KENYA STANDARD

KS 2767-16:2021

ICS ##.###

1st Edition

Wastewater treatment plants - Part 16: Physical (mechanical) filtration

TECHNICAL COMMITTEE REPRESENTATION

The following organizations were represented on the Technical Committee:

1. CSI International ltd
2. Dousglobal Management solutions
3. Ecosave Africa Ltd
4. Embu Water and Sanitation Company LTD
5. Environment Institute of Kenya
6. Green Kenya Investment Corporation
7. Jomo Kenyatta university of agriculture and technology
8. KenGen PLC
9. Kenya Chemical Society
10. Kenya water Institute
11. Kenyatta university
12. Nairobi City Water and Sewerage Company
13. National Environment Management Authority
14. National Public Health Laboratory
15. Synergy Ltd
16. Taita Taveta University
17. TANATHI Water Works Development Agency
18. United States International University-Africa
19. Kenya Bureau of Standards — Secretariat

REVISION OF KENYA STANDARDS

In order to keep abreast of progress in industry, Kenya Standards shall be regularly reviewed. Suggestions for improvements to published standards, addressed to the Managing Director, Kenya Bureau of Standards, are welcome.

KS 2767-16:2021

Wastewater treatment plants - Part 16: Physical (mechanical) filtration

Kenya Bureau of Standards, Popo Road, Off Mombasa Road,
P.O. Box 54974 - 00200, Nairobi, Kenya

+254 020 6948000, + 254 722202137, + 254 734600471

info@kebs.org

@KEBS_ke

kenya bureau of standards (kebs)

Foreword

This Kenya Standard was prepared by the Water and Sanitation Technical Committee under the guidance of the Standards Projects Committee, and it is in accordance with the procedures of the Kenya Bureau of Standards

During the preparation of this standard, reference was made to the following document (s): EN 12255 Wastewater treatment plants — Part 16 Physical (mechanical) filtration

Acknowledgement is hereby made for the assistance derived from this (these) source (s)

The parts of these series are as follows:

– Part 1: General construction principles

– Part 3: Preliminary treatment

– Part 4: Primary settlement

– Part 5: Lagooning processes

– Part 6: Activated sludge processes

– Part 7: Biological fixed-film reactors

– Part 8: Sludge treatment and storage

– Part 9: Odour control and ventilation

– Part 10: Safety principles

– Part 11: General data required

– Part 12: Control and automatization1)

– Part 13: Chemical treatment

– Part 14: Disinfection1)

– Part 15: Measurement of the oxygen transfer in clean water in activated sludge aeration tanks

– Part 16: Physical (mechanical) filtration1)

Wastewater treatment plants - Part 16: Physical (mechanical) filtration

1. Scope

This Standard specifies design principles and performance requirements for tertiary clarification (receiving effluent from secondary treatment) by physical filtration plant at wastewater treatment plants serving more than 50 PT.

2. Normative references

The following referenced documents are indispensable for the application of this Standard. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

KS 2766, Wastewater treatment — Vocabulary

KS 2767–1, Wastewater treatment plants — Part 1: General construction principles

KS 2767–10, Wastewater treatment plants — Part 10: Safety principles

3. Terms and definitions

For the purposes of this Standard, the terms and definitions given in KS 2766:1997 and the following apply.

3.1.
granular media
filter bed of filter media which is submerged in either an upflow or downflow of effluent to remove solids within the bed

3.2.
drum filter or microstrainer
cylindrical sieve or cloth filter which rotates about a horizontal axis and is partially-immersed in a horizontal flow of effluent to remove solids

4. Requirements

4.1. General

Physical filtration processes may include the following:

- granular media filters;
- sieves such as microstrainers and drum filters.

Filter processes are used to remove fine suspended solids from treated wastewater by mechanical filtration. Where aeration is involved, it is normally limited to air scouring to remove solids accumulation trapped by filtration. Physical filters may also be designed to remove phosphate.

4.2. Process types

4.2.1. Granular media filters

4.2.1.1. Static bed filter

An upflow or downflow of effluent percolates rapidly through a bed of filter media trapping solids within the bed. For shallow bed and downflow filters, solids are predominantly captured at the surface. The rate of filtration is high causing a rapid accumulation of solids in the bed and a high rate of increase in headloss. At regular intervals a bed shall be taken out of service and washed using filtered effluent with or without air scour to remove accumulated solids. Washing can be affected by either a pumped or siphonic upflow of filtered effluent across the entire bed or by a travelling bridge washing individual compartments.

4.2.1.2. Moving-bed filter (continuous operation)

In this type of filter, an upflow or downflow of effluent passes continuously through a bed of mineral media to remove solids. An air lift raises mineral media from the bottom of the bed for washing and returns cleaned media to the top of the bed, enabling continuous filtration.

4.2.2. Microstrainers and drum filters

Microstrainers and drum filters are based on a sieve or cloth covered cylinder rotating horizontally about the longitudinal axis. The cylinder is suspended in a tank to which the effluent to be filtered is supplied. Drum filters are partially or completely submerged in the effluent to be filtered, whilst a microstrainer cylinder is only immersed to about two thirds of its diameter. In microstrainers the liquid flow is from inside to outside the cylinder. In drum filters the liquid flow is from the outside to inside the cylinder.

For a microstrainer, backwash nozzles situated vertically above the rotating cylinder, direct effluent onto the upper cylinder surface and dislodge trapped solids into a trough within the rotating cylinder. For a drum filter a backwash pump with nozzles situated laterally and close to the filter cloth surface induces flow of filtered effluent back through the cloth against the main flow of the wastewater. The flow of filtered effluent dislodges trapped solids which are then pumped away from the equipment. Drum filters generally do not rotate except when backwashing takes place.

5. Planning

The choice of physical filtration process depends on the size of the treatment plant, space available, the type, quality, quantity and variability of effluent to be treated, the final quality of effluent required, and the frequency of maintenance that is required for the process.

Physical filtration may be used to supplement efficient secondary solids separation.

The following factors shall be considered in design:

- type and efficiency of secondary treatment and clarification processes;
- capacity and dimensions of the filtration plant;
- quality required for treated effluent;
- Final destination of the treated effluent
- range and variation in hydraulic or suspended solids loads;
- prevention of dead zones and detrimental deposition in tanks or channels;
- establishment of multiple units or other technical means to ensure maintenance of required final effluent quality if one or more units are out of operation;
- final destination of the liquors generated from backwashing;
- head loss to be minimised;
- measurement and control;
- media specification;
- tests to determine the required dimensions of filter media or cloths.

6. Process design

6.1. Design parameters

The following operational parameters shall be considered and values shall be selected which are appropriate for the required level of treatment:

- surface loading rate required ($m^3/m^2 \times h$);
- suspended solids load (kg/h);
- pore or media size;
- maximum wash water requirement as a percentage of the treated flow rate;
- frequency of backwashing to maintain filtration rate;
- disposal route for backwash liquors;
- control of influent flows to the treatment process during washing;
- control of excessive instantaneous wash water flow rates.
-

6.2. Selection of filter media

6.2.1. General

Filter media should have an extensive surface area with narrow pores or channels designed to flocculate and trap suspended solids, and to allow effluent flow with minimum head loss. The filter media shall be capable of being cleansed through some form of backwashing or scouring.

Influents to the filters include varying proportions of colloidal to non-colloidal suspended solids. Microstrainers can be less suited to removal of colloidal material than other processes.

Filterability tests should be carried out and the required effluent quality shall be considered before making a choice of process for physical filtration.

The following factors shall also be considered in choice of media:

- design life;
- quality of influent;
- requirements for replacement;
- ease of replacement;
- durability to withstand weathering and exposure to sunlight
- durability to withstand weathering and exposure to sunlight where applicable;
- durability to withstand corrosion and chemical attack;
- non-biodegradability;
- ease of cleaning by backwashing;
- resistance to abrasion during backwashing;
- pore sizes.

6.2.2. Granular media filters

Filter media can be made from the following materials:

- graded mineral;
- Carbon
- synthetic material of regular size and shape and randomly arranged.

The filter media should have a spherical shape and narrow size distribution to form a bed with a high porosity, and smooth surface to enable efficient washing.

The particle size distribution, shape for the materials constituting the bed and also the depth of the bed shall be selected taking account of the effluent to be treated and the desired filtrate quality requirements. For filters which contain shallow beds (0.3 m to 0.5 m deep) of dual media, typical particle size distributions are between 0.5 mm to 0.8 mm and 0.6 mm to 1.2 mm. For both static and moving-bed filters with deep beds (1.0 m to 3.0 m) of dual media, typical particle size distributions are between 1.0 mm to 2.0 mm and 2.0 mm to 4.0 mm.

For filters constructed with a bed of multilayer media, the types of media shall have sufficient difference in specific gravity to ensure segregation of each type into separate material layers. This will enable solids penetration into the full depth of the bed through the channels between elements of media and thus 3 Microstrainers and drum filters

Sieves of microstrainers can be made of stainless steel or synthetic mesh. Drum filters can be made of cloth fabric over a perforated drum. The mesh for microstrainers is available in pore sizes ranging from 65 µm to 15 µm.

6.3. Cleaning systems

6.3.1. General

During physical filtration, the bed or sieve becomes laden with retained solids clogging channels between elements of the bed or sieve which increases head loss and impairs filtrate quality. Affected media shall be washed for efficient operation of the filter but backwash systems should use less than 10 % of the average daily flow to avoid imposing an excessive additional hydraulic load on the treatment works.

When a treatment unit is taken out of service, the other units should be capable of taking the extra load and be capable of maintaining the required operational efficiency. Where backwashing is not continuous a balancing tank for sludge liquors should be provided.

6.3.2. Granular media filters

Backwashing is carried out using treated effluent often assisted with air to scour the bed. Treated effluent for backwashing should be stored in a tank. Backwashing is carried out on a time interval or head loss basis. When carried out on a time interval basis, backwashing shall also be initiated if head loss exceeds a critical level to prevent the treatment unit being by-passed.

A backwashing programme is necessary as air and backwash water may be used separately or in combination during separate phases of the backwashing process. The programme for a multi-layer filter shall achieve both the cleaning of the bed and classification of individual filter layers. With a moving-bed filter such a programme is not necessary as a portion of the filter media is transferred to a separate washing system.

The intensity of washing used for static and moving-bed filters shall be sufficient to minimise the growth of biological slime on elements of media which would reduce their effective specific gravity and cause their loss in the filtered effluent overflow.

6.3.3. Microstrainers and drum filters

Factors which shall be considered in the design of the backwash system include the following:

- optimum pressure across the sieve or cloth;
- amount of filtrate used for backwashing;
- controls on rotation speed or backwash pump operation;
- resistance of the drum filter backwash pump and pipework to solids clogging;
- angle of inclination of the microstrainer backwash drainage trough;
- equipment required for periodic intensive cleaning of the microstrainer mesh, which can include the use of chemical or steam cleaning;
- type and design of nozzles used for backwashing to minimise blockages;
- measures to reduce slime growth, e.g. UV lamps; Use of chemical disinfection that can affect effective micro-organisms in the system is discouraged.
- operational limits e.g. head loss, volume or frequency of backwash before the need for intense cleaning or filter cloth replacement.

For drum filters, the cloth should be replaced at regular intervals to maintain adequate filtration rate.

6.4. Dimensions

6.4.1. General

The number of units and their dimensions shall be determined to meet the overall plan area requirements of the plant taking into account the criteria of this clause, along with those of 6.4.2 and 6.4.3:

Results from the filterability tests may be used to provide guidance on the loading rates which may be applied to the equipment.

The total hydraulic retention time of the unit processes shall be considered.

6.4.2. Granular media filters

Granular media filters are either rectangular or circular. Rectangular units should normally have an aspect ratio greater than 2:1 to ensure sufficient crossflow velocity to minimise solids deposition during washing. Depths of filter media can be from 0.3 m to 0.5 m for shallow beds and from 1 m to 3.0 m for deep beds.

Moving-bed filters are usually circular with typical diameters from 2 m to 4 m. Bed depths may be 1 m to 2.5 m.

The height of the retaining wall shall be sufficient to hold the expanded bed during backwashing. In addition, for downflow units, the height of the retaining walls or overflow above the top of the bed of media shall ensure that a sufficient depth of effluent is held above the bed to provide the desired filtration rate.

NOTE There should be at least three beds to allow one bed to be taken out of service for maintenance, one bed to be cleaned and one bed to be filtering. For moving-bed filters there should be at least two units to give standby capacity in the case of failure.

6.4.3. Microstrainers and drum filters

The drum of a microstrainer is usually 1 m to 4.5 m in diameter and up to 9 m long. Drum filters can be of similar size. The rotation speed at the circumference typically has a maximum of 0.5 m/s, or 2 rpm to 4 rpm.

NOTE Normally at least two units should be installed to give standby capacity in case of failure.

6.5. Flow distribution

6.5.1. General

Physical filtration plants shall allow a uniform distribution of flow passing through the filter media.

The design of plants shall take into account the method of distributing effluent into a filter and withdrawing filtered effluent. For plants fitted with backwashing systems the design shall take into account the following:

- method of collecting filtered effluent for backwashing;
- distribution of effluent and scouring air (if required) during backwashing;
- storing dirty wash water for continuous re-injection back to the wastewater treatment plant to minimise its effect on overall plant performance.

When the process involves multiple lines or parallel units, the incoming flow shall be distributed by an adjustable distribution device (for example, valve, gate, plug), that can also be used to isolate each treatment unit. This device should provide the required flow distribution over the range of flow rates considered.

6.5.2. Granular media filters

For granular media filters the inlet arrangement shall allow flow over the surface of the bed with as little disturbance as possible to the elements of media. Distribution of influent flow can be provided by a weir channel or perforated pipe.

Filter beds should be held on either a suspended floor perforated with nozzles or tiles, through which filtered effluent drains in downflow units or influent enters in upflow units.

For upflow filters, the outlet arrangement shall either allow flow of filtered effluent over the surface of the bed with as little disturbance as possible to the elements of media or shall have a retaining device to prevent loss of media (e.g. buoyant plastic) into the flow of filtered effluent.

6.5.3. Microstrainers and drum filters

For drum filters, arrangements for collection and removal of flocculated solids which can be deposited at the base of the unit shall be considered.

6.6. Construction principles

6.6.1. General

The plant and equipment shall be constructed in accordance with the requirements of KS 2767-1 and designed so as to withstand all potential mechanical stresses of operation. This shall include differential forces as a result of emptying or refilling the equipment with wastewater or during backwashing. Automatic cut-off or diversion devices should be installed to protect the equipment from excessive mechanical or hydraulic loads.

The structures shall be designed to allow draining either by gravity flow or by pumping. Drainage shall not affect the stability of structures, irrespective of the groundwater level. It can be useful to slightly incline the receiving tank floor (not filter floor) to the lowest drainage points. When a pump is used for drainage a drain pit should be built into these low points.

Fixed and moving parts of filtration plant are submerged in effluent or filtered effluent. The choice of all parts shall be made with regard to chemical and electrolytic corrosion. Parts which can require maintenance or replacement should be designed with regard to minimising the need for dismantling or operator access.

6.6.2. Granular media filters

The structural design of the walls and the base shall be watertight and withstand the hydraulic pressure if the tank is full of effluent. Tanks should be open-topped to facilitate inspection.

Consideration shall be given to the installation of a chamber to hold filtered effluent for washing and a separate chamber to hold liquors generated from washing the media.

6.6.3. Microstrainers and drum filters

Durability, operation, maintenance and access for replacement of the following parts shall be considered:

- cylinder shaft bearings;
- cylinder end seals;
- load bearing or stabilising wheels if present;
- cylinder driving gear;
- cloth or sieve plate replacement.

For microstrainers the following factors shall be considered:

- sides of the backwash hopper should be at an angle of not less than 55° from the horizontal;
- backwash nozzles should be self-cleaning, and replaceable;
- UV lamps used to restrict microbial growth should be readily replaceable;
- equipment required to supply chemical cleaner to the backwash nozzles and microscreen.

For drum filters the following factors shall be considered:

- filter cloth fixings;
- backwash pump, nozzles and pipelines;
- solids withdrawal from the tank base.

6.7. Mechanical and electrical equipment

6.7.1. General

All electro-mechanical equipment and its installation shall comply with KS 2767-1.

Instrumentation should include indicators for the state of operation of the following:

- pumps;
- drive motors;
- level sensors;
- pressure sensors.

Unless otherwise agreed the design service life of the equipment should be at least:

- class 4 for gears and bearings;
- class 3 for all electrical motors.

6.7.2. Granular media filters

Granular media filters should have a minimum backwash rate of 30 m^3/m^2 x h and a minimum air scour rate of 0.5 m^3/m^2 x min to ensure adequate cleaning.
Washing is usually automated and can be initiated at a predetermined head loss across the bed, by water level indicator, or at set time intervals.

6.7.3. Microstrainers and drum filters

The pressure shall be sufficient to remove solids and minimise backwash volume. Backwash water pressures should be between 100 kPa to 350 kPa.

Control systems are linked to the differential head across the rotating cylinders. For drum filters a high liquid level sensor can operate the backwash pump. For microstrainers a high liquid level sensor can increase the speed of cylinder rotation.

6.8. Performance monitoring

Provisions should be made to allow for:

- sampling of the wastewater influent and effluent.
- flow measurement through the process;
- head loss measurement;
- controlling of backwash frequency.

6.9. Additional considerations

6.9.1. Maintenance

Factors which shall be considered for safe inspection and maintenance include:

- suitable lifting points on individual parts;
- size and position of access ports or hatches to the equipment;
- frequency of maintenance;
- complexity of maintenance tasks.

Aids to regular inspection and maintenance shall be considered. Parts which need regular inspection can include the following:

- filter fabric;
- pumps;
- water jets;
- bearings;
- drive units;
- drum seals.

6.9.2. Protection of the equipment

The equipment should be protected from excessive loads, for example by the use of overflow devices and surge/overload protectors.

6.10. Hazard protection

The health and safety requirements as specified in KS 2767-10 shall be fulfilled.

.