
- soil types, and
- proximity to beaches.

Actual data on the quantities of grit in particular systems are difficult to obtain mainly due to the fact that these are not normally recorded in a wastewater treatment plant. However, the range generally taken is between 5 and 50 m³ per 10⁶ m³ of sewage and possibly up to 200 m³ per 10⁶ m³. A typical design value would be 30 m³ per 10⁶ m³.

4.4 PROBLEMS

In general, the solids contained in wastewater flows are deposited when flow rates are low. These solids will then be resuspended and transported in the sewers when flow rates increase. Because of its specific gravity, this phenomenon is more common with grit. For this reason, designers of collection systems and ancillary structures try to ensure that self-cleansing velocities (0.75 m/sec) are achieved at least once per day. At this velocity, grit is resuspended in the flow and transported. This cannot always be achieved and grit can settle out:

- when flow rates are low;
- in flat sewer sections;
- in inverted syphons; and
- in pump sumps.

In some cases, this settled grit is not resuspended and is only removed by a sewer cleaning programme, necessitated by loss of sewer capacity. Abnormal storms causing high sewer flows will tend to resuspend substantial quantities of grit sediments. For these reasons, grit arrives at a wastewater treatment plant in irregular quantities and at irregular intervals.

In wastewater treatment plants, grit can cause problems mainly by:

- excessive wear on mechanical plant;

blockages of pipes and channels:

accumulation on the floors of primary settlement tanks, aeration basins and digesters; and

settling out in tankage taking up treatment space and causing further depositions of putrescible materials.

It appears however, that grit particles less than 0.2 mm. (65 mesh) cause few problems.

4.5 SETTLEMENT THEORY

Grit consists of discrete particles which settle independently of one another with a constant velocity. When a discrete particle is left alone in a liquid at rest, it is subjected to a settlement force of gravity and to a resistance resulting from the viscosity of the fluid and inertia. For any given size and density of particle, there is a particular settling velocity. This settling velocity is changed somewhat when the liquid in which the particle is contained is subjected to a horizontal velocity.

Grit settlement is generally regarded as following Stokes' Law which may be stated as:

Stokes' Law

$$V_0 = \frac{g}{18\eta}(l_s - l_l)d^2$$

where:

- V_0 = settling velocity (m/s);
- g = gravitational acceleration (m/s^2);
- η = viscosity of liquid (kg/ms);
- l_s = density of particle (kg/m^3);
- l_l = density of liquid (kg/m^3); and
- d = diameter of particle (m).

In practice, Stokes' Law is valid only for fine particles (< 0.1mm). However, the following data may be used to check the performance of grit removal chambers (a specific gravity of 2.65 has been assumed):

TABLE 4.1: SETTLING VELOCITY OF GRIT

Particle Diameter (mm)	0.05	0.1	0.2	0.3	0.4	0.5	1.0	2.0	3.0	5.0	10.0
Settling Velocity (m/s)											
V_0	0.002	0.007	0.023	0.04	0.056	0.072	0.15	0.27	0.35	0.47	0.74
V_{01}	0	0.005	0.017	0.03	0.04	0.05	0.11	0.21	0.26	0.33	
V_{02}	0	0	0.016	0.03	0.045	0.06	0.13	0.25	0.33	0.45	0.65
V_c	0.15	0.20	0.27	0.32	0.38	0.42	0.60	0.83	1.00	1.30	1.90

where:

- d = diameter of particle;
- V_0 = settling velocity at zero horizontal velocity;
- V_{01} = settling velocity at critical horizontal velocity;
- V_{02} = settling velocity at 0.3 m/s horizontal velocity; and
- V_c = critical horizontal velocity.

It can be seen from the foregoing table that the horizontal velocity is of critical importance in determining the size of particle to be settled. Normally, a horizontal velocity of 0.3 m/s is taken as the optimum horizontal velocity. A detention time of 45 - 90 seconds is typically used.

4.6 CONSTANT VELOCITY GRIT CHANNELS

4.6.1 PARABOLIC CHANNEL

It has been found that the optimum settling velocity for grit is 0.3 m/s. At this velocity, most discrete particles of diameter 0.2 mm and greater will settle readily while organic material will not. The principle of the constant velocity grit channel is to construct a channel in which the flow velocity is 0.3 m/s in all conditions of flow. This is possible by using either parabolic channels controlled by a flume or channels controlled by a suture weir (Fig. 4.2).

A channel of parabolic cross-section means that the cross-sectional area of the channel at any depth of flow is directly proportional to the rate of flow. In this way, a constant liquid velocity can be maintained. The length of these channels is dictated by the depth of flow in the channel. A number of channels can be provided to cater for varying flow conditions. The number of channels in use at any particular time can be controlled by the use of hand or actuated penstocks.

These channels are often constructed in a trapezoidal shape or, indeed, in a W shape (dual channel) to approximate to the parabolic shape which is difficult to construct. Degritting of the channels may be by means of a mechanical grab or air lift pump. In many of the grit channels in Ireland, degritting is by hand and, in these cases, a standby channel should be provided for use during cleaning operations.

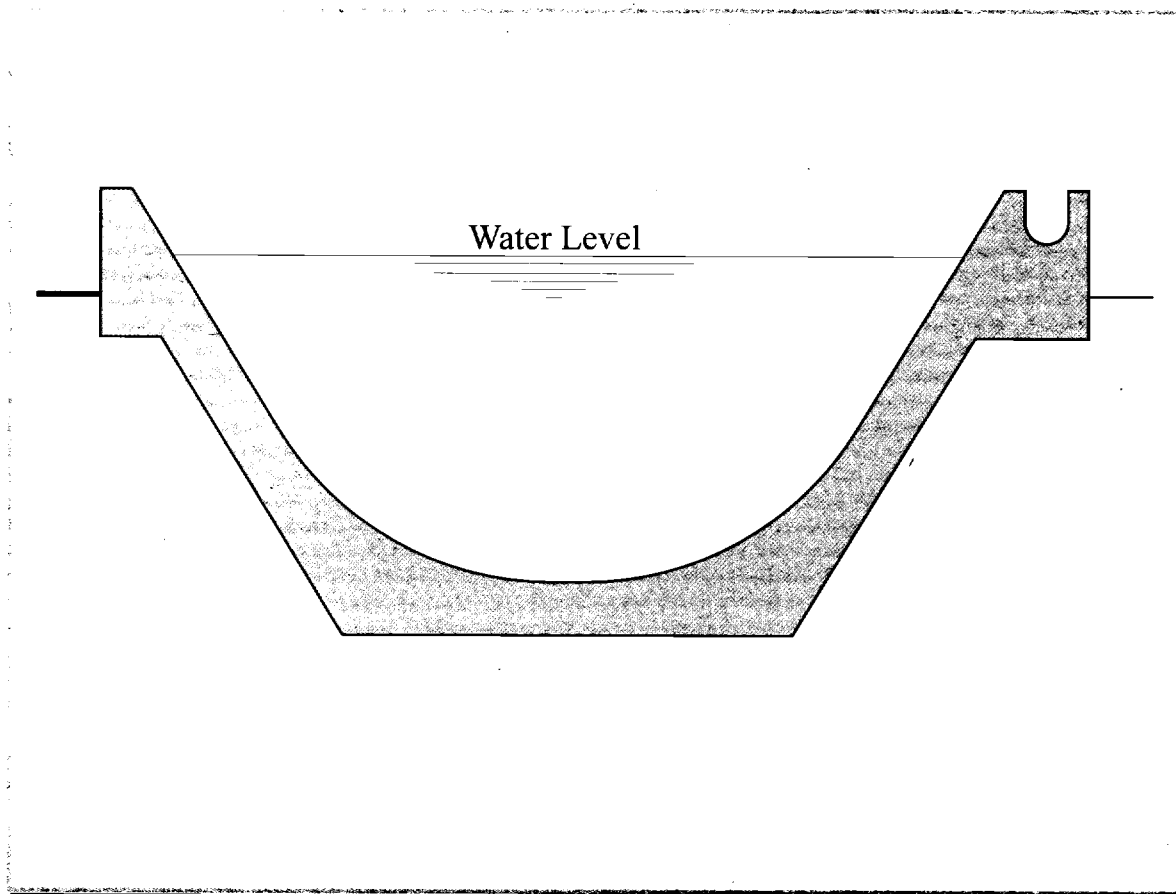


FIGURE 4.1: CROSS-SECTION OF PARABOLIC CONSTANT-VELOCITY DETRITUS CHANNEL

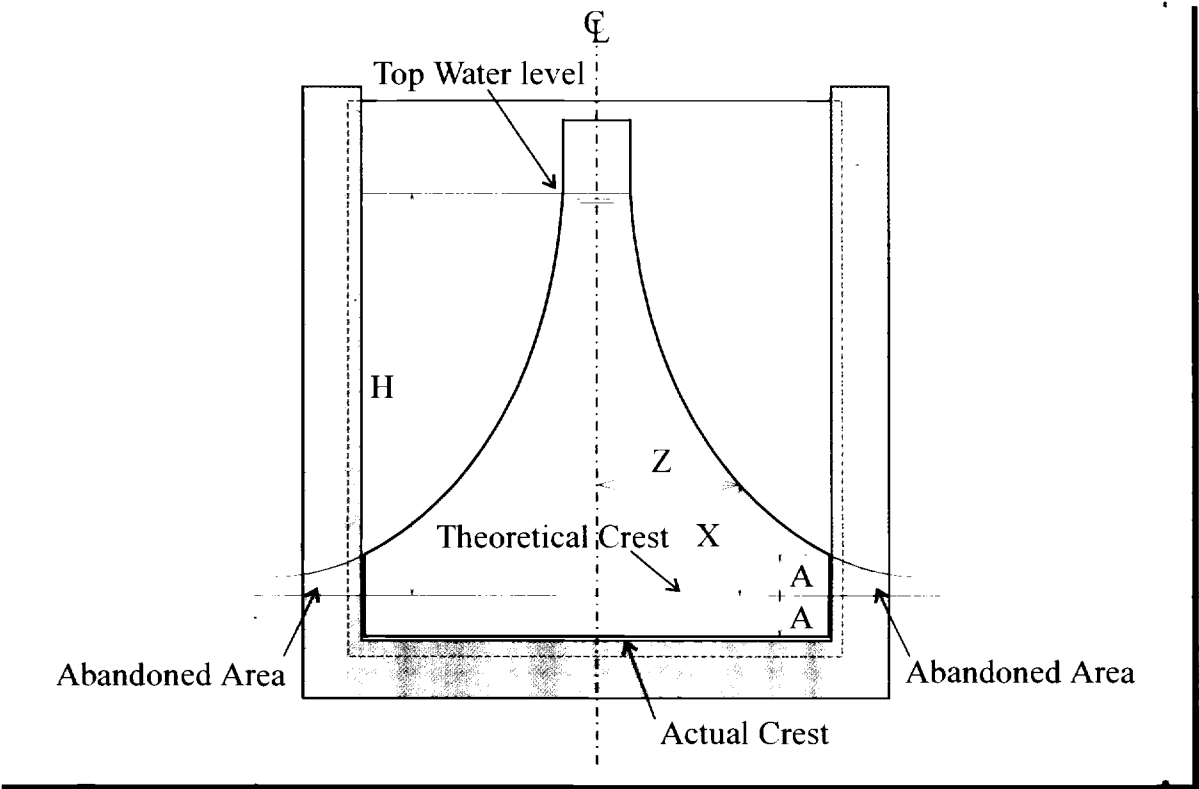


FIGURE 4.2: PROPORTIONAL FLOW PLATE WEIR (SUTRO WEIR) (REFER TO TEXT FOR DEFINITIONS).

4.6.2 CHANNEL WITH SUTRO WEIR CONTROL

The second type of constant velocity grit channel, is the rectangular channel controlled at the downstream end by a sutro weir. This weir is specially shaped as shown in **Fig. 4.2** to maintain a constant velocity in a rectangular channel no matter what the head of flow. One of the drawbacks of this weir is that it cannot be backed up at any time and this involves a considerable loss of head in the inlet works.

This plate is shaped according to the formula given for this type of weir (Ref. 2).

$$Q = \frac{1}{2} C \sqrt{2g} b \pi h$$

where:

- Q = flow (m³/s);
- h = depth of flow over theoretical crest (m);
- b = weir constant; and
- C = co-efficient for thin plate weir (normally 0.104).

From this formula, the value of b is calculated. The curves of the weir sides may then be calculated from the formula:

$$Z = \frac{b}{2\sqrt{X}}$$

where:

- X = vertical distance from the theoretical weir crest to the curve of the plate (m); and
- Z = distance from the centreline of the opening to the curve of the plate (m).

The application of this formula would mean that the arms of the inverted tee would continue off to infinity. In practice, the arms are shortened and an additional area is added to the orifice by lowering the actual crest below the theoretical crest to compensate for the lost area.

4.6.3 LENGTH OF CONSTANT VELOCITY CHANNEL

The length of the channel (L) required for grit settlement is the same in both cases and depends on the depth of flow (D) in the channel and the particle size to be settled. As stated, a flow velocity of 0.3 m/s is considered optimal for grit settlement. It is desirable to remove particles down to 0.2 mm diameter and to do this, the theoretical length of channel required may be calculated from:

$$L = \frac{\text{velocity}(0.3\text{m/s})}{0.016} D$$

i.e., Length = 18.75 times depth of flow.

It is normal to allow an extra length to store the smallest particles and the typical grit channel length is 20 times the depth of flow.

4.7 DETRITUS TANK

Detritus tanks were the first method of grit removal employed at sewage treatment works. These tanks were simple square tanks having a sloping bottom with a channel or sump for discharge of the grit. These were normally installed in duplicate to aid degritting by hand at regular intervals.

Design of these tanks was arbitrary but, in general, the capacity of each tank would be approximately 1/100 of the daily dry weather flow. As a result, many of the tanks were too large and substantial organic matter settled with the grit. This, together with the fact that these tanks were infrequently cleaned, meant that they became septic and malodorous. Detritus tanks of this type are no longer used.

4.8 VORTEX GRIT SEPARATORS

There are two types of grit separator which use a vortex flow pattern. One is a mechanical device while the second is a hydraulic device.

In the mechanical device, the wastewater enters and exits the chamber tangentially. A rotating turbine maintains a constant flow velocity within the chamber. The grit settles into a lower hopper from where it is removed at fixed intervals, either by means of an air lift or a grit pump. The most common machine available on the Irish market is

the jeta from Jones & Attwood. The previous model from the same company installed at many works was called the pista grit trap.

In the hydraulic device, a free vortex is generated by the flow entering tangentially at the top of the unit. The effluent exits through the centre of the unit at the top. Gravitational forces mean that the heavier grit particles are released to the outside of the unit, while the lighter organics are retained in the main flow and rise to the outlet. The grit settles along the outer wall to a sump in the bottom of the unit from where it is abstracted. During the settlement process, further organics are released from the grit so that a reasonably clean grit is obtained. Head loss in this type of unit increases with the size of particle to be removed. The most common unit of this type on the Irish market is the grit king separator from Hydro Research and Development.

4.9 AERATED GRIT TRAPS

Aerated grit traps are a derivation of spiral flow aeration tanks used in sewage treatment. Basically, the inflow to the plant is slowed down to well under 0.1 m/s for peak flow. A circular spiral shaped velocity is generated in the chamber using air diffusers (Fig. 4.3). This velocity can be varied in accordance with the specific gravity and size of the grit to be removed and the organic content. In this way, almost 100% grit removal may be obtained and the grit is well washed.

The grit tank is normally a rectangular tank having a floor sloping to a hopper either centrally located or to one side. Air diffusers are located over the hopper along the side wall to induce the spiral flow. Grit can be removed either by air lift pump, screw conveyor or grab bucket. The air lift pump is the normal method. The use of an aeration process in the inlet works can be beneficial in reducing septicity in stale sewage and can assist in odour reduction. One further advantage of the aerated grit trap is that it can also provide a degree of oil, fat and grease removal. Table 4.2 gives a summary of typical design data for an aerated grit trap.

4.10 CROSS-FLOW DETRITER

The cross-flow detritter is a variation on the original detritus tank into which the mechanical grit removal system and classifier have been installed. These tanks are normally square or circular in plan and the influent is distributed

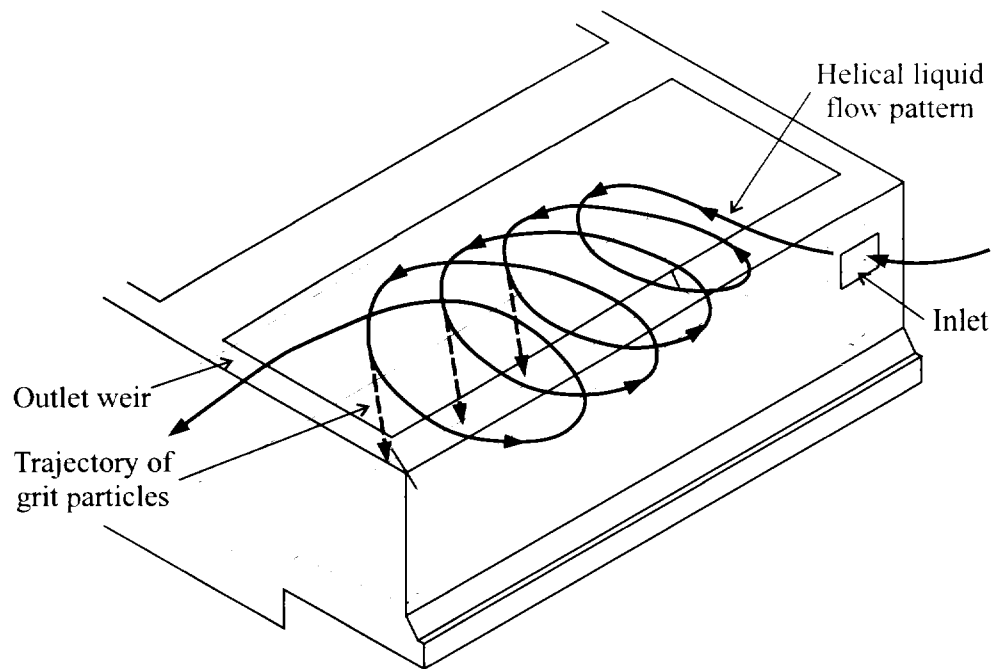


FIGURE 4.3: HELICAL FLOW PATTERN IN AN AERATED GRIT CHAMBER (METCAFF & EDDY)

TABLE 4.2: TYPICAL DESIGN DATA

ITEM	RANGE	TYPICAL VALUE
Detention Time, Peak Flow (min)	2 - 5	3
Dimensions:		
Depth (m).	2 - 5	
Length (m).	7 - 20	
Width (m).	2.5 - 7	
Width/Depth Ratio.	1:1 - 5:1	1.5:1
Length/Width Ratio.	3:1 - 5:1	4:1
Air Supply (m ³ /min per m).	0.2 - 0.5	

evenly across the full width of the tank by means of adjustable vanes or deflectors.

The settled grit is moved by means of a rotating scraper to the periphery of the tank where it is discharged into a sump which forms the base of a grit cleaning mechanism. Alternatively, the grit can be pumped from the sump to an independent grit washing device.

This type of grit chamber is only suitable for large wastewater treatment plants, i.e., plants over 20,000 p.e.

4.11 GRIT DEWATERING/WASHING

Grit removed from channels and other separators will contain large quantities of moisture and some organics. In an inefficient grit removal system,

the organic content of unwashed grit can be up to 50%. Obviously, this high organic content will putrefy and create odour and vermin nuisance.

Typical values of organic content in wastewater detritus are:

unwashed grit: 50-60%;

dewatered grit: 30-40%; and

washed and dewatered: 15-25%.

Grit was traditionally dewatered by settling on perforated slabs or by decanting over a weir. In more recent times, mechanical dewatering devices, such as the archimedian screw or reciprocating rake classifiers, have been developed which effectively dewater the grit. Air and water washes separate out much of the organic material from the grit. Nevertheless, washed grit is unlikely to contain less than between 10 and 15% organic matter. This washed grit is unlikely to cause a nuisance. **Fig. 4.4**

shows a typical grit washing and classification system.

4.12 DISPOSAL OF GRIT

Traditionally, grit has been disposed of with screenings because of its organic content. This disposal was either to landfill or by burying on site, depending on volumes. These methods continue to be the main options for disposal. However, with the advent of grit washing and classifying, the grit could potentially be reused for fill material, depending on its quality.

4.13 MAINTENANCE

Regular maintenance of a grit removal installation is of utmost importance to maintain removal efficiency. Grit must be removed on a regular basis and, where mechanical or aerated grit traps are used, the operator must ensure that these are operating correctly by regularly checking all mechanical items.

The organic content of the removed grit should be regularly checked so that the necessary

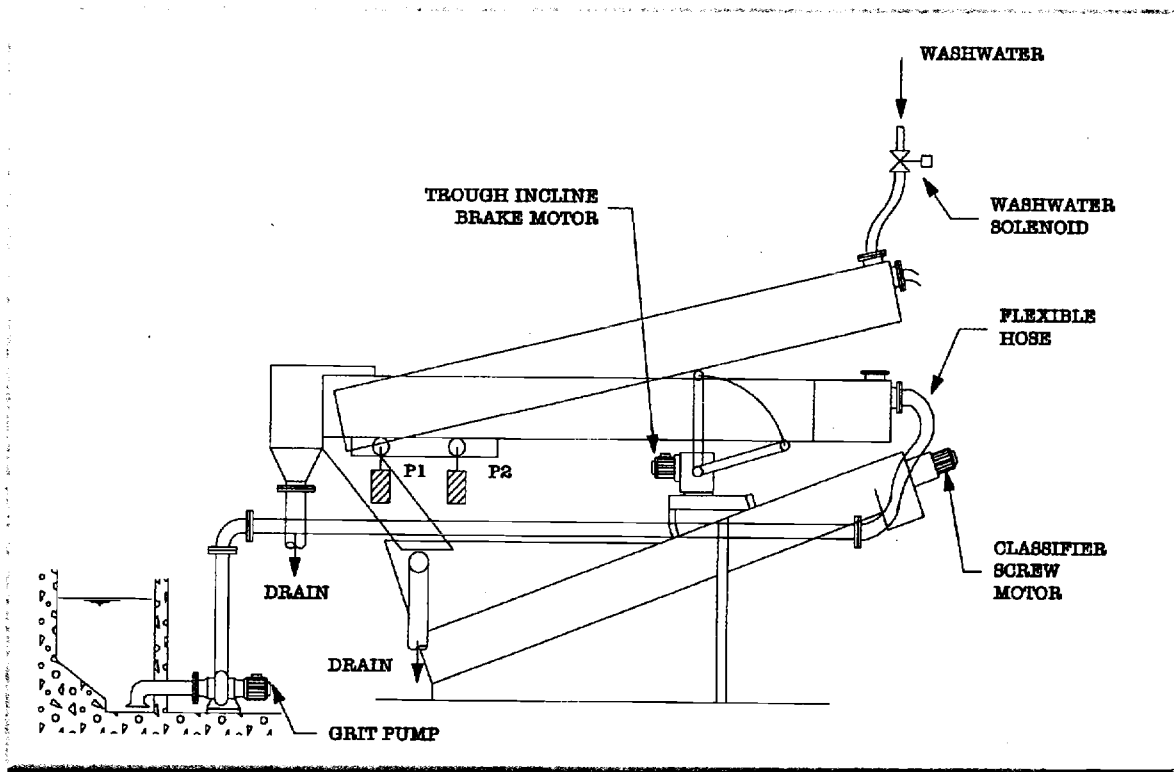


FIGURE 4.4: GRIT WASHER AND CLASSIFIER

adjustments to the plant can be made. The mechanical mechanisms should be inspected daily and all moving parts should be lubricated and adjusted as recommended by the manufacturer. Each unit should be taken out of service for maintenance on a routine basis and all necessary repairs made.

Depending on the type of grit removal, the accumulated grit may have a high organic content and could cause nuisance if stored for long periods. Ideally, grit should be removed on a daily basis or at the very least on a weekly basis and the whole area thoroughly hosed off with a

disinfectant such as chlorine or hydrogen peroxide.

4.14 COMMON PROBLEMS

In general, if problems arise with grit channels or detriters, there are no remedial measures which can be taken other than improved maintenance. With the mechanical devices, however, adjustments can be made. The following are some of the common problems which arise, as set out in Table 4.3.

TABLE 4.3: PROBLEMS AT GRIT PLANTS

Problem	Cause	Solution
Obnoxious odour.	Hydrogen sulphide formation.	Increase aeration or paddle speed. Wash down walls and channels with chlorine or hydrogen peroxide.
Grit is grey, smells and is greasy.	Organics being settled with the grit.	Increase air supply or paddle speed.
Surface turbulence reduced.	Diffusers covered with rags or grit.	Clean diffusers as required.
Lower recovery of grit.	Excessive aeration or paddle speed.	Reduce air supply or paddle speed.

5.1 DEFINITION

Fats, oils and grease are a major component of food stuffs. The term "grease" is commonly used and sometimes includes the fats, oils, waxes, and other related constituents found in waste water. Greases are solid products (as long as the temperature is sufficiently low) of animal or vegetable origin present in municipal waste water and in some industrial waste waters. They are present either in the form of free particles or, more frequently, coalesced with different suspended solids.

Fats and oils are compounds (esters) of alcohol or glycerol (glycerine) with fatty acids. They have the common property of being soluble to varying degrees in organic solvents (ether, ethanol, acetone and hexane) while being only sparingly soluble in water. The glycerides of fatty acids that are liquid at ordinary temperatures are called oils and those that are solids are fats or grease. They are quite similar chemically, being composed of carbon, hydrogen and oxygen in varying proportions. A simple fat is a triglyceride composed of a glycerol unit with short or long chain fatty acids attached.

5.2 SOURCES

Grease inputs to domestic wastewater include butter, lard, margarine, and vegetable fats and oils. Fats are also commonly found in meats, cereals, seeds, nuts and in certain fruits.

Various liquid products such as vegetable oils, mineral oils and light hydrocarbons are generally referred to as "oils". Petroleum and coal tar derivatives such as kerosene, lubricant and road oils sometimes reach the collection system in considerable volumes from shops, garages and streets. Light oils can be discharged from machining industries and pharmaceutical plants. Generally oils will float on the surface, although a significant portion can settle out by adsorbing onto settleable solids.

The typical oil and grease content of untreated domestic waste water ranges from 50 - 150 mg/l.

The level of grease and oils in industrial waste water can be much higher and arises principally in the agricultural and food sectors.

5.3 NATURE AND EFFECTS

Because of their limited solubility, the degradation of fats and oils by micro organisms is very slow. Fats are among the more stable organic compounds and are not easily decomposed by bacteria. They are present either in the form of free particles or, more frequently, coalesced with different suspended solids. Their presence in sewage results in reduced efficiency of biological treatment if not removed at the pre treatment stage.

As fats, oils and grease are not easily biodegradable in waste water treatment plants they can cause many problems in the collection network and waste treatment works. If fats and grease are not removed before discharge of the waste, they can interfere with biological life in surface waters and create unsightly floating matters and films. Fats and oils tend to coat surfaces and they tend to interfere with biological action and cause maintenance problems. Grease has a tendency to coat the inside of piping used for transporting primary sludge and scum. They can build up on insulated submersible pump motors causing over-heating of the motor and can prevent mercury tilt switches from operating. Other disadvantages of fats and grease are their contribution to odour and aesthetic nuisance.

A discharge limit on grease content and the absence of iridescent oil films on waste water discharges to natural waters are typical examples of standards that are set for discharges of final effluent. Typical limits of 15 - 20 mg/l of grease content have been set for grease and fat concentrations of such effluents.

5.4 REMOVAL TECHNOLOGIES

5.4.1 PHYSICAL REMOVAL METHODS-GENERAL

Grease removal is a liquid/solid separation procedure while oil removal is a liquid/liquid separation procedure. Flotation is the method used in the solids/liquid or liquid/liquid separation process and is effective in removing particles whose density is lower than the liquid medium. There are three types of flotation as follows:

- **natural flotation** where the difference in density is naturally sufficient for separation of the solid from the liquid;

- **aided flotation** where external means are used to promote the separation of particles that are naturally floatable.; and

- **induced flotation** where the density of the particle is originally higher than that of liquid and is artificially lowered by the linking of the particle with gas (usually air) bubbles to form "particle gas" composites with a density less than that of the liquid in which they occur.

Ideally grease removal is desirable at source, prior to discharge to the collection network. "At source" removal is recommended and sometimes compulsory at many enterprises, restaurants, hotels, hospitals, garages and filling stations, guest houses, etc. Standardised grease separators (or grease traps) are used and these devices are designed for a retention time of 3 - 5 minutes and the design velocity is in the range of 2-6 m/hr.

Gravity grease traps are usually concrete tanks in series fitted with baffle walls in which grease floats to the surface for manual or mechanical removal. Proprietary glass reinforced plastic (GRP) sections are now available and these are easy to install and effective in the separation of grease and oils (**Fig. 5.1**). If operated correctly they can retain up to about 80% of solidified grease.

Regular cleaning is essential and water temperature must be less than 30°C at the outlet. Unfortunately, many grease traps are poorly maintained. When they become filled up with grit

and debris, they cease to be effective and can result in discharge of effluent with high grease concentrations to the collection network.

In waste-waters from the food and agricultural industry, such as slaughter houses, food processing and the dairy industry, which contain high amounts of grease, it is advisable to have a separate grease separator installed to remove grease and fat prior to discharge to the sewer.

In industries where oils and hydrocarbons are discharged, such as petroleum production and refining, edible oil mills, cold rolling mills, and the storm water from refineries, storage heating condensers, oil fire stations and hot rolling mills, it is necessary to have separate oil separators in place to remove the oils prior to discharge to the sewer. This is also necessary for stormwater run-off at airports to avoid hydrocarbon contamination of receiving waters. If the contaminated flows are accepted into the main sewer, oil and grease removal facilities must inevitably be on a much larger scale, since the size of the facilities is determined by the hydraulic load (i.e., the flow rate).

Primary settling tanks can provide some separation of grease which settles at the surface but, in general, the removal efficiency is very poor. Grease collection on the surface can lead to operational difficulties such as scums, and if these accumulate, they may carry-over into the effluent. The accumulation of grease balls on the surface of aeration tanks is quite a common phenomenon and, while it does not cause major operational difficulties, is unsightly and may lead to odour problems. Grease removed with the sludge can accumulate in conveyors and rising mains, causing obstruction and loss of efficiency.

At municipal and industrial wastewater treatment plants, where large quantities of grease and fat are to be removed, both aided and induced flotation systems are used to separate the grease and fat from the sewage. These systems involve the use of gas (normally air) bubbles to promote the separation of fat and grease particles from the liquid medium in which they are carried. The rising velocity of the gas bubble determines the efficiency of removal of grease and fat.

This is sometimes calculated from Stokes equation which is as follows:

Stokes Equation

$$V = \frac{g}{18\eta} (P_i - P_g) d^2$$

where:

- V = the rising velocity;
- d = diameter of air bubbles;
- P_g = density of the gas;
- P_i = density of the liquid;
- η = absolute viscosity; and
- g = gravitational acceleration.

The types of grease and fat removal systems used at wastewater treatment plants are dependent on the flow to the plant, the quantities of grease and fat in the influent. These are described in the following sections. It should be restated that these processes are not normally required in municipal

wastewater treatment works. In general, oil, grease and fat problems should be dealt with at source within the development (at waste outlet, etc), where possible.

5.4.1.1 Skimming Tanks

A skimming tank is a chamber so arranged that floating matter rises and remains on the surface of the waste water until removed, while the liquid flows out continuously through deep outlets or under partitions, curtain walls or deep scum boards. This may be accomplished in a separate tank or combined with primary sedimentation, depending on the process and nature of the waste water.

The design of skimming tanks is straightforward only where they are arranged for downward or horizontal flow, the surface area then depending on the minimum rising velocity of the impurities to be floated off. The simplest efficient arrangement is a relatively long and shallow tank

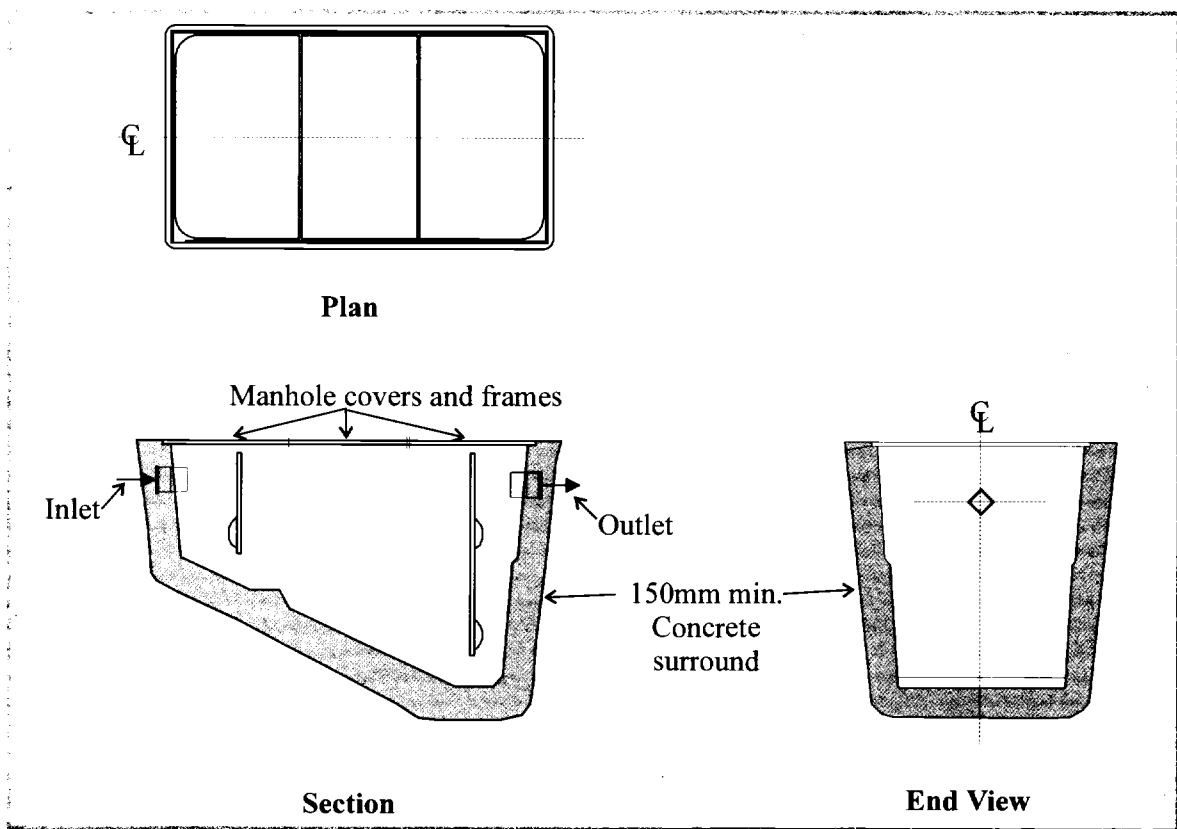


FIGURE 5.1: GLASS-REINFORCED PLASTIC (G.R.P.) GREASE TRAP

with inlets and outlets designed to secure uniform horizontal through flow, with a minimum disturbance of the scum layer.

Most skimming tanks are rectangular or circular and provide for a detention period of 1 to 15 minutes. The outlet, which is submerged, is sited at the opposite end to the inlet, and at a lower elevation to assist in flotation and to remove any solids that may settle.

These simple fat removal tanks are generally used on small installations such as the outlet sewer from garages, service stations, canteens and similar oil and fat producing activities.

5.4.1.2 Circular Grease Separator

This type of separator recovers dispersed grease and oil from waste water by means of flotation by the aeration of the liquid with very fine bubbles in an aeration chamber of special design. The Pista Grease Separator is typical of this type (**Fig. 5.2**). The grease separator is usually constructed in the form of a truncated cone having a maximum capacity of 50 m³ and units in parallel are used for flows in excess of this. The effluent is retained within the separator for a period varying between 5 - 20 minutes, depending on the type and quantity of oil/grease present and also on the degree of removal required.

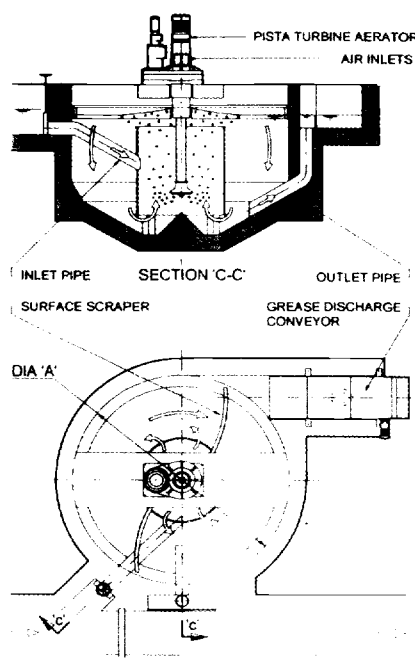


FIGURE 5.2: GREASE SEPARATOR

Aeration of the liquid is carried out by a turbo aerator and air is drawn through the body of the aerator and dispelled towards the bottom of the central chamber as very fine bubbles. Aeration takes place within a central chamber and rising currents are created from the aeration causing circular flow throughout the separator tank. The outlet from the tank is positioned near the base of the chamber and the extracted grease accumulates as a floating scum on the top of the tank which is skimmed by a rotating surface scraper and transported to a collection hopper.

5.4.1.3 Circular Grit/Grease Separator

In this type of unit both grease and grit are removed. The principle for grease removal is similar to that implied in the pista grease separator. The diameter of the unit is 3 - 8 m and its liquid depth at the centre is 3 - 5 m. It is again equipped with a submerged turbo aerator which introduces very fine bubbles to the liquid. Water is introduced tangentially into the central, submerged, cylindrical baffle which surrounds the turbo aerator and it is removed through a submerged opening in the tank wall.

The lower tapered zone of the unit forms a hopper with an angle of approximately 45° in which settled grit accumulates in a similar fashion to a vortex grit separator. Settled grit slides on the sloped surface towards the recovery point of the bottom of the unit. This movement is aided by a

sweeping velocity greater than 0.15 m/s produced by a mixer.

Grit is removed from the bottom of the hopper by means of air lift pumps. The floating grease on the surface is removed by low speed rotating scraper assemblies or by a surface scraper to a collection hopper.

5.4.1.4 Aerated Skimming Tanks

Aerated skimming tanks are used in the treatment of domestic and municipal sewage where the proportions of floating grease are unusually high and removal of most of it before sedimentation could simplify the arrangements for skimming the larger tanks. The aeration and skimming tank is an elongated rectangular, trough shaped tank with a relatively large surface area (Fig. 5.3).

Turbulence is confined to an inner aeration zone from which the floating foam and scum pass through adequate but not large openings to the stilling zones at either side where heavier solids are freed and sink to the bottom. These leave the tank with the effluent of skimmed sewage which is taken off from the bottom at the far end in such a way that all sludge and silt is scoured through. Foam and scum are taken off manually or mechanically from the still zone to small decanting tanks for ultimate disposal.

Detention is about 3 minutes for peak flow for the aeration tank and the air consumption is about 180 litres of air/m³ of sewage.

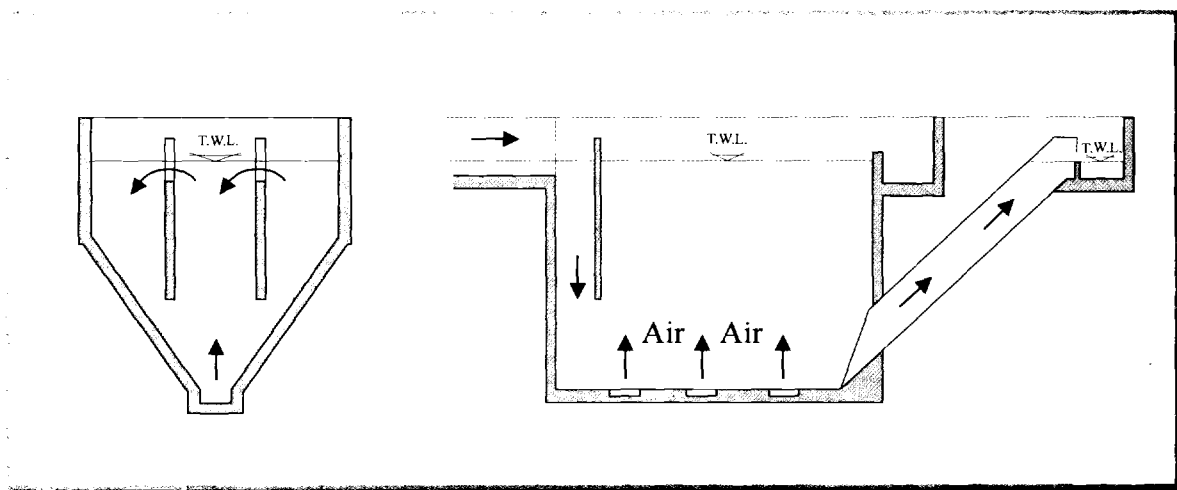


FIGURE 5.3: AERATED SKIMMING TANK

5.4.1.5 Rectangular Grit/Grease Separator

The rectangular grit/grease separator is a tank in which grease and grit removal is carried out and is similar in concept to the aerated grit channel in which spiral flow conditions are produced by the injection of compressed air into the tank. Units are about 4 m wide with a liquid depth of about 4 m and a maximum length of about 30 m. They are suitable for large flows and units can be arranged in series with modules of 4 metres width.

The spiral flow in the tank is initiated by the incoming sewage entering tangentially at the base of the tank and is maintained by the air lift effect of a row of diffusers mounted close to the opposite longitudinal wall. This produces a slow horizontal forward flow in the tank along with a transverse spiral flow. Water is recovered at the far end of the tank through a wide submerged opening in the wall, passing through a downstream weir to maintain the water level constant.

Grit settles out and is carried into collecting hoppers below the air diffusers. Grit is automatically extracted by either an air lift system extracting grit from individual hoppers or by means of a reciprocating travelling bridge with a mounted air lift pump. In each case the grit is deposited in a grit channel at the side of the unit for disposal or classification.

Flotation of the grease takes place in a calm zone separated from the aerated zone by means of a scum baffle with slotted plates. The grease floating on the surface of this calm zone is scraped towards the end of the unit by a chain scraper or a scraper fitted to the travelling bridge.

5.4.1.6 Dissolved Air Flotation

In a dissolved air flotation (DAF) system part of the effluent is recycled from downstream of the DAF unit. The recycle flow is retained in a pressure vessel for a few minutes where mixing and saturation of this flow with air occurs. The recycled effluent, saturated with air, is then reintroduced into the flotation tank. As the pressure returns to atmospheric, the dissolved air comes out of solution in the form of minute bubbles which become attached to particles of fat,

etc., and assist in floating it to the surface, where it is automatically skimmed off.

The design upward flow velocity is generally in the range of 4-6 m per hour and the air to solid ratio is in the range 0.005 to 0.06 kg of air per kg of solids removed.

5.4.1.7 Vacuum Flotation System

The vacuum flotation system consists of a pre-aerated stage followed by a basin where a vacuum is applied. Minute bubbles which attach to the particles of fat, are released from the liquid and flow to the surface where they are again automatically skimmed off.

5.4.1.8 Electroflotation

Electroflotation is another technique in which bubbles of hydrogen or oxygen are produced by electrolysis of water using appropriate electrodes. The anodes are highly sensitive to corrosion and the cathodes to scaling by carbonation. There are high capital costs associated with this type of unit and the annual cost of electrode replacement may also be prohibitively high.

5.4.1.9 Oil Separators

Oil separators are normally only required for the treatment of industrial effluents where a regular amount of oil is produced in the effluent and storm water systems.. The oils and hydrocarbons can be present in the effluent in either the free state, as fine but unstable mechanical emulsions, more or less absorbed on suspended solids or as chemical emulsions.

Oil separation can be achieved under pressure using closed separators and cyclones followed by filtering of the effluent or in an open gravity system where preliminary separation is carried out by longitudinal, lamellar or circular separators followed by mechanical flotation units and dissolved air flotation units. The preliminary oil separators can cope with large and irregular peaks of oil as well as large droplets.

5.4.2 BIOLOGICAL TREATMENT

Notwithstanding that it may give rise to some operational problems, it is common practice in Europe to add fat and grease to anaerobic

digesters for ultimate treatment. This section reviews options for biological removal at pretreatment stage. It should be stated that these processes are rarely used in practice in Ireland.

The biological methods used to remove grease and fat from wastewater involve the use of a select mixture of bacteria specifically designed to digest grease deposits. The bacteria are supplied in liquid, dry or gel cultures and the process involves the addition of the bacterial medium to the wastewater flow at the location where the grease problem is manifesting itself.

The bacterial medium contains live bacteria in a dormant state. When added to the wastewater containing grease or fats they secrete enzymes which solubilise the solid fat and grease. This process can take place in the presence or absence of oxygen. In the presence of oxygen, the fatty acids can be converted to carbon dioxide and to the components needed for growth of the bacterial cell. The glycerol molecule is used as an energy source and is metabolised by the bacteria.

The bacterial medium is safe to handle, non pathogenic and non toxic. It is normally stored in a cool dry place and minimum safety precautions need to be taken by the operators handling the material.

The application of the bacterial medium depends on the type used. Liquid media can be applied at controlled dose rates using dosing pumps or can be applied by the operators in one-off doses by hand. The dry or gel media are normally applied at specific locations, e.g. a pump wet sump, using a suitable tether which can be tied to any convenient point. In this way, with the medium attached to the tether, it can be placed wherever treatment is needed. Over a period, the medium will dissolve, constantly releasing the grease breaking bacteria and this is replenished at intervals.

The biological grease removal methods can be used in a number of applications. In collection systems they are used with a high degree of success to de-grease gravity and rising main lines which have become clogged with grease and fat deposits. At pumping station sites, they can be used to prevent the build up of grease and fat in the station wet well. At waste water treatment

plants, the bacterial medium can be used at specific locations where fat and grease build up is problematic. The use of the bacterial medium can also assist in the reduction of H_2S odours and they can sometimes have a beneficial effect on the settleability of solids.

The rate of application of the bacterial medium is dependent on the manifestation and severity of the grease problem. It normally involves the seeding of the area with a high dose of bacteria and the subsequent continual dosing of the medium at lower dose rates. The cost of dosing is dependent on the application rate, but a reduction in labour and routine maintenance costs can be derived from the use of these biological grease removal methods.

5.4.3 CHEMICAL REMOVAL METHODS

Chemical grease, oil and fat removal is sometimes used in industrial applications, but rarely used in municipal plants on a large scale basis apart from at localised trouble spots.

In the chemical treatment methods chemicals can be used to either break down the fat or oil to a saponified state to relieve the build up of the material or assist in the conglomeration of saponified oil and fat prior to removal in a physical grease removal system.

Specific chemicals are used in industrial situations in discriminatory reactions to coalesce fat particles prior to dissolved air flotation or aerated skimming tanks. An example of this is the use of acid or alumino ferric compounds. Another example is described in the next section where recovery and recycling of protein and oil is achieved.

Where grease, fat or oil build up is causing a localised problem chemicals can be used to emulsify or saponify the material and disperse the problem. A variety of solvents are used as is caustic soda, potassium hydroxide, etc. Generally, this removal method is locally successful but further along the sewer or works the fat particles coalesce again and the problem is transferred to another location. In addition the solvents and other chemicals can have a harmful effect on the environment or biological system.

Sludges from flotation plants, particularly when treating a meat waste may be rendered to recover the valuable oil and protein content. Protein recovery from meat waste can be achieved utilising chemical precipitation, e.g. the Alwatech process. Sodium ligno-sulphonate will precipitate protein from solution at pH 3 which is normally achieved by the addition of sulphuric acid. Dosage rates vary with the composition of the waste. This is essentially a product recovery process rather than a wastewater treatment system.

5.4.4 DISPOSAL OF OIL, FAT AND GREASE SLUDGES.

Grease and scum collected at municipal waste water treatment plants generally cannot be reused. One possibility is to send it to anaerobic digestion, but this arrangement usually increases the gas production and there is a risk of a production of a scum layer in the anaerobic digester.

It is preferable to store the grease sludge in a container which could be equipped with an overflow outlet scum baffle and then remove it periodically, for recycling, to landfill or for incineration with sludge or screenings, if the furnace and handling conditions allow it.

5.5 OPERATIONAL PROBLEMS

Grease has a tendency to coat the inside of piping used for transportation of sludges and scum. Grease accumulation is more of a problem in

large plants than in small ones. The coating results in a decrease in the effective diameter and a large increase in pumping head. For this reason low capacity positive displacement pumps are designed for heads greatly in excess of the theoretical head.

Build up of head, due to grease accumulation, appears to occur more slowly in systems where more dilute sludges are pumped. In some plants provisions have been made for melting the grease by circulating hot water, steam or digester supernatant through the main sludge lines. Availability of hot water pressure washing facilities is recommended at treatment works for this purpose.

Scum separates from most wastes as a floating layer, regularly seen in sedimentation tanks. These scums give rise to odours if not removed continuously or at frequent intervals (maximum 3-4 hours). Not only oils, greases or fats separate in this way but other solids of low effective density may enter into such scum layers and it is found that with ordinary municipal sewage only about 20 - 30% of the scum consists of substances which would normally be classified as oils, greases or fats.

Because of the low solubility, grease separates from water adhering to the interior pipes and tank walls and reduces biological treatability of waste and produces greasy sludge solids difficult to process. These problems are summarised in **Table 5.1**

TABLE 5.1: OPERATIONAL PROBLEMS WITH GREASE

PROBLEM	CAUSE	SOLUTION
Scums	Floating Grease or oil in Wastewater	- Consider removal by biological means. - Ensure effective scumboards and removal.
Mud balling	Fat accumulation on biological plant	- Consider removal at Pretreatment. - Remove at scumboards.
Increased head losses in pipes	Fat absorbed in sludge	- Allow for increased head in design. - Recycle of digestion supernatant may clear.
Fat on Impellers	Fat absorbed in sludge.	Occasional removal using hot water pressure washer.
Fat on Sewer Conveyors	Fat absorbed in sludge.	Clear using hot water pressure washer, regularly

6.1 PRINCIPLES OF FLOW MEASUREMENT

6.1.1 INTRODUCTION

The preliminary treatment of waste water invariably incorporates measurement of incoming flow to the treatment plant. This flow measurement is a critical part of the overall treatment process, in that control of subsequent stages will depend on continuous, accurate flow information in order to function correctly and determine the following:

- hydraulic loading on treatment units;
- treatment unit retention times;
- solids and Biological Oxygen Demand (BOD) loading;
- prediction of physical and biological performance of process;
- prediction of and reaction to shock loads, i.e., industrial and stormwater;
- chemical treatment feed rate settings;
- control of return rates;
- calculation of flow to mass ratios;
- calculation of treatment unit costs, i.e., power, chemicals, labour; and
- scheduling of maintenance.

Operational Control in the modern treatment plant will require automatic and often remote adjustments to be made between balancing tanks, storm tanks, flow to full treatment and chemical treatment, as well as the activation of automatic sampling and alarm systems. These actions and controls will be initiated by the incoming flow measurement device and will therefore be dependent on its continued accuracy and reliability.

Flow measurement is provided on inflow and outflow at most plants. Increasingly measurement of sludge return rate is also seen as a critical process control requirement. The most popular method of flow measurement in wastewater treatment is the flume due to its simplicity of operation and performance reliability.

6.1.2 BASIC PRINCIPLES OF FLOW MEASUREMENT

Flow can be measured either as a volumetric quantity or an instantaneous velocity (which is normally translated into flow rate). **Fig. 6.1** demonstrates the relationship and interdependence of these measurements can be seen. They are defined as follows:

$$\begin{aligned}\text{Flow Rate} &= \text{Velocity} \times \text{Area} \quad (\text{m/s} \times \text{m}^2 = \text{m}^3/\text{s}) \\ \text{Quantity} &= \text{Flow Rate} \times \text{Time} \quad (\text{m}^3/\text{s} \times \text{s} = \text{m}^3)\end{aligned}$$

If the flow rate is recorded for a period of time, then the quantity of the flow (i.e. m^3) is equal to the area under the curve as shown on **Figure 6.1** (shaded area). This is often automatically calculated and displayed by the measuring instrument. This value gives the total cumulative volume entering the works.

Other factors which are taken into account in the derivation of theoretical flow rate formulae equations are:

- * type of flow [*streamlined/ turbulent (Reynolds Number)*];
- * energy of liquid [*potential/kinetic/pressure/internal*];
- * density of liquid;
- * viscosity of liquid; and
- * temperature of liquid.

In practice, the above factors are taken into account by the use of a Discharge Co-efficient (C), which is a measure of the actual volume flowing through a device divided by the theoretical volume flowing. This together with the measurement of heads or pressures, (H_1 , H_2 or P_1 , P_2), areas (a) and forces of gravity (g), are used in practical flow formulae for the calculation of actual flows.

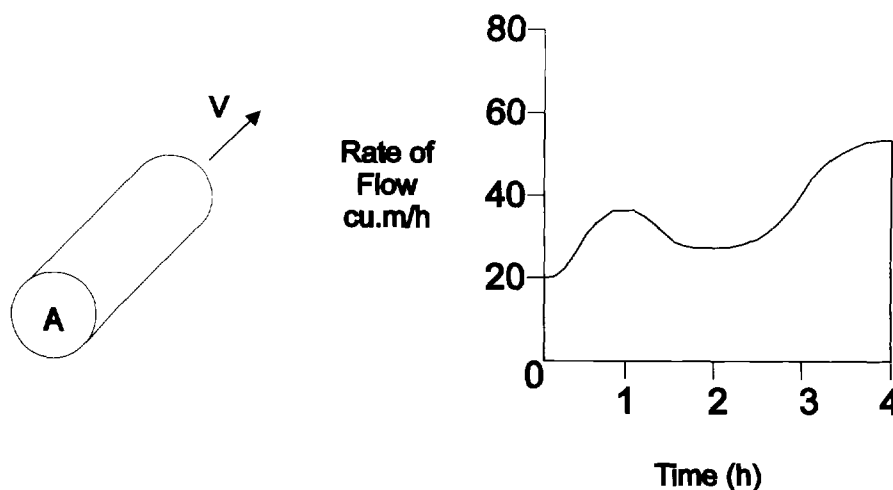


FIGURE 6.1: FLOW-TIME GRAPH (REF. 27)

6.1.3 UNITS OF MEASUREMENT

The standard units of measurement are those specified in the "Système Internationale d'Unités", commonly referred to as S.I. units. The S.I. units for measurement of distance, weight and time are the meter (m), the kilogramme (kg) and the second (s), respectively.

Flow rates therefore are measured as Cubic Metres per Second (m^3/s); and

Flow quantities therefore are measured as Cubic Metres (m^3)

Whilst the S.I. unit of volume is the cubic metre, the Litre (l) is also accepted as measurement of volume and capacity. A litre is defined as being the volume of one cubic decimetre (dm^3) and is often used in the measurement of fluids. Thus flow-rates will often be expressed as l/s ($1\text{m}^3/\text{s} = 1000\text{ l/s}$).

6.1.4 STANDARDS

The standards applying to the measurement of flows are primarily those outlined in British Standards, as follows:

B.S. 3680: Measurement of Liquid Flow in Open Channels;

B.S. 1042: Measurement of Fluid Flow in Closed Conduits; and

B.S. 6739: Code of Practice for Instrumentation in Process Control Systems - Installation, Design and Practice.

These standards comply with the "International Organisation for Standardisation" (I.S.O.) Standards.

All electrical and electronic equipment and installation work should also comply with "The National Rules for Electrical Installations" as published by the Electro - Technical Council of Ireland and of course the Safety, Health and Welfare at Work Act (1989) and its ensuing regulations.

6.1.5 LOCATIONS OF FLOW MEASUREMENT DEVICES

Flow measurement can be made at many locations throughout the treatment process and the most commonly used are shown diagrammatically in **Fig. 6.2**. It will be noted that while there is only one inflow measurement shown here, there are three possible outlet measurements (treated effluent, storm overflows both direct and via storm tanks). Nowadays, measurement of sludge return and sludge wasting rates are regarded as essential for accurate process control.

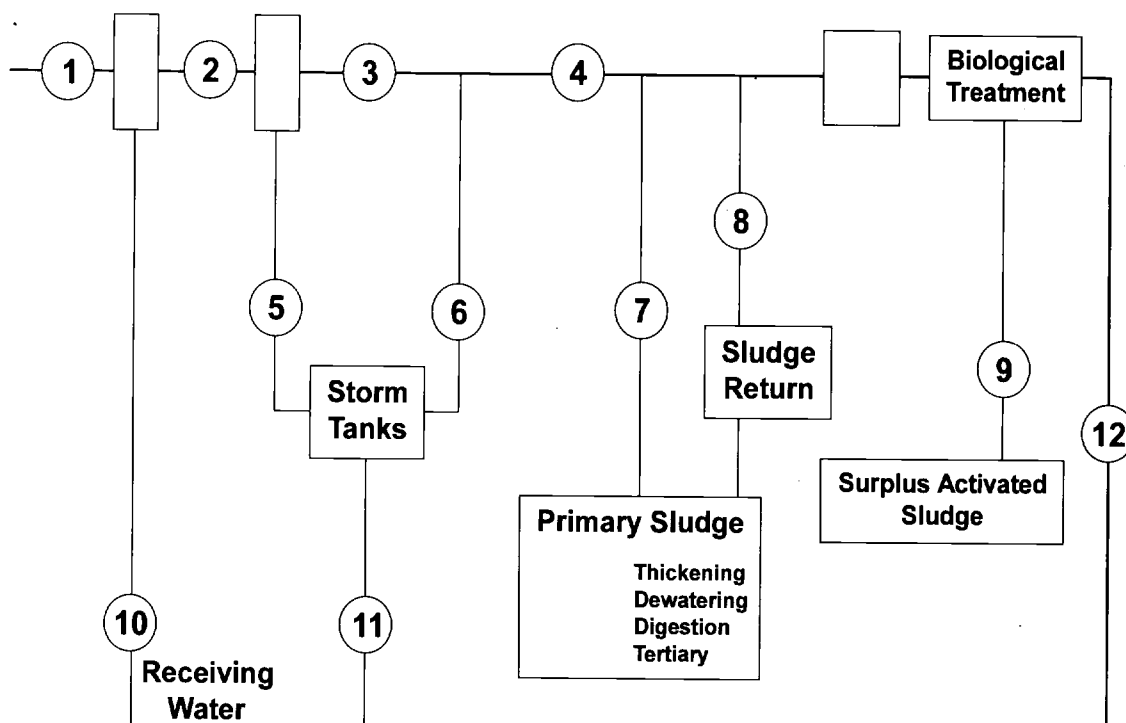
Although flows should ideally be measured at several locations, in many instances, design and cost constraints limit the possibilities. Metering at the works inlet and outlet must be considered as a minimum requirement for all plants, in order to meet statutory requirements. For larger plants, the following should be considered as a minimum:

- inflow,
- flow to full treatment,

flow to storm tanks,
stormwater spills to receiving waters,
outflow, and
sludge return rate.

Because of the multiplication of instrument inaccuracy, the deduction of flow measurement from a combination of meters should be avoided where possible.

Metering locations must be carefully considered at the design stage with due regard to the standards and guides referred to in **Clause 6.1.4**. Although not necessary for all types of metering a rule of thumb to ensure primary metering accuracy, is that metering sites should be selected so as to provide 10 diameters upstream and 5 diameters downstream of free, unturbulent, unobstructed flow. This requires straight lengths of channel or pipe, free of valves, sectional variations or other controls.



- | | |
|---|-------------------------|
| 1 | Total flow |
| 2 | Flow to Inlet Works |
| 3 | Flow to Full Treatment |
| 4 | Flow to Full Treatment |
| 5 | Flow to Storm Tanks |
| 6 | Return from Storm Tanks |

- | | |
|----|-----------------------------------|
| 7 | Sludge Treatment Liquors |
| 8 | Treatment Return Liquors |
| 9 | Surplus Activated Sludge Draw-off |
| 10 | Untreated Storm Effluent |
| 11 | Settled Storm Effluent |
| 12 | Final Effluent |

FIGURE 6.2: FLOW MEASUREMENT LOCATIONS

6.1.6
VARIATION AND ACCURACY

The flow-rate to the wastewater treatment plant will vary diurnally and seasonally. The range of incoming flow can vary widely, as is indicated by a typical diurnal pattern for a dry day from a gravity sewerage system, **Fig. 6.3**. Flows of up to 40 x D.W.F. can arise under storm conditions from combined sewer networks.

Choice of type and size of metering equipment requires that it be capable of catering for this flow range with acceptable accuracy. Problems are frequently experienced at low flows, with poor accuracy where meters are over-sized or where design flows are not realised in the early stages of plant operation.

Other factors which will affect the accuracy of metering are:

- location of the metering site;
- turbulence at entry and exit to meter;
- obstructions and accumulations of solid matter;

additional inflows after metering (i.e. flooding, return flows);

unmetered recirculation; and

surcharge, causing backup of critical depth meters.

6.2
MEASUREMENT DEVICES AND STRUCTURES

6.2.1
TYPES OF MEASUREMENT DEVICE

A wide variety of flow measurement devices are commercially available and can be used for the determination of flows in wastewater applications. The selection of the proper measuring method or device will depend on such factors as cost, type and accessibility of flow conduit, hydraulic head available, type and characteristics of liquid stream. In general, wastewater flow measurement falls into two categories as follows:

- open channels (or open conduits); and
- pressure pipes (or closed conduits)

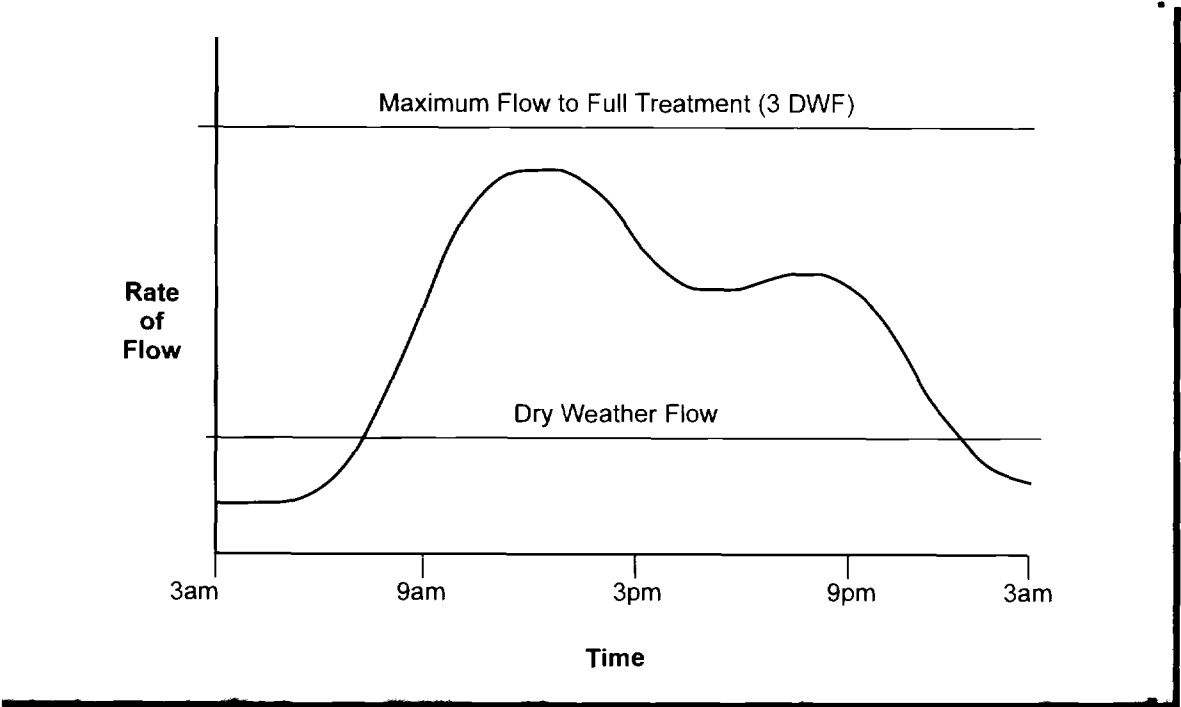


FIGURE 6.3: TYPICAL DIURNAL FLOW PATTERN IN DRY WEATHER (REF. 1)

Table 6.1 contains a list of methods and devices applicable to flow measurement. Devices commonly used for flow measurement on municipal and industrial wastewater applications are indicated. **Table 6.2** summarises the advantages, disadvantages and application of the devices to preliminary treatment processes. They are briefly described in the following paragraphs, together with a typical diagrammatic illustration of each, shown in **Fig. 6.4**.

6.2.2 STANDING WAVE FLUME

The Standing Wave Flume is based on the fundamental energy conservation principles of flow in open channels. The flume consists of a quickly converging entrance section, a throat and a slowly diverging exit section, with a constant floor level. The throat creates a restriction which creates critical velocity conditions. The upstream water depth approximates to the total energy which can be related to the critical velocity in the flume. Only one height measurement is required and this is measured in the approach channel and it is converted to flow (Q).

$$Q = C B H^{1.5}$$

where:

Q = discharge of meter (m^3/s);
 B = width of flume throat (m);
 H = head of liquid over throat invert (m); and
 C = flume constant (typical 1.71).

The flume must be sited such that approach velocities are less than critical velocity, otherwise the readings will be low. On the other hand, if levels after the flume are high, the flume would be drowned, giving a high reading.

6.2.3 PARSHALL FLUME

The Parshall Flume is one of the most common measuring devices used at the inlet stage of wastewater treatment plants. It consists of three parts: a converging section, a throat and a diverging section. The throat section also incorporates a drop in floor level. The flume creates a change in flow pattern by a decrease in width and a simultaneous drop in water surface height at the throat. Because the throat is of constant width, only the upstream pressure or head needs to be measured in order to obtain a free discharge value. Flow velocity restrictions apply as in 6.2.2. The following flow formula is applicable to flumes of 300 to 2,400mm.

$$Q = 4 W H^{1.522} W^{0.026}$$

where:

Q = discharge of meter (m^3/s);
 W = width of flume throat (m); and
 H = head of liquid upstream of throat (m).

6.2.4 PALMER BOWLUS FLUME

The Palmer Bowlus flume creates a change in the flow pattern by decreasing the width of the channel without changing its slope. Normally it is installed in a sewer at a manhole. It backs up the water in the channel. By measuring the upstream depth the discharge is read from the calibrated curve prepared for that unit. It has a lower head loss than the Parshall Flume but less accuracy and flow velocity restrictions apply as in 6.2.2.

6.2.5 WEIRS - RECTANGULAR AND VEE NOTCH

Weirs are widely used to measure flow in open channels. They are cheap, portable if necessary, and easy to install in partly filled pipes, channels or streams. They act as a dam or obstruction over which the liquid must pass. The weir plate is of a precisely defined shape, (typically rectangular or vee notch), and is set at right angles to the flow.

Weir operation is by head measurement in that the liquid level over the weir crest, measured at a given distance upstream from the weir, is proportional to the flow discharge (critical depth/velocity at weir). The head measurement must be accurate and the choice of measuring sensor is therefore extremely important. Weir plates are installed with a chamfered downstream edge to enable the liquid nappe to spring clear. The nappe may also need to be vented to prevent negative pressure build up.

TABLE 6.1: TYPES OF FLOW MEASUREMENT DEVICES AND THEIR OPERATION

Open Channels			Pressure Pipes		Others
Type	Operating Principle	Type	Operating Principle	Type	Operating Principle
Flume - Standing Wave - Parshall - Palmer Bowllus	All based on creation of "Critical Depth" conditions at Flume	Venturi meter	Differential pressure across throat restriction	Free discharge	Water jet data in X and Y axis
		Flow Nozzle meter	Differential pressure across nozzles/orifices	Vertical open end discharge	Vertical height of jet
		Orifice Plate	Differential pressure across plate	Partial full pipe- Open Jet	Free falling water jet
Weir - Rectangular - V notch	Head over crest Head over notch	Electromagnetic meter	Induced magnetic field and residual voltage measured	Open Flow Nozzle- partial full pipe	Depth of flow at free falling end
Current Meter	Velocity from element rotation				
Pitot Tube	Differential Pressure at obstruction	Acoustic meter (Ultra sonic)	Sound waves used to measure velocity	Dilution	Tracer dye concentration
Depth Measurement	Float used to measure depth	Pitot tube	Differential pressure across obstruction	Bucket and Stopwatch	Calibrated volume and time to fill
Acoustic Meter	Sound waves used to measure depth or velocity at a cross-section	Rotameter	Rise of float in a tapered tube is measured	Change in Reservoir Level	Change in volume stored in measured time
		Turbine Meter	Velocity of rotational element in flow path	Pumping rate	Known pump duty and operating duration
		Elbow Meter	Differential pressure across band		

TABLE 6.2: APPLICATION OF FLOW MEASUREMENT IN WASTEWATER TREATMENT

Measuring Device	Sensors	Advantages	Disadvantages	Applications
1. Standing Wave Flume	Float Air bubbler Acoustic	Large Flow Range No solids Retention Low maintenance Ease of calibration	High construction accuracy needed Needs length approach channel Approach velocity must be moderate	Total Inflow/Outflow Flow to treatment Flow to Storm tanks Storm Effluents
2. Parshall Flume	As 1	As 1 Low head loss Accurate at high and low flows	As 1 Expensive to construct	As 1
3. Palmer Bowlus Flume	Float Acoustic	Low maintenance Ease of calibration Can be fitted at manhole	Lower accuracy Backs up flow	As 1
4. Weirs	Float Air bubbler Acoustic	Cheap & easy to install Can be portable Good accuracy Low maintenance Ease of calibration	Backs up flow Causes solids buildup Limited to cleaner streams	Flow to Storm tanks Storm Recycle
5. Venturi Meter	Differential pressure Transducer Mechanical Arm Indicators	Simple Operation Low head losses Tolerant of solids Reliable	Expensive Critical installation requirements Loss of accuracy at low flows	Total Inflow Storm Return Transfer of Liquors
6. Flow Nozzle and Orifice meters	As 5	Simple operation Inexpensive No long approach required	Higher head loss Liable to clogging Critical installation requirements Loss of accuracy at low flows	Transfer of Liquors Inflow/Outflow trans. of liquors Storm effluents
7. Electromagnetic Flowmeter	Electrodes	High accuracy Large flow range No obstruction to flow No head loss	High initial cost Specialised maintenance Accuracy affected by solids, turbulence Needs pipe full flow	As 7
8. Ultrasonic Flowmeter	Piezo - Electric Crystal Transducer	High accuracy Large flow range No obstruction to flow No head loss	High initial cost Specialised maintenance Accuracy affected by solids, turbulence Needs pipe full flow	Storm flows
9. Developments of 7& 8 for open channel applications	As 7,8	Large conduits	Too expensive for normal applications	

Weirs have some disadvantages in sewage applications, which include a relatively large head loss and possible solids accumulation behind weir plate. They are useful for short-term flow measurement, rather than in permanent applications. Weir flow formulae are as follows:

Rectangular

$$Q = \frac{2}{3} C_d L^1 \sqrt{2g} H^3$$

Vee Notch

$$Q = C_d \frac{8}{15} \tan\left(\frac{a}{2}\right) \sqrt{2g} H^{2.5}$$

where:

- Q = discharge of weir (m³/s);
- C_d = coefficient of discharge (Usually 0.6);
- L¹ = L - 0.2 H;
- L = length of Weir (m);
- a = angle of notch;
- g = acceleration due to gravity (m/s²); and
- H = head of liquid upstream of throat (m).

6.2.6 VENTURI METER

The Venturi Tube Flow Meter utilises the principle of differential pressure and is in common usage in the wastewater industry. A commercially available Venturi Meter consists of a converging section (called the approach), a throat and a diverging recovery section, all mounted between standard flanges. Due to the converging section the velocity at the throat is increased. As a result, the piezometric head is decreased.

The difference in the piezometric head between the throat and the beginning of the approach is measured by suitably located tapings, usually fed to a differential pressure transmitter. This pressure differential is converted by electromechanical means into a flow reading, based on the direct proportional relationship between head loss and flow.

Whilst the venturi meter is basically simple in operation, with long term reliability and has no

moving parts, it is expensive to purchase and install. Also it has critical installation requirements and poor accuracy at the low end of its range. They are not particularly reliable for sewage applications.

6.2.7 FLOW NOZZLE AND ORIFICE PLATE METERS

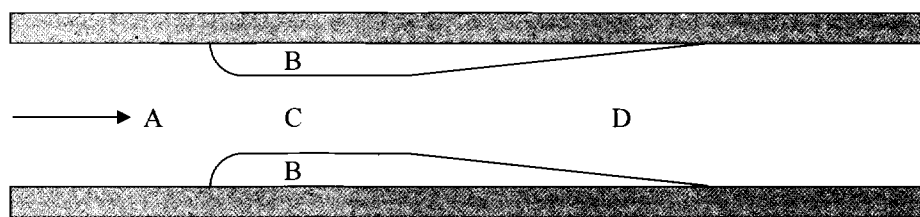
Essentially Flow Nozzle and Orifice Plate Meters are similar to Venturi Meters and work on the same principle. The Flow Nozzle has a short approach section, whilst the Orifice Plate has none and both devices have no recovery section. In each case the pressure is measured upstream and downstream of the restriction and the resultant differential pressure is used to determine the rate of flow. Both are cheap and easy to install. However, they incorporate a substantial headloss and clog easily. They also have critical installation requirements, together with poor accuracy at the low end of their range.

6.2.8 ELECTROMAGNETIC FLOWMETER

The Electromagnetic Flowmeter, commonly called the Magflow Meter, utilises Faraday's law to measure the flow. This law states that if a conductor is passed through a magnetic field, a residual voltage will be induced, which will be proportional to the velocity of the conductor.

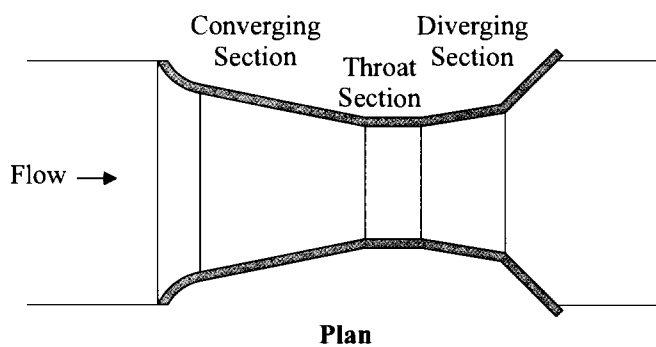
In electromagnetic meters, the wastewater acts as a conductor, a pair of electromagnetic coils mounted on the crown and invert of the pipe create the magnetic field and two electrodes on the pipe side walls measure the induced voltage (mV). This voltage is then converted to a current signal (mA), which can be read as the rate of flow. There is also an open channel version of the electromagnetic meter which can be used to measure flows in wastewater collection systems.

This type of meter offers exceptional accuracy and can measure a large range of flows. Additionally, because there is essentially no obstruction to flow, there is no head loss. Performance can however be affected by turbulence, viscosity, temperature, conductivity, the presence of suspended solids and possible accumulation of deposits on measuring electrodes. Other disadvantages are the high initial purchase cost and specialised maintenance.



A	Approach Channel	C	Throat
B	Side Contractions	D	Free Discharge

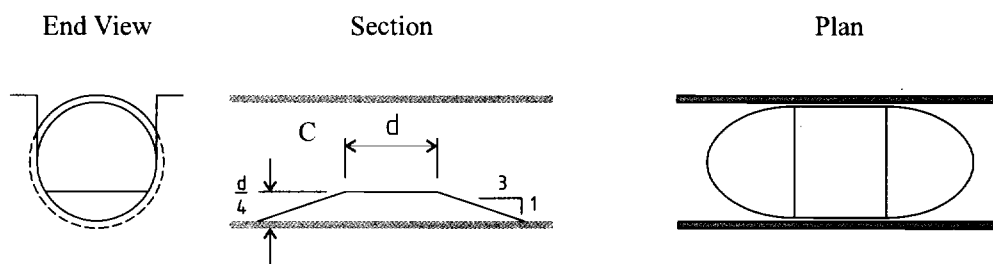
(a) Standing Wave Flume



Plan

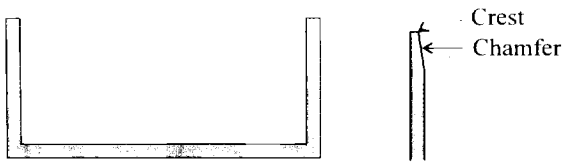
Section

(b) Parshall Flume

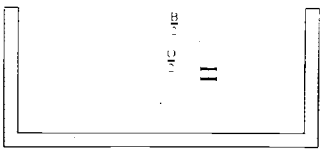


(c) Palmer Bowlus Flume

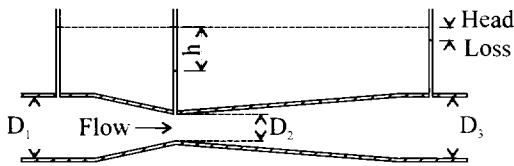
FIGURE 6.4: FLOW MEASUREMENT DEVICES (SHEET 1 OF 2)



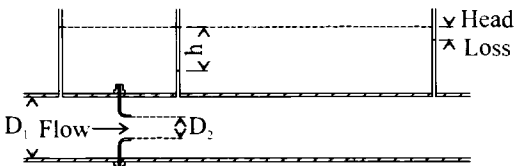
(d) Rectangular Notch Weir (Ref. 27)



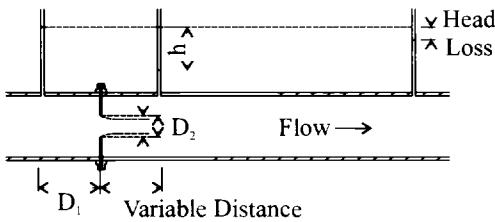
(e) Triangular Notch (V-Notch) Weir (Ref. 27)



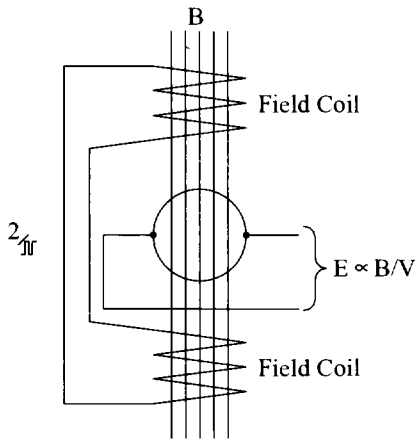
(f) Venturi Meter (Ref. 29)



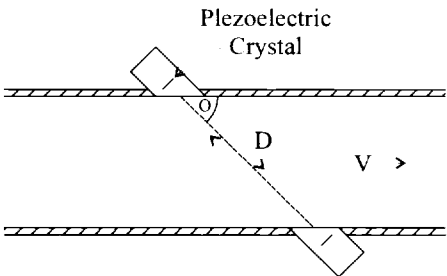
(g) Flow Nozzle Meter (Ref. 29)



(h) Orifice Plate Meter (Ref. 29)



(i) Electromagnetic Flowmeter (Ref. 27)



(j) Ultrasonic Flowmeter (Ref. 27)

FIGURE 6.4: FLOW MEASUREMENT DEVICES (SHEET 2 OF 2)

6.2.9 ULTRASONIC FLOWMETER

More recently developed and widely used as a replacement for float and air reaction systems, is the Ultrasonic or acoustic Meter, types of which can be used to measure flow in both open and closed conduit systems. In open conduit systems a reflective, "time of return" type is used, whilst in closed conduit systems two variations are in use, the "Doppler" meter and the "time of flight" meter. The example shown on **Fig. 6.4 (j)** is a time of flight meter.

In the Time of Return Meter, a transducer is mounted above the surface of the liquid at 90 deg to the flow to be measured. Ultrasonic pulses are generated by the transducer and bounced off the liquid surface. The time of delay between transmitted and received pulses is measured and from this an attached microprocessor unit deduces the flow of liquid, (usually over a flume or weir) and converts the signal to a milliamp reading.

The Doppler Meter is normally used as a clamp on flowmeter, the only necessity being that the flow to be measured must contain some suspended solids and the pipeline must be acoustically transmissive. It operates by making use of the Doppler effect, which states that the frequency of sound changes if its source changes relative to the listener. A single transducer is mounted on the pipeline at an angle to the direction of flow. Acoustic pulses are directed into the flowstream and if the flowstream contains particles or other discontinuities some of the transmitted pulses will be reflected back to the transducer. The altered frequency of the reflected sound will be proportional to the flow and can be converted by a microprocessor into a milliamp flow signal.

The Time of Flight Meter is a transmissive flowmeter in that it relies on the transmission of an ultrasonic pulse through the flowstream and does not therefore rely on the properties of the medium for its operation. The principle of operation is based on the transmission of an ultrasonic sound wave at an angle to the direction of flow between two points, first in the direction of flow and then opposing the direction of flow. In each case the time of flight of the sound wave will have been modified by the velocity of the liquid. The difference between the flight times will be directly proportional to the flow velocity and can be converted by a microprocessor into a milliamp flow signal.

Acoustic Meters have some advantages in that they offer low or no head loss, good accuracy and the ability to be used in any pipe size, no fouling with solids and operation over a wide range of flows. Also in the time of return and Doppler meter, the measuring element has no contact with the liquid. However, accuracy and repeatability are difficult to achieve in the Doppler meter. Time of flight meters are susceptible to flow profile effects and the possible accumulation of deposits on transducers. Other general disadvantages include high purchase cost and specialised maintenance.

6.2.10 OTHER DEVELOPMENTS (ELECTROMAGNETIC AND ULTRASONIC)

Electromagnetic and Ultrasonic open conduit meters are now being developed for flows in large liquid streams (20 Metres wide), and for flows in large partially filled to filled closed conduits. In the electromagnetic versions strip coils and electrodes are used and in the ultrasonic versions cross path multi-point transducers are used. In each case the basic principles are unaltered. Sophisticated calculations are performed by an integral microprocessor unit which also takes into account the conduit profile and open channel, or filled and partially filled applications.

Typically these meters are for use on watercourses and storm flow applications.

6.3 SELECTION OF APPROPRIATE FLOW MEASUREMENT SYSTEM

In the design of Preliminary wastewater systems, care must be taken to select the most appropriate flow measurement device to suit the particular need. Unfortunately, there is no device that is perfect for all situations. This requires evaluation of the advantages and disadvantages of the available devices in order to choose the one which offers the least overall disadvantage for the situation. **Table 6.3** discusses criteria to be considered in the selection and specification of flow metering devices. **Table 6.4** contains an evaluation of the different metering devices in Wastewater Preliminary Treatment.

In pressure conduits, the installation of solids bearing venturi, nozzle or orifice meter should be considered. The venturi meter is accurate (+ or - 2%), offers little head loss, is free from solids accumulation but is relatively expensive. The orifice meter is inexpensive, has greater flexibility in covering the flow range but has the

disadvantage of high pressure loss and possible accumulation of solids. The flow nozzle meter falls between the two.

Electromagnetic meters, while expensive and involving specialist maintenance, are extremely accurate (+ or - 0.1%), will tolerate high suspended solids loading and can be used on ranges of pipework from 32mm up to 1600mm. Ultrasonic meters have good accuracy (+ or - 1%), can be used in pipe ranges from 75mm to 1600mm and can be used for fast flow rates of up to 12 m/s.

Both offer no head loss; however, the ultrasonic meter is susceptible to effects from the liquid such as deposits on transducers.

For sewers and open channels, Flumes and Weirs are commonly used. Flumes can handle wastewater with high suspended solids, are self cleaning and offer low head losses. Weirs are less expensive but require more maintenance and have large head losses. In each case it is now common to use Ultrasonic "time of return" transducers to measure the liquid head. However, installation is critical and flow calculations may give errors due to incorrect installation or inaccurate determination of flume slope and coefficient of roughness or weir crest characteristics.

Venturi Meters, Parshall Flumes and Palmer Bowls Flumes have received wide application in wastewater treatment and more recently Electromagnetic Flowmeters are in common use. The operator/designer should undertake an evaluation of operating characteristics for the particular application, taking into account the nature of the measuring site as well as the merits of flow measurement devices.

6.4 ACCURACY OF FLOW MEASUREMENT

In practise the overall accuracy of any flow measurement system is determined by the "Instrument Loop" accuracy. Each measurement system will contain the following components, at minimum:

- flow sensor;
- transmitter;
- recorder/integrator/display; and

interconnecting cabling.

The loop signal may also be transmitted over a distance to either a telemetry or remote operator display and may be used in the control of other plant equipment. In these cases, further signal conditioning, isolation and conversion may be introduced into the loop which will further affect the overall accuracy.

Table 6.5 shows the theoretical accuracy of individual meters compared with the expected accuracy of the installed instrument loop for each meter.

It should be noted that instruments operating by differential pressure, either in open or closed conduit applications, incorporate a root formula derivation and are therefore inherently less accurate at low flows than linear instruments, whose accuracy remains a constant over the flow range. Also, electronic instruments which rely on the velocity of the media will be less accurate at low velocities.

6.5 CALIBRATION AND MAINTENANCE

6.5.1 INTRODUCTION

There are various methods available for the calibration of flowmeters and the requirements are split into two categories, in situ and laboratory. The most important tests for the operator are in situ tests and it is these that will be dealt with here for open and closed conduit flows.

The most critical area to ensure the ongoing accuracy of all metering is the proper installation and proofing. At the time of installation the operator should ensure the following:

- all manufacturer's installation requirements have been met in full. In particular, approach channel alignment may be critical to avoid turbulence at the measurement element;
- primary meter calibration figures and curves are provided by the manufacturer;
- the meter is factory certified for its application, size, range and span; and
- on site proofing tests, preferably volumetric, have been undertaken, witnessed and signed.

TABLE 6.3: TYPICAL CRITERIA USED IN THE SELECTION OF FLOW METERING DEVICES (REF. 1).

CRITERIA	CONSIDERATION
Application	Is the metering device suitable for open or closed conduit flow ?
Sizing	Is the device appropriately sized for the range of flow that needs to be monitored ? Are suitable operating velocities maintained ?
Fluid Composition	Is the device compatible with the fluid being monitored ? Is the solids content of the fluid suitable for the measuring device? Does the device have the recommended minimum clear opening for the fluid being monitored ? Are the wetted components constructed of materials nonreactive with the fluid ?
Accuracy and Repeatability	Is the accuracy and repeatability of the device consistent with the application ? Is the stated accuracy of the individual system components consistent with overall system accuracy? Has the effect of environmental factors on the stated accuracy been considered ?
Headloss	Is the headloss caused by the device within constraints of the hydraulic profile ?
Installation Requirements	Is sufficient straight length of pipe or channel provided upstream or downstream of the meter ? Is the device located properly with respect to valves and pumps ? Are all system devices accessible for service ? Are quick disconnect couplings and by-pass piping provided ?
Operating Environment	Is the equipment associated with the flow metering device appropriately rated for its intended application to prevent explosion hazard ? Where necessary, is the equipment resistant to moisture, dust and corrosive gases (i.e., IP rating) ? Have provisions been made to ensure operation of the device within an acceptable temperature range ?
Provisions for Maintenance	Are provisions made for flushing or rodding the meter and tap lines ?

TABLE 6.4: EVALUATION OF VARIOUS TYPES OF FLOW METERING IN WASTEWATER PRELIMINARY TREATMENT

No.	Type	Application			Flow Range and Accuracy				Effects of Solids	Head Loss		Maintenance	Ease of Calibration		Cost
		Closed Conduit	Open Conduit	Plant Size	Range Min	Range Max	Accuracy Min	Accuracy Max							
1.	Standing Wave Flume	N	Y	A B	10 to 1	20 to 1	± 5	± 3	S	L	L	L	G	G	M
2.	Parshall Flume	N	Y	A B	10 to 1	20 to 1	± 5	± 3	S	L	L	L	G	G	M
3.	Palmer-Bolus Flume	N	Y	A	20 to 1	75 to 1	± 10	± 5	S	L	L	L	G	G	L
4.	Weirs	N	Y	A B C	20 to 1	500 to 1	± 5	± 1	H	H	H	M	G	G	L
5.	Venturi Meter	Y	N	A B	4 to 1	10 to 1	± 3	± 1	M	L	L	M	G	G	H
6.	Flow Nozzle Meter	Y	N	B C	3 to 1	5 to 1	± 5	± 2	H	M	M	L	G	G	M
7.	Orifice Meter	Y	N	B C	3 to 1	5 to 1	± 5	± 2	H	H	H	H	G	G	L
8.	Electromag. Meter	Y	Y	A B	10 to 1	1500 to 1	± 0.5	± 0.1	S	L	L	M	F	F	H
9.	Acoustic Meter	Y	Y	A B C	10 to 1	20 to 1	± 1.5	± 0.5	M	L	L	M	F	F	H

TABLE 6.5: TYPICAL FLOW METERING ACCURACY

No.	Type of Meter	Accuracy ($\pm\%$)	
		Theoretical	Expected *
1	Standing Wave Flume	3	5
2	Parshall Flume	3	5
3	Palmer Bolus Flume	5	10
4	Weirs	1	5
5	Venturi Meter	1	5
6	Flow Nozzle Meter	2	5
7	Orifice Meter	2	5
8	Electromagnetic Meter	0.1	1
9	Acoustic Meter	0.5	2

* = Based on an overall instrument loop accuracy, (Sensor, Transmitter, Recorder)

6.5.2 OPEN CONDUIT FLOWMETERS

Access should be provided for checking that the flume or weir channels are free from obstruction. A datum peg or calibrated measuring gauge should be provided in the upstream stilling pond and the sensor element should be regularly inspected to ensure that it is free from dirt, grease or other solids accumulation. They should be accessible and regularly cleaned to prevent build-up of slime or debris, which would affect measurement accuracy.

At routine intervals (preferably weekly) and at a time of day when the flow is reasonably constant, the depth of liquid upstream of the flume or weir should be accurately measured and converted to a rate of flow using the calibration curve.

This exercise should be repeated several times over a period of 30 mins with the time intervals arranged to coincide with movements of the meter totalizer (integrator). The various flow rates should then be averaged for the test period and compared with the volume shown on the totalizer.

At the time of commissioning and at appropriate intervals thereafter (preferably every six months), a more thorough positive displacement test should be carried out. This should consist of allowing an empty or partially filled tank (i.e. Storm Tank), of known area to fill over a given period of time (say one hour). Readings of tank level and meter totalizer should be taken at the commencement and end of the time interval. The displaced volume in the tank is calculated by multiplying the area by the displaced level and this volume is

compared with the volume registered on the meter.

An alternative but less accurate method of measurement is the dilution test, using lithium chloride or radioactive trace element, metered into the liquid flow upstream of the flume or weir and retrieved afterwards. By measuring the tracer concentration in the sample(s), the tracer dilution can be established and from this and the injection rate the volumetric flow can be established. This method is more commonly used in sewers and other closed and inaccessible systems.

6.5.3 CLOSED CONDUIT FLOWMETERS

Apart from positive displacement tests, (described in 6.5.2.), there is no exact way that the operator can measure the accuracy of closed conduit flowmeters on site, without the aid of specialist equipment. The operator can ensure, however, that the primary measuring devices function correctly. In the case of differential pressure meters, pressure tapings should be cleaned regularly (say three months), and the instrument checked for "true zero" reading by opening the cross connection between high and low pressure tapings. In the case of acoustic meters, transducers should be cleaned at regular intervals (say one month).

For true differential pressure calibration it is necessary to remove the primary sensing element (differential pressure transmitter) and check its accuracy against a pressure standard, such as a Dead Weight Tester, Bourden Tube or Manometer in an instrument laboratory. This operation is recommended to be done at least

annually and more frequently for strategically important meters.

For Electromagnetic and Ultrasonic Flowmeters it is normally necessary to bring specific calibration equipment to site, which will simulate flow signals by generating millivolt voltages and ultrasonic pulses and use these to calibrate the particular flowmeter. This operation is recommended to be done at least annually and more frequently in the case of strategically important meters.

7.1 INTRODUCTION

The nuisance issues which arise in connection with a wastewater pretreatment plant are those related to odour, noise and visual impacts. These issues are not unique to pretreatment works and arise throughout the treatment works.

As regards preliminary treatment, the specific issues and control requirements can be summarised as follows:

- **odours:** odours can arise from septicity in the wastewater flow but is more likely to be caused by storage of screenings and grit containing putrescible matter. The problem is addressed by maintaining effective washing of screenings and grit, regular removal from site and maintenance of clean storage areas. Ultimately, where odour potential exceeds acceptable standards, it may be appropriate to enclose elements of the works with collection and treatment of contaminated air. Where this is necessary, a compact arrangement of the plant is required to avoid excessive costs;
- **noise:** noise arises primarily from the operation of mechanical plant such as electric motors, compressors, conveyors, etc. Where necessary, noise is controlled by use of shrouded equipment and ultimately by enclosure of plant units or the whole of the works;
- **visual:** visual nuisance can arise from unsightly views of structures, plants or accumulated screening or grit. It is also related to the form scale and texture of works. The principal requirement is for effective screening of such works from general view.

Standards can be set for noise and odour emissions from parts or the whole of the works. The standards should be appropriate to the particular environment, so as to minimise, by best practical means, the adverse impacts.

7.2 SOURCES OF NUISANCE

7.2.1 ODOURS

Odours emanating from wastewater treatment plants are due to gases or fumes given off by some of the compounds of waste water. The objectionable odours of sewage are due mainly to the presence of nitrogen, sulphur and phosphorus containing organic matter which readily undergoes putrefaction by anaerobic bacteria, with the formation of foul smelling compounds. These malodorous compounds include hydrogen sulphide, organic sulphide, mercaptans, and certain organic amines, especially indole and skatole, which impart a characteristic unpleasant faecal odour to the septic sewage. The sulphur compounds in sewage include, not only proteins and their decomposition products, but also synthetic detergents (mainly organic sulphonates) and inorganic sulphates.

Although it is difficult to classify sources of odour by order of importance it is recognised that gravity inlet sewers and pretreatment systems at waste water treatment plants are major sources of odours. Odour levels vary significantly from one treatment plant to the next and from one type of treatment system to another. Sewage maintained in a fresh condition, i.e., containing some dissolved oxygen, will be relatively odour free as hydrogen sulphide is not formed in the presence of an abundant supply of oxygen. Therefore, the duration of retention in the sewerage network is a significant influence on odour potential at the pretreatment works.

Adequate grades in the sewerage collection systems will ensure self cleansing velocities which will prevent the sewage becoming septic in areas of low gradient. Where free flowing pipes are used, the waste usually absorbs sufficient oxygen from the atmosphere in the sewer to maintain freshness and remain free from foul odours. It is common practice to provide ventilation columns to foul sewers at each domestic dwelling and this ventilation is normally adequate to ensure an odour free atmosphere in a well designed and maintained sewer system.

In long gravity trunk sewers the air emanating from the inlet sewer at treatment plants can be highly odorous having been in contact with sewage for many hours. Under septic conditions, hydrogen sulphide could be present giving rise to odours from the sewer system. Industrial waste discharging to the sewer collection system can also give rise to odours, particularly high strength organic wastes.

Odours can also arise from grit removal and screening plant at the pretreatment works. Regular maintenance of grit traps and screens will help to reduce this odour nuisance. Uncovered storage on site of unwashed screenings, contaminated grit or grease sludges can be a significant source of odours.

7.2.2 ODOUR CONCENTRATIONS

The perception of odour at some point downwind of an emission source depends on the type of odour compound and the air concentration of the odorous gas. The measurement used to quantify the odour nuisance potential is the odour concentration, expressed as odour unit per cu.m (ou/m³). This is equal to the number of times a sample must be diluted with odour free air before 50% of an odour panel cannot detect the odour. Therefore 1 ou/m³ is regarded as the detection level.

Odour values of 2 ou/m³ would be regarded as slight odour, while values of 5 ou/m³ indicate recognisable levels likely to result in complaint. Sensitivity will also depend on location and duration.

Table 7.1 sets out typical ranges of odour and sulphur compound concentrations in gas emissions at pretreatment works. It is interesting to note that hydrogen sulphide, with the characteristic smell of rotten eggs, has an odour detection limit of the order of about 0.2 µg/m³. Values of 2 µg/m³ are usually used as the odour threshold for hydrogen sulphide, where a nuisance is thought likely to occur.

7.2.3 NOISE

Noise is considered as a level of sound greater than that of the background level. It follows that the impact of noise levels will vary depending on location and local circumstance (i.e., urban, semi-urban or rural).

Noise is a complex sound, characterised by the frequency and amplitude of the pure sounds comprising it. It is expressed in bels or decibels (dB) according to a logarithmic law.

TABLE 7.1: TYPICAL RANGES OF ODOUR AND SULPHUR COMPOUND CONCENTRATIONS IN GAS EMISSIONS AT PRETREATMENT WORKS

Location	Odour (ou/m ³)	Hydrogen Sulphide (ppm)	Methyl Mercaptan (ppm)	Allyl Sulphides (ppm)
Inlet Works (gravity feed)	50 - 5,000	< 1	< 1	< 1
Inlet Works (rising mains)	1,000 - 10,000	1 - 10	0.5 - 5	0.5 - 5
Screening Plant	100 - 5,000	1 - 10	0.5 - 5	0.5 - 5
Grit trap	500 - 5,000	1 - 5	0.5 - 1	0.5 - 1

Note: Odour expressed in odour units per m³ (ou/m³).

Noise measured at the receiver, as sound pressure levels (L_p) is expressed by the equation:

$$L_p = 20 \log \left(\frac{P_i}{P_o} \right)$$

where:

L_p = decibels;
 P_i = pressure sound wave in Pascals; and
 P_o = reference pressure, equivalent to 2×10^{-5} pascals (threshold of audible sound).

The measurement signal is usually weighted to reflect the response of the human ear. Type A weighting is usually applied in industrial engineering acoustics.

In general, noise criteria for industrial noise in European countries are related to zones such as residential, industrial, commercial, etc. "Acceptable levels" in various countries can vary from 35 - 60 dB (A) at night and 40-70 dB (A) during the day depending on the type of area. Precedence set in planning conditions in Ireland by various local authorities and by An Bord Pleanála have shown that, for general acceptability, noise level criteria outside nearby residences should be selected within the following ranges:

Night 35 - 40 dB (A)
 Day 45 - 55 dB (A)

An important aspect of these criteria is the absence of prominent discrete tones or impulses.

The selection of the preferred noise criteria values within the range of values above depends on the pre-existing noise levels, the character of the area and the nature of the development. In all instances, the disturbance caused by noise is related to its amplitude as well as its duration, which has given rise to the concept of a noise equivalent level [$L(Aeq)$] representing the sound pressure level of a noise that, remaining constant for a certain duration, radiates the same sound energy as the combination of sounds of variable intensities, emitting for the same length of time. Clearly audible and impulsive tones outside dwellings at night time should be avoided, where possible.

At a pretreatment plant, the noises which would arise result from mechanical equipment such as screens, grit screw conveyors, conveyor belts, scrapers or the maintenance of screens, etc. Aerodynamic noise would also be produced by air blowers or air lift pumps.

7.2.4 VISUAL APPEARANCE

Visual appearance is a value laden concept. People have different perceptions, tastes and associations. These can be difficult to take into account at a local level, although visual appearance of sites of national or regional importance will often be protected through various planning designations.

The visual impact of a development is perhaps the most obvious of environmental impacts and forms the basis of initial judgements on the effects of that development; whether they are enhancing, neutral or degrading. It is an impact immediately accessible to public and professionals alike. Most people, for instance, can offer an opinion on the visual qualities of a particular development, knowing nothing of the details of its other environmental implications.

Invariably, the public at large has an adverse reaction to the visual appearance of a sewage disposal works. The public perception of wastewater treatment plants is based, in most cases, on poor experiences at old works where operational procedures are inadequate to prevent visual obtrusions evident from within or outside the plant.

The presence of concrete, man made structures and large scale mechanical equipment can produce a visual nuisance when in an improper setting. When the visual impact of grit, screenings, and grease/oil deposits are added to the equation, there is a high probability that a detrimental visual impact will result. Containment of these materials and screening of their storage areas are necessary to minimise these adverse impacts.

7.3 CONTROL TECHNOLOGIES/ PERFORMANCE

7.3.1 ODOUR NUISANCE CONTROL

Action to prevent the formation of odorous conditions in a sewer is usually based on either maintaining aerobic conditions or by adding oxygen in some form or inhibiting bacterial activity with chlorine. The formation of hydrogen sulphide can be prevented by maintaining a dissolved oxygen concentration greater than 0.2 mg/l in the sewage. Oxygen may be added in a rising main, where in addition to preventing septicity, it can reduce the biochemical oxygen demand of the sewage before it arrives at the sewage works. Ferric or aluminium sulphate or nitrate chemicals can also be used to prevent formation of hydrogen sulphide.

The prevention of odour is not always possible and it may be necessary to provide some form of odour control to achieve the required standards. In such cases the optimum solution normally involves the containment and treatment of malodorous air.

Chemical destruction of malodorous air can be achieved by oxidation with ozone, potassium permanganate, peracetic acid or sodium hypochlorite. Biological treatment is possible by passing the air through beds of peat or compost for microbial digestion of the impurities.

To treat foul smelling gases, the latter must be drawn off and directed towards the treatment unit. In a majority of cases, the premises to be ventilated are maintained in a state of negative pressure. Normally the fresh air input rate should be a maximum of 90% of the extract rate. For buildings with high leakage rates this may need to be as low as 75%. This usually involves low level abstraction and high level fresh air inlets.

The ventilation of tanks and wells, where required, is usually carried out at ventilation rates of 2 - 4 air changes/hour, though cognisance should be taken of the rate of air displacement during the filling of the tank. The ventilation of a building, where required, is usually carried out at rates of 10-15 air changes/hour. Ventilation of the building or a room as a whole may be necessary though the ventilation of localised areas is sometimes acceptable where the odour sources

are enclosed using canopies or overlapping curtains.

Stainless steel, P.V.C. or G.R.P. ducting is usually used and duty/stand-by fans are provided for air extract and air input where required.

Monitoring of odours should be carried out at intervals, the frequency depending on the site conditions. Incidents which give rise to abnormal odours should be recorded, stating the reasons for the occurrence, the abatement measures taken, if any and the measures to prevent an occurrence.

7.3.1.1 Chemical Odour Control Methods

Ozone treatment of malodorous air is carried out by producing ozonized air. This is achieved by passing dried air through a silent high voltage electrical discharge and then drawing it into scrubbing water and spraying it downwards through an inert packing against the upper flow of the malodorous air. The treated air passes through a mist eliminator before being returned to atmosphere. (Fig. 7.1)

Malodours can also be removed by passing the air through dry scrubber columns packed with activated carbon derived from coconut shell, coal or wood. Depending on the grade chosen for the application, the structure can provide a large surface area and odorous compounds are absorbed onto the surface of the carbon.

Proprietary systems are available, such as Purifil and Puracarb. Purifil is made up of activated alumina pellets impregnated with potassium permanganate and other reagents. The pellets adsorb hydrogen sulphide onto the surface and in moist conditions it is oxidised. Puracarb medium consists of a mixture of activated carbon and alumina impregnated with sodium bicarbonate to neutralise acid gases and potassium hydroxide and iodide for control of hydrogen sulphide. Inlet and outlet plenums are provided to ensure air distribution across the face of the filters. The media requires replacement regularly, typically annually, in a well designed unit.

7.3.1.2 Biological Odour Control Methods

Biological methods using peat and compost beds are finding increasing use for odour destruction at sewage works, where the extra space required can

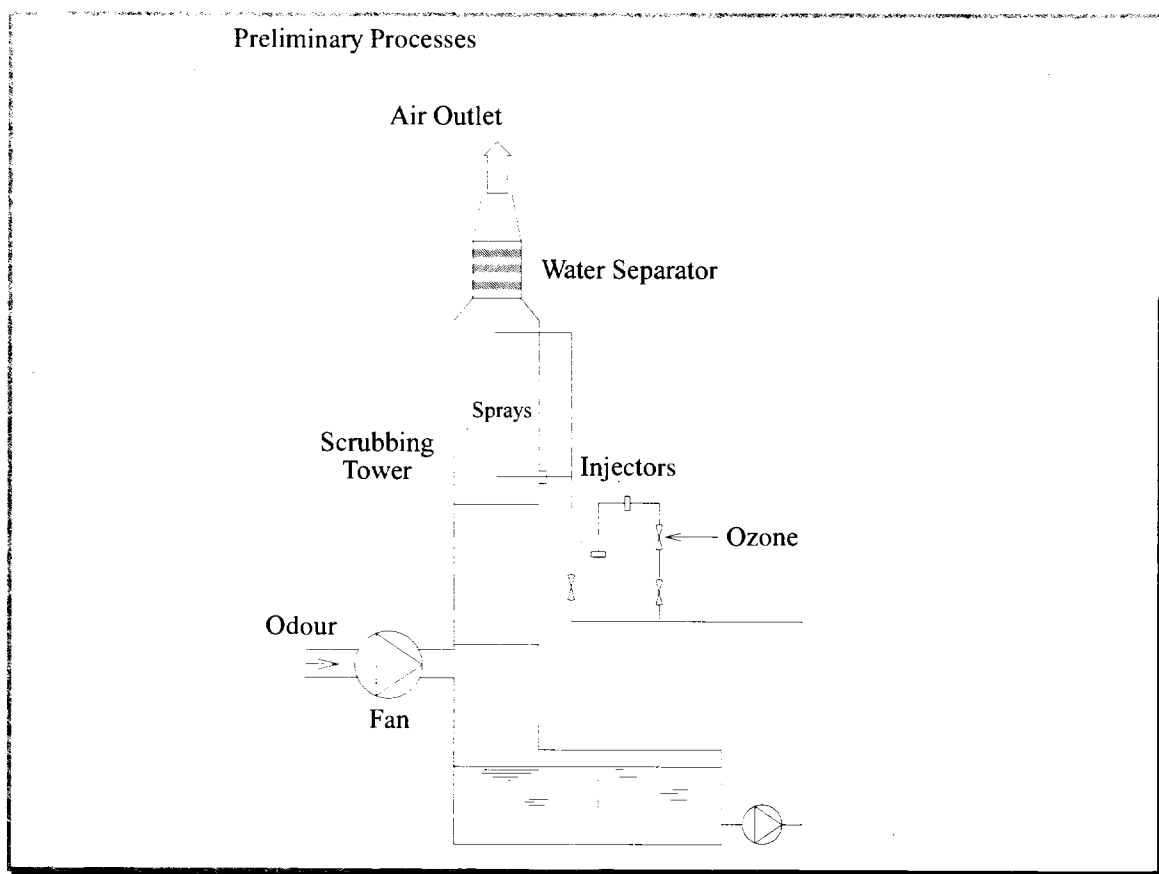


FIGURE 7.1: WET OXIDATION ABOUT OZONE

be made available. They utilise moist layers of peat, heather or compost supplied in packaged units. The malodorous air is extracted and directed into the base of the bed and rises upwards through the peat. The odorous compounds are adsorbed onto the organic material and absorbed onto the layer of water surrounding them (Fig. 7.2).

A chemical reaction takes place on the surface of the biofilter material and the components of the waste gases are broken down by micro organisms. As the odorous gas passes through the filter media the odorous compounds present in the gas stream are oxidised to produce odourless end products such as carbon dioxide, water, nitrates, and sulphates.

Site erected bio filter housings are typically of concrete, bolted glass coated steel panels, bolted G.R.P. panels or other durable material. The filter medium, slatted raised floors and water sprinkler systems are installed in the housing. Modular

biofilters are also available with the housing constructed using bolted G.R.P. or stainless steel sections.

The operation of the bio-filter requires little attention apart from the necessity to keep the bed moist.

7.3.1.3 Short Term Odour Prevention

Odour masking is sometimes used as a short term solution to the prevention of odour nuisance. It involves mixing the odour with a masking chemical which has a more pleasant smell. The chemical is atomised using compressed air and sprayed over the affected area from a height of approximately 4 m. The malodorous substances pass through the atomised chemical and they combine to produce a more acceptable odour. The procedure is not always successful as it is dependant on the proper balance of the masking chemical with the malodour, and other parameters

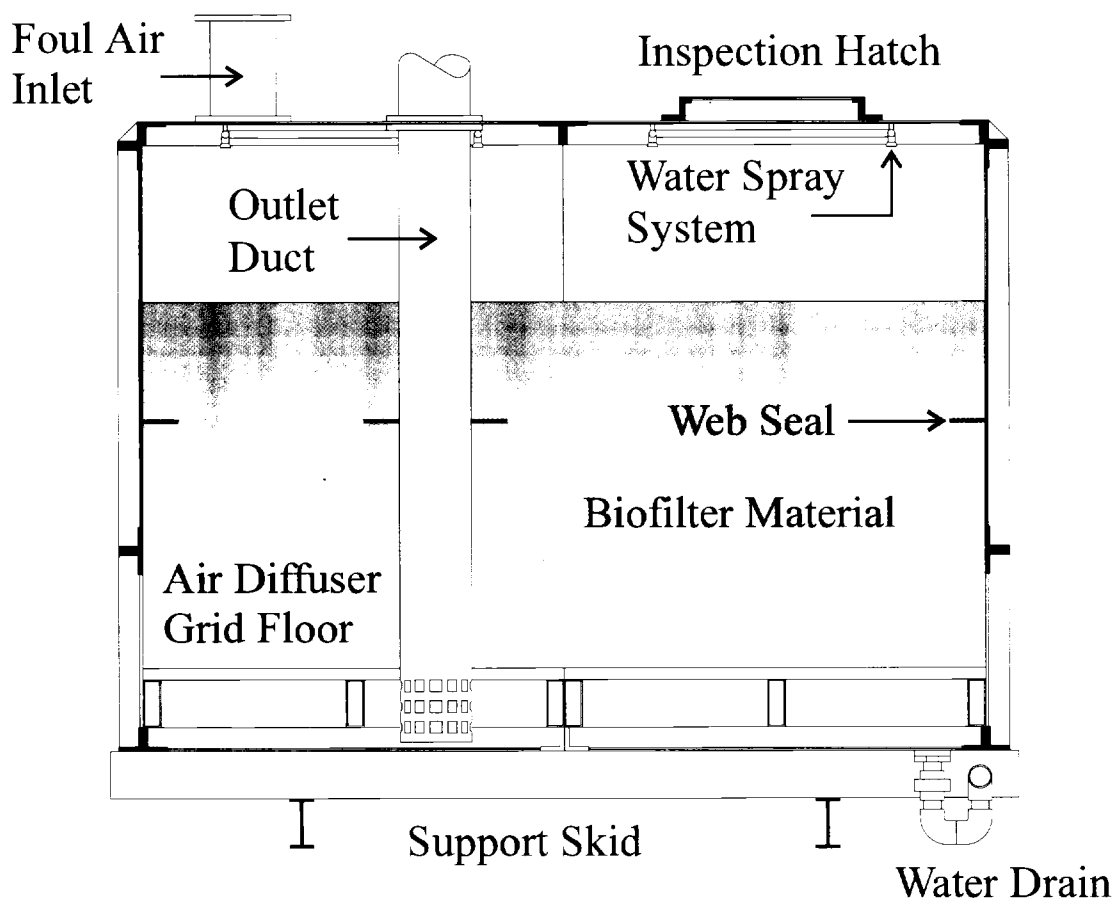


FIGURE 7.2: SECTION THROUGH PEAT BED BIOFILTER

such as wind direction, wind speed and rates of application can influence the effects of the process. Occasionally, the combination of the malodour and the atomised chemical form another unpleasant odour. The procedure is normally employed as an interim step, pending implementation of a long term solution to the problem.

7.3.2 NOISE NUISANCE CONTROL

7.3.2.1 Noise Criteria

Site selection is an important feature in the control of noise and is based on several criteria such as distance from residential areas, prevailing wind direction and availability of natural sound barriers. The existing ambient noise level can have particular relevance and must always be

considered. Plant structural design is also a factor in protection against noise as is plant layout. It is important to remember that the noise at any point may be due to more than one source and that additionally it may be aggravated by noise reflected from walls (reverberant noise) augmenting the noise radiated directly from the source.

With any noise problem there are three distinct elements:

- the source of the noise;
- the path of the noise; and
- the receiver.

7.3.2.2 Noise Alleviation

The alleviation of a noise problem can be tackled by addressing these three elements:

source: the control of noise at source is the most obvious solution, though the feasibility of this method is often limited by machine design, process or operating methods. Noise levels are slower at lower operating speeds and the resulting frequencies are less disturbing to the human ear. Therefore, the use of rotary machines at low operating speeds is necessary. The choice of air conduits with a diameter to ensure a velocity of less than 12 m/sec. is recommended, as well as limiting of the air inlet and outlet velocities by increasing the size of orifices;

path: if the noise cannot be controlled at source, then the reduction of the noise levels between the source and the receiver can be achieved by the following methods:

- *orientation and location* - control can be achieved by moving the source of the noise away from the noise sensitive area. In other cases where the machine does not radiate equally in all directions, careful orientation can achieve significant reductions at the sensitive site;
- *enclosures* - enclosures can be provided around noise sources which give an attenuation of between 10 - 30 dBA and they will control both the direct field and reverberant field noise components. In enclosing any source, the provision of adequate ventilation, access and maintenance facilities must be considered. Where ventilation is required each vent should be silenced and access doors should be provided with specific acoustic features. Noise control measures worth considering are the provision of full hoods for Archimedes screws, the enclosing of lift stations, the construction of buildings around air blowers, compressors, generators, the construction of houses around pretreatment plant, the construction of pipe galleries around pipelines;
- *silencers* - silencers are used to suppress the noise generated when air, gas or steam flow in pipes or ducts are exhausted to atmosphere. They fall into two forms, absorptive and reactive. Absorptive

silencing takes place when sound is absorbed by an acoustic absorbent material. Reactive silencing takes place where noise is reflected by changes in geometrical shape. The absorptive silencer normally has the better performance at higher frequencies whereas the reactive type of silencer is more effective for controlling noise at low frequencies;

- *lagging* - on pipes carrying steam or hot fluids, thermal lagging can be used as an alternative to enclosure and can achieve attenuations of between 10 and 20 dBA, but it is only effective at frequencies above 500 Hertz. Lagging normally takes the form of mineral wool wrapped around the pipe with an outer steel, aluminium or lead loaded vinyl layer. It is important that there is no contact between the outer layer and the pipe wall, otherwise the noise reducing performance may be severely limited;
 - *damping* - where large panels are radiating noise, a significant reduction can be achieved by fitting proprietary damping pads, fitting stiffening ribs or using a double skin construction;
 - *screens* - acoustic screens are effective in reducing the direct field component of noise transmission by up to 15 dBA. However, they are of maximum benefit at high frequencies, but of little effect at low frequencies and their effectiveness reduces with distance from the screen; and
 - *absorption treatment* - in situations where there is a high degree of reflection of sound waves the reverberant component can dominate the noise field over a large part of the work area. The introduction of an acoustically absorbent material in the form of wall treatment and/or functional absorbers at ceiling height will reduce the reverberant component by up to 10 dBA but will not reduce the noise radiated directly from the source;
- receiver:** where it is not possible to sufficiently reduce the noise levels by source or path treatment, protection of the personnel from noise is necessary. The two major methods of personnel protection are the provision of a quiet room or work area and the wearing of either ear-muffs or ear plugs. A quiet room can be provided by the

construction of an acoustic enclosure to keep the noise out. The selection of ear-muffs or ear plugs should be made with care having regard to the noise source, the environment and comfort of the wearer. Ear plugs are only generally effective up to noise levels of 100 - 105 dBA while ear-muffs can provide protection at higher noise levels to meet a 90 dBA criterium for the noise received by the wearer.

7.3.2.3 Noise Monitoring

Ongoing monitoring at regular intervals should be carried out. The frequency of such monitoring should be determined having regard to the location of the works and the particular sensitivities of the site. Records of both noise and vibration monitoring data should be maintained as a basis for assessing claims of nuisance, should they arise.

7.3.3 VISUAL NUISANCE CONTROL

The proper site selection and layout can contribute to minimising visual nuisance. Due regard should be given to cleanliness and proper operation to ensure that unsightly features are kept to a minimum. Careful planting and landscaping of an area with the provision of suitable plant life, including shrubs and areas of well kept lawn and the encouragement of bird life greatly assists cleanliness and appearance within the sewage treatment plant.

From an operational point of view, therefore, the key issues are:

- containment of sludges, screenings and other debris, without spilling or over-loading;

- maintenance of a clean neat site with regular grass cutting, trimming of verges and washing of paved areas;

- protection of exposed surfaces from splashing, lichen growth and other deterioration;

- maintenance of site fencing and boundary screening in good condition;

- prevention of aerosols or windblown debris from screenings; and

regular painting of gates, doors, building finishes such as plinths, soffits and fascias.

7.4 GAS CONTROLS

Legislation demands and good sense dictates that a safe working environment should be provided for the work force in all work areas. This is especially relevant at sewage disposal works where the collection of hazardous gases can take place in confined environments. Entry should be limited or avoided into a confined space unless the atmosphere has been tested by an authorised competent person having relevant local knowledge of the system or installation. A safe result has to be obtained before entry is attempted and arrangements made thereafter for the continuous monitoring whilst persons are in the confined spaces. Alternatively suitable breathing apparatus has to be provided and used.

The most common hazardous gases to be found at waste water treatment plants are hydrogen sulphide and methane. Hydrogen sulphide is a colourless gas with a pungent odour similar to rotten eggs. It is heavier than air and is flammable and toxic. It occurs in sewers and it can be detected at concentrations of 0.2 - 2 $\mu\text{g}/\text{m}^3$, but increasing the duration of exposure impairs the sense of smell. Even at low concentration, the gas irritates the eyes.

Methane, which is a constituent of natural and reformed gas is colourless and odourless, lighter than air and highly flammable. It can give rise to an explosive atmosphere. Similar conditions can arise from the presence of petrol which can enter the sewer system from spillages.

Oxygen deficiency can also present a significant hazard, obviously in confined spaces but also where there is the potential for release of inert gases such as nitrogen which could reduce oxygen levels. Lack of oxygen is a common cause of death and early warning is vital. Fresh air contains approximately 21% oxygen. At oxygen concentrations of 21 - 18% the fit body tolerates exercise well. Below 18% the response depends upon the severity of work undertaken. At a level of 10% or lower unconsciousness will take place and possibly death.

There are many types of gas monitoring equipment available at present for permanent installation in confined spaces or portable monitors for the testing of atmosphere in confined spaces prior to entry by the work force. The monitors can be as simple as a grab sampler with a stain detector tube. More complex units which make a quantitative analysis give a direct readout of contaminant level on a meter and these use either infra red gas analysers or sensors which react with the chemicals and produce an electrical signal proportional to the gas concentration.

The hazardous gas warning system can be linked to a local alarm station which gives audible and visual warnings as well as readout of the levels of gas encountered. Alternatively, the monitoring system can activate ventilation equipment or shut-down relevant plant in the vicinity of the hazardous gas.

Where measurements of air borne contamination levels have been made, it is necessary to interpret results against a standard. This interpretation will form the basis for the control strategy. These standards vary for the type of hazardous gas being monitored and especially in the case of flammable gases and toxic gases.

The standards applied to a flammable gas is dependent on the level of gas in air which will cause an explosion if ignited. For an explosion to occur, three conditions must be present; fuel (gas), oxygen from the air and heat (the ignition source). The explosion can only occur if the gas/air mixture is within specific limits. This is known as the explosive range. (Refer to B.S. 5345; Part 1: 1989, Section 5 and Table 7).

Below the lower explosive limit (LEL), there is insufficient gas and above the upper explosive limit (UEL), there is too much gas and insufficient air. In the case of methane the LEL is 5% by volume in air while the UEL is 15% by volume in air. Therefore, for a flammable gas warning system, alarm levels are set which trigger audible or visual alarms to warn the operators of the hazardous condition. Electrical equipment in such situations must have appropriate rating in accordance with B.S. 5345, Part 1, 1976.

The standards applied to a toxic gas refer to threshold limit values for airborne concentration

of substances and represent conditions under which it is believed that nearly all workers may be repeatedly exposed day after day without adverse effect. The manufacturers of toxic gas sensors and monitors generally use the Control of Substances Hazardous to Health Regulations (COSHH) 1988.

The U.K. Health and Safety Executive guidance note EH40 sets out the long and short term exposure limits for most toxic gases. The level used for hydrogen sulphide is based on the occupational exposure standard (OES) and this is the concentration of an air borne substance (average over a reference period) at which according to current knowledge there is no evidence that it is likely to be injurious to employees if they are exposed by inhalation day after day to that concentration. The hydrogen sulphide eight hour OES is ten parts per million while the ten minute OES is fifteen parts per million.

Deficiency of oxygen in the atmosphere of confined spaces can also be measured instantaneously. Portable analysers are available which measure the concentration of oxygen in the air by the depolarisation produced at a sensitive electrode mounted in the instrument. Long extension probes can be attached to the analyser which allow remote inspection of confined spaces. Alarms are normally set at 19 and 18% levels of oxygen by volume in air.

At pretreatment works it is necessary to satisfy Health and Safety Regulations to have sufficient monitoring equipment to test the presence of hazardous gases in confined areas. As the two main hazardous gases which normally arise at pretreatment works are hydrogen sulphide and methane, portable or permanent monitoring of these gases should be carried out. It is also necessary to have monitoring equipment available to monitor the oxygen deficiency in confined areas.

These requirements will form part of an overall Safety Statement which will incorporate a "Safe System of Work" which must be put in place for all plants. All operators must be familiar with the contents of the site safety statement and must comply with the work practises and procedures therein. Regular calibration of equipment is

necessary to ensure satisfactory operation. Safety requirements are governed by the Safety, Health and Welfare at Work Act, 1989 and its associated Regulations. Reference should be made to the Sanitary Services Training Manuals - Safety Module for more detailed information on health, safety and hygiene issues.

Ventilation requirements of buildings with a hazard potential will vary depending on:

- the humidity control requirements;
- the dispersion of light and heavy gases;
- maintaining negative pressures; and
- whether buildings are manned or unmanned.

The air change rate will be selected based on consideration of the foregoing. Forced ventilation of preliminary treatment buildings is likely to require odour treatment, the design/operating criteria for which will be influenced significantly by ventilation rate.

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Activated sludge. A flocculant microbial mass of bacteria, protozoa and other micro-organisms with a significant proportion of inert debris, produced when sewage is continuously aerated.

Adsorption. A surface phenomenon involving the adhesion of molecules to interfaces with which they are brought into contact.

Aerobic. A condition in which elementary oxygen is available and utilised in the free form by bacteria.

Anaerobic. A condition in which oxygen is not available in the form of dissolved oxygen or nitrate/nitrite.

Automatic Sampler. A device which takes a sample continuously or at regular intervals of cumulative flow or time over a stipulated period. Individual increments or samples may have equal volumes or be roughly proportional to the rate of flow at the time of sampling.

Autothermic combustion. The condition under which the calorific value of a sludge is sufficient to maintain combustion without auxiliary fuel.

Bacteria. Micro-organisms, of simple structure and very small size (average 1 μm diameter); typically unicellular rods or rounded cells (cocci), occasionally filamentous.

Baffle. Used to check eddies and promote a more uniform flow through the tank. A scum baffle is used for retaining scum.

Bar screen. A screen for removing gross solids from sewage, consisting of a series of bars, either straight or curved, often with the upstream edge of each bar being slightly wider than the downstream edge. The gaps between the bars of such screens are usually in the range 10 to 150mm. Screens with straight bars may be set with the bars vertical or at an angle of 60° to the horizontal.

Benching. Sloping surfaces on either side of a channel, at pipe soffit level, designed to reduce deposition of solids.

Biogas. Gas produced by the anaerobic biological degradation of organic matter. The major constituents are methane and carbon dioxide.

Biomass. The total weight of activated sludge or biological film.

British Standards Institution (BSI). A British institution founded in 1901 and incorporated by Royal Charter in 1929, its main purpose being to prepare and issue codes of practice and standard specifications (British Standards) for quality, safety, performance or dimensions for use in commerce and industry.

Catchment area. The area drainage naturally to a watercourse or to a given point.

Coarse screen. A screen used for removing gross solids from domestic or industrial wastewater, with spaces between the bars at least 50 mm wide.

Combined system. A system of sewerage in which wastewater and surface water are carried in the same drains and sewers.

Comminutor. A machine, introduced about 1938, which intercepts gross solids in sewage and shreds them without their being removed from the sewage. It consists essentially of a large hollow drum with horizontal slots, rotating continuously on a vertical axis and driven by an electric motor. As the drum rotates, teeth projecting from it engage fixed hardened-steel combs; material retained by the screen is shredded by the action of the teeth and combs until small enough to pass through the slots with the sewage.

Constant-velocity grit channel. A channel through which sewage is passing, the depth of flow being controlled by a standing-wave flume at the outlet end. The channel is so designed that for any depth of flow the cross-sectional area of the submerged portion is proportional to the rate of flow so that the velocity of the sewage is maintained constant at about 0.3 m/s. At this velocity grit settles, leaving the organic matter in suspension in the sewage.

Crest. The highest point on a sill or weir over which a liquid flows.

Critical velocity. In hydraulics, the velocity at which the flow changes from laminar to turbulent.

Detritus. In sewage treatment, an inorganic grit associated with a relatively high proportion of organic matter.

Discreen. A trade name for a fine-screening assembly which consists of a number of shafts, each fitted with overlapping and intermeshing discs with an aperture distance to suit the fineness of screening required. The line of shafts is set at an angle to the flow and each shaft rotates slightly faster than its upstream neighbour, thus inducing a conveying action of solid across the face of the screen to the discharge point.

Doppler flow meter. When the liquid flowing in a pipe contains solid particles or air bubbles, the doppler phenomenon can be used to measure the velocity. Two transmitter/receivers are bonded into opposite sides of the pipe, and ultra-sonic pulses are transmitted at an angle of 60° through the flowing liquid. The movement of the particles causes a shift in frequency between the transmitted and received signals which is proportional to the velocity of the particles.

Drum screen. A screen used for removing gross solids from sewage. It consists of a cylindrical drum or truncated cone rotating on a horizontal axis, with the sewage passing through the screen radially and flowing away in an axial direction. Gross solids are collected on the inside or outside of the drum as it rotates and are then washed off the surface.

Dry solids content. The weight of dry solids per unit weight of sludge, expressed as a percentage or as mg/kg.

Dry-weather flow (DWF). When the sewage flow is mainly domestic in character, the average daily flow to the treatment works during seven consecutive days without rain (excluding a period which includes public or local holidays) following seven days during which the rainfall did not exceed 0.25 mm on any one day. With an industrial sewage the dry-weather flow should be based on the flows during five working days if production is limited to that period. Preferably, the flows during two periods in the year, one in the summer and one in the winter, should be averaged to obtain the average dry-weather flow.

Effluent. As applied to sewage treatment, a liquid which flows out of a process or system, but more particularly the domestic or industrial wastewater, treated to a greater or lesser extent, which flows out of a section of the treatment plant, or from the treatment works as a whole.

Emergency bypass. A channel or pipe which enables a treatment unit or units, or a machine, to be bypassed so that it can be taken out of service for maintenance or repair, or if a power failure occurs.

Explosive limits. The lower explosive limit (LEL) is the lowest concentration in air of an inflammable gas such as methane at which, when the mixture is ignited, sufficient heat is generated to bring the temperature of successive layers of unburnt gas to the ignition point, at which the flame becomes self-propagating. Similarly, the upper explosive limit (UEL) is the highest concentration of an inflammable gas in air at which the flame is still self-propagating.

Extended-aeration process. A modification of the activated-sludge process whereby the sewage and activated sludge are subjected to prolonged aeration; the sludge being returned at a high rate, with the aim of bringing about considerable oxidation and aerobic digestion of the organic matter in the activated sludge.

Fine screen. A screen with apertures of 3 to 15 mm.

Foul sewer. A sewer conveying sewage, i.e. wastewater of domestic or industrial origin, excluding rainwater or surface water.

Grease. In sewage treatment, grease includes fats, oils, waxes, free fatty acids, calcium and magnesium soaps, mineral oils, and other non-fatty materials. The type of solvent used for its extraction should be stated.

Grease trap. A receptacle designed to collect and retain grease and fatty substances in kitchen wastes or in an industrial wastewater and installed in the drainage system between the point of production and the sewer.

Grit. The heavy mineral matter in sewage, such as silt, sand, gravel, cinders, ashes, metal and glass. It is abrasive in character and may vary in composition seasonally. Soil originating from vegetable washing and preparation is also classified as grit.

Grit washer. A device for washing grit to remove organic matter.

Head. The total head against which a pump is to deliver is made up of the static head, plus friction head, plus velocity head. The static head is the actual lift, from the minimum level of the liquid in the wet well to the point of discharge. The friction head is the energy lost by friction in the suction and the delivery pipes, including losses at bends and obstructions. The velocity head is the energy per unit weight of liquid being pumped due to its velocity.

Integrator. A device which indicates the total volume of liquid or gas which has passed over or through a measuring device, or which summates the hours run by operating units or the number of operations carried out.

International System of Units (SI). Or the Systeme International des Unites, a modified and simplified form of the metric system, approved internationally in 1960 and to which the UK has changed. It rationalizes the main metric units of measurement and standardizes their names and symbolic representation. The system is based on seven units, the metre (m) as the unit of length, the kilogramme (kg) as the unit of mass, the second (s) as the unit of time, the ampere (A) as the unit of electric current, the degree kelvin ($^{\circ}\text{K}$) as the unit of temperature, the candela (cd) as the unit of luminous intensity, and the mole (mol) as the unit of substance amount.

Invert. The lowest point on the internal surface of a drain, sewer or channel.

Jeta grit trap. A development of the earlier Pista grit trap, its principal difference is an impeller designed to produce an upward spiral flow around the centre to carry lighter sewage solids to the surface with grit settling in the hopper.

Jetting machine. A machine using high-pressure water for cleansing purposes.

Level-sensing device. A device for automatically controlling the operation of a centrifugal pump, depending on the level in the wet well, or for recording the volume of sludge or chemical in a storage tank. Such devices include conductivity or capacitance electrodes, pneumatic tubes or cells, float-mounted relays, ultrasonics, gamma rays, or float systems.

Magnetic flow meter. A meter which can be installed in a pipeline for measuring flows, based on the principle that the voltage induced in a conductor of known length and moving through a magnetic field set up inside the pipe between electrical probes is proportional to the velocity of that conductor, and hence to the rate of flow, since the conductor is in this case the fluid. It can also measure the flow when this is in the opposite direction.

Medium screen. A screen with apertures of 15 to 50 mm.

Milligrammes per litre (mg/l). Used for expressing concentration of impurities in a wastewater or effluent. In SI units the equivalent is gm/m^3 .

Muncher. A trade name for a proprietary design of screenings disintegrator for sewage or sludge. The machine is a twinshaft, slow-speed, high torque grinder.

Odour Unit. The number of times a sample must be diluted with odour free air before 50% of an odour panel cannot detect the odour is the odour concentration expressed in odour units per cu.metre (ou/m³).

Organic polluter. The pollution of a receiving water due to the consequences of the breakdown of excessive concentrations of putrescible organic matter.

Orifice meter. Used for measuring flows of clean water and of air. A thin metal plate with a sharp-edged circular orifice is installed in the pipe-line conveying the air or water, at right angles to the direction of flow. The difference in pressure at a point a short distance upstream of the orifice and at the orifice is measured and this can be related to the rate of flow, variations of which are recorded on a chart.

Orifice plate. A metal plate with a central orifice of smaller diameter than the pipeline in which it is installed by inserting it between flanges; used for measuring the flow of air or liquid through the pipeline.

Outfall. The site of discharge of a liquid from a pipe. Applied particularly to the point at which the sewer discharge to a treatment works or receiving water, or the point at which a conduit discharges the effluent from a treatment works into a receiving water.

Peat bed. A biological method of odour treatment. Odorous air is passed into the bottom of a bed made up of layers of peat and heather, and micro-organisms absorb and oxidise odorous compounds to carbon dioxide, water sulphates and nitrates.

Polluting load. The quantity of polluting matter entering a treatment plant or in the effluent discharged into a receiving water during a given period.

Pollution. The impairment of the suitability of water for some considered purpose.

Population equivalent. The volume and strength of an industrial wastewater expressed in terms of an equivalent population, based upon a figure of 0.060 kilogramme BOD per capita per day; the population equivalent of an industrial wastewater is therefore calculated using the relationship.

$$\text{Population Equivalent} = \frac{\text{5-day BOD (mg/l)} \times \text{flow (m}^3\text{/d)}}{0.060 \times 10^3}$$

Preliminary treatment. The removal or disintegration of gross solids in sewage and the removal of grit. Also sometimes the removal of oil and grease from sewage, prior to sedimentation.

Pretreatment. The treatment which an industrial wastewater receives at the source before discharge into the public sewer. Pretreatment of a sludge refers to conditioning before dewatering.

Primary treatment. The first major stage of treatment following preliminary treatment in a sewage works, usually involving removal of settleable solids.

Receiving water. A body of water, flowing or otherwise, such as a stream river, lake, estuary or the sea.

Rectangular weir. A thin-plate measuring weir of rectangular shape, at right angles to the direction of flow. Such a weir is 'full width' when the sides are flush with the sides of the channel, or 'contracted' when the weir does not extend across the full width; it is then said to have 'side contractions'.

Rotameter. A trade name for a float-type variable-area flow meter consisting of a float moving within a vertical graduated tube of uniform taper. As the rate of flow in the tube alters the float rises or falls, changing the area of the annular space to maintain a constant differential pressure across the float. The flow causes the float to rotate (hence the name), so preventing sticking.

Screenings. The gross solids in sewage intercepted by screens and removed manually or by raking mechanism. The quantity depends on the bar spacing and ranges from 0.01 to 0.03m³/d per 1000 population equivalent. Screenings weigh between 600 and 900kg/m³ and have a dry solids content of from 10 to 20 per cent, the dry solids containing from 80 to 90 per cent of organic and volatile matter and calorific value of approximately 15 kJ/kg DS. Unwashed screenings usually have a foul odour and are objectionable in appearance.

Screenings press. A hydraulic press used for dewatering screenings.

Screezer. A development of the comminutor where the rotating drum becomes a fine screen, its movement transferring debris to one side for subsequent removal.

Screw compactor. A machine by which free water is squeezed from the debris removed from the screens at the inlet to a sewage works. The wet debris is deposited onto the screw which operates against a back pressure induced by an inclined discharge or a spring tensioned outlet flap. Some variations incorporate a reducing pitch screw to promote the squeezing action.

Scum. A layer of fats, oils, grease and soaps together with particles of plastics, plastics wrapping materials and sludge which has risen to the surface owing to gasification, and which collects on the surface of primary sedimentation tanks and anaerobic digesters.

Scum baffle. A plate or board which dips below the surface of sedimentation tanks to prevent scum flowing out with the effluent. Also termed a 'scum board'.

Separate system. A sewerage system in which foul sewage and surface water are conveyed in separate pipes.

Septic. A condition produced by lack of dissolved oxygen and oxidised nitrogen (nitrate or nitrite). Putrefaction can occur.

Side-weir overflow. A weir constructed along the length of the sewer. When the crest of the weir is below the level of the horizontal diameter of the upstream pipe it is called a 'low side-weir overflow', when above it is called a 'high side-weir overflow'.

Storm overflow. A device on a combined or partially-separate sewerage system, introduced for the purpose of relieving the system of flows in excess of a selected rate, the excess flow being discharged, possibly after removal of gross solids, to a convenient receiving water.

Storm-sewage tank. A tank into which, in wet weather, is diverted all the sewage biological treatment. Its purpose is to store as much of the storm sewage as possible, for return to the works inlet after the flow has returned to normal, and to remove settleable solids from the remainder which overflows from the tank to a receiving water.

Surcharge. A condition obtaining when the flow in a sewer increases after it is already flowing full.

Ultrasonic level detector. The ultrasonic energy emitted from a combined transmitter/receiver installed above the liquid is reflected back from the surface. The time elapsed between transmission and reception of the signal is proportional to the distance travelled, and hence the depth of the liquid can be derived.

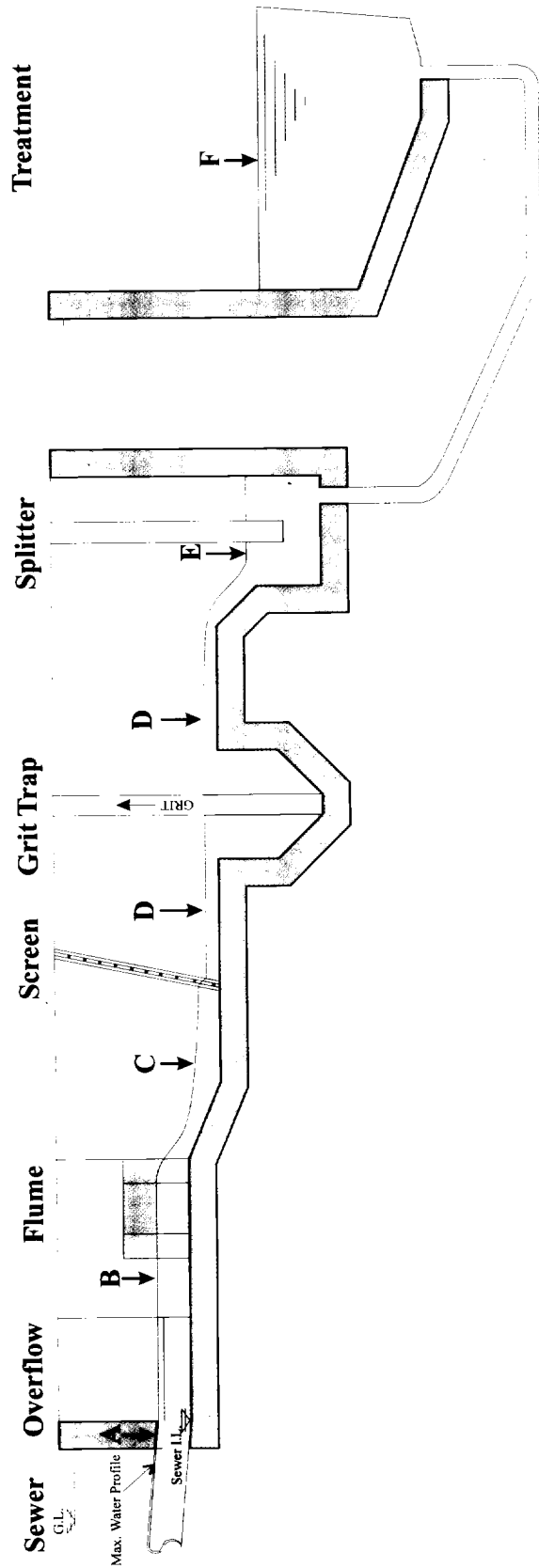
Velocity of approach. With a rectangular weir or V-notch, the velocity of the liquid at the point where the upstream head is measured.

V-notch weir. A measuring weir of V-shape with the angle at the apex usually 90°, used for measuring small discharges.

Vortex grit separator. A grit separating tank with a cylindrical top portion and a conical bottom. The sewage enters tangentially and separation of grit is assisted by an electrically-driven rotating paddle at the

base of the cylindrical portion and compressed air issuing from a diffuser ring in the hopper. Grit settling in the hopper is transferred by an air-lift pump to a vortex washer whilst the sewage containing the organic matter overflows a peripheral weir.

Vortex grit washer. A grit washer consisting of a chamber at the centre of which is a cylindrical vortex chamber with an open-ended conical bottom. Water-borne grit from the vortex separator enters the vortex chamber tangentially and is separated from organic matter by centrifugal force, the washed grit falling from the vortex chamber to the floor of the main chamber from whence it is removed by a bucket elevator. The carrier water with the organic matter is withdrawn through a central siphon for return to the sewage flow.



WORKS SIZE (P.E.)	INLET SEWER "A"	STORM OVERFLOW WEIR "B"	DOWNSTREAM FLOW MEASURING FLUME "C"	DOWNSTREAM SCREEN "D"	GRIT REMOVAL T.W.L. "D"	SPLITTER CHAMBER T.W.L. "E"	PIPE LINK	TREATMENT UNIT T.W.L. "F"
500	0.0	-0.2	-0.4	-0.5	-0.5	-0.7		-0.9
2,000	0.0	-0.3	-0.5	-0.6	-0.6	-0.9		-1.1
20,000	0.0	-0.5	-0.75	-0.9	-0.9	-1.2		-1.4

USER COMMENT FORM

NOTE: Completed comments to be forwarded to: The Environmental Management and Planning Division, Environmental Protection Agency, Ardavan, Wexford

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Environmental Protection Agency

ESTABLISHED

The Environmental Protection Agency Act, 1992, was enacted on 23 April, 1992 and under this legislation the Agency was formally established on 26 July, 1993.

RESPONSIBILITIES

The Agency has a wide range of statutory duties and powers under the Act. The main responsibilities of the Agency include the following:

- the licensing and regulation of large/complex industrial and other processes with significant polluting potential, on the basis of integrated pollution control (IPC) and the application of best available technologies for this purpose;
- the monitoring of environmental quality, including the establishment of databases to which the public will have access, and the publication of periodic reports on the state of the environment;
- advising public authorities in respect of environmental functions and assisting local authorities in the performance of their environmental protection functions;
- the promotion of environmentally sound practices

through, for example, the encouragement of the use of environmental audits, the establishment of an eco-labelling scheme, the setting of environmental quality objectives and the issuing of codes of practice on matters affecting the environment;

- the promotion and co-ordination of environmental research; and generally overseeing the performance by local authorities of their statutory environmental protection functions.

STATUS

The Agency is an independent public body. Its sponsor in Government is the Department of the Environment.

Independence is assured through the selection procedures for the Director General and Directors and the freedom, as provided in the legislation, to act on its own initiative. The assignment, under the legislation, of direct responsibility for a wide range of functions underpins this independence. Under the legislation, it is a specific offence to attempt to influence the Agency, or anyone acting on its behalf, in an improper manner.

ORGANISATION

The Agency's headquarters are located in Wexford and it operates five regional inspectorates, located in Dublin, Cork, Kilkenny, Castlebar and Monaghan.

MANAGEMENT

The Agency is managed by a full-time Executive Board consisting of a Director General and four Directors. The Executive Board is appointed by the Government following detailed procedures laid down in the Act.

ADVISORY COMMITTEE

The Agency is assisted by an Advisory Committee of twelve members. The members are appointed by the Minister for the Environment and are selected mainly from those nominated by organisations with an interest in environmental and developmental matters. The Committee has been given a wide range of advisory functions under the Act, both in relation to the Agency and to the Minister.

