

Sewerage —

Part 2: Guide to pumping stations and pumping mains

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Committees responsible for this British Standard

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- Water Research Centre

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- British Effluent and Water Association
- British Pump Manufacturers' Association

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Foreword

This British Standard has been prepared under the direction of the Civil Engineering and Building Structures Standards Committee and is directed at general engineering practitioners who may either be embarking on a career in sewerage or be dealing with a particular aspect for the first time. It is not intended to be exhaustive in any field but sets out to present guidance on basic principles and good practice, indicating where a more detailed and comprehensive study may be made. BS 8005 supersedes and enhances CP 2005:1968, which is withdrawn, although some of the material incorporated is a restatement or a revision of the earlier text.

BS 8005 gives guidance on the planning, design, construction, operation and maintenance of works to convey sewage, including storm sewage, surface water and trade effluents to a sewage treatment works, tidal waters or other final place of disposal. Recommendations are given for the repair, renovation and replacement of sewers.

Many end users of this British Standard, such as governments, public authorities, sewerage authorities and consultants, issue their own recommendations and specifications for sewerage which BS 8005 is intended to complement rather than replace.

BS 8005-0 directs the reader to sources of more detailed information, particularly on important and specialized fields such as health and safety. It should be regarded as supplying essential background information for the other Parts of BS 8005.

BS 8005 is to be published in six separate Parts, as follows.

- *Part 0, Introduction and guide to data sources and documentation;*
- *Part 1, Guide to new sewerage construction;*
- *Part 2, Guide to pumping stations and pumping mains;*
- *Part 3, Guide to sewers in tunnel¹⁾;*
- *Part 4, Guide to design and construction of outfalls;*
- *Part 5, Guide to rehabilitation of sewers¹⁾.*

It has been noted that substantial one-part codes and guides take a long time to revise and if they are reviewed at infrequent intervals, they tend to become out of date quickly, especially in a field where technological development is rapid. It is intended therefore to keep a constant watch on new developments and to update BS 8005, Part by Part, as soon as the work can be justified.

BS 8301 sets out recommendations for building drainage and, while it relates generally to smaller pipelines, there is some overlap between it and BS 8005. BS 6297 gives recommendations for the design and installation of small sewage treatment works and cesspools.

Apart from Part 0, which is directed more specifically at the UK sewerage field, BS 8005 is for use both in the UK and, in appropriate circumstances, overseas.

Suggestions for the improvement of any Part of BS 8005 will be welcomed by the Secretary of CSB/5 at 2 Park Street, London W1A 2BS.

A British Standard does not purport to include all the necessary provision of a contract. Users of British Standards are responsible for their correct application.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 18, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

¹⁾ In preparation.

Section 1. General

1 Scope

This Part of BS 8005 provides guidance on the components, appliances and design of pumping stations and pumping mains.

NOTE The titles of the publications referred to in this standard are listed on the inside back cover.

The titles of British Standards not referred to in this Part of BS 8005 but of interest as dealing with closely associated subjects are listed in Appendix A of BS 8005-1:1987.

Other publications that may be of interest are listed in Appendix B of BS 8005-1:1987.

2 Definitions

For the purposes of this Part of BS 8005 the definitions given in BS 8005-0 apply.

3 Abbreviations

For the purposes of this Part of BS 8005 the abbreviations given in BS 8005-1 apply.

Section 2. Range of components and appliances

4 General

The type and size of sewage pumping stations and equipment depend upon their duties, location and any special operational requirements, such as remote or automatic control. This section covers the main range of components, whilst methods of installation and housing are dealt with in section 3.

Components and appliances are required to be reliable, robust, easy to maintain and appropriate for pumping water and other liquids. In addition, the aggressive nature of sewage, with its variable solid content and possibility of toxicity and explosive gases, calls for a high degree of caution and the adoption of the latest safeguards to meet all possible hazards.

5 Pumps

5.1 General

Pumps for handling sewage should be unchokeable and wear resisting. They may be divided broadly into four groups: rotodynamic; reciprocating; pneumatic and Archimedean screw. (See also BS 6297.)

5.2 Rotodynamic pumps

Rotodynamic pumps are relatively cheap to buy, of small overall dimensions in relation to capacity, light in weight and can be arranged vertically or horizontally. They may vary from moderate to high efficiency according to the size of the pump, type of impeller and the head/quantity characteristic of the duty to be performed. All types of rotodynamic pumps afford a high degree of flexibility. Both quantity and head can be varied by changing the speed and/or diameter of the impeller.

When two or more pumps are required to discharge in parallel to a common rising main the head/quantity characteristics should be studied in order to obtain stable conditions and a good overall efficiency.

This important group of pumps is divided into three types.

- a) *The centrifugal pump.* The capacity of traditional dry well centrifugal pumps for reasonably economic working may vary from a minimum of about 7 L/s up to 700 L/s and more, with heads varying from 3 m to about 45 m. With small to medium capacities the pump should be of the unchokeable type wherein any solid, up to a maximum of about a 100 mm sphere, that may enter the pump suction will be passed through the pump.

The recessed impeller type of centrifugal pump (also called vortex or torque flow pumps), although of lower efficiency, is less likely to be affected by fibrous material and can be easier to open up for maintenance.

Submersible centrifugal sewage pumps are available for a similar range of duties, either as stationary submerged units or as transportable submersible installations. They are self-priming with both pump and motor totally submersible and are accordingly suited for use in wet wells or in dry wells where there is a flooding risk.

Cooling is a problem in a dry well and special design precautions may be necessary. The discharge connection of the pump is adaptable for either a flexible hose or static pipework, and the electric motors are available certified for use in a hazardous area in accordance with BS 5345.

For wet well installations submersible centrifugal pump units are available which will slide down guides and seat automatically on the permanent discharge connection. The weight of the pump forces the mating flanges into contact thus providing a seal on the discharge side.

Centrifugal disintegrator pumps may be used to assist the treatment of the sewage. Running and maintenance costs are higher, especially if they are on a combined sewerage system where there is a high content of grit in the sewage.

- b) *The mixed flow pump.* The mixed flow pump is more efficient where the volume of sewage to be pumped is large and where the head lies in the range of 6 m to 18 m.

- c) *The axial flow or propeller-type pump.* The axial flow pump is suitable where large volumes of sewage have to be pumped against low heads.

The above pump classifications are generalized and, in particular, the mixed flow design of impeller overlaps the head ranges of both axial and straight centrifugal pumps. Many modern design unchokeable pumps have mixed flow impellers but are of relatively low efficiency. High efficiency centrifugal pumps, mixed flow pumps and axial flow pumps should only be installed in association with preliminary screening or the reduction of the coarser suspended solids.

For very small flows a small high efficiency centrifugal pump can be used as part of a sewage diverter where the coarser solids are prevented from passing through the pump.

5.3 Reciprocating pumps

The reciprocating pump is heavy and of large dimensions in relation to its capacity. It is reliable, efficient when first installed, and is capable of operating with a high suction lift and of discharging against very high heads. It is susceptible to choking, heavy wear and tear, and loss of efficiency through wear and valve jamming. The reciprocating pump may be either of single-acting or double-acting type. Reciprocating pumps are more expensive in first cost than other types. They are expensive to maintain and therefore are rarely used for pumping crude sewage. Preliminary screening of sewage to remove large solids is advisable.

As a safeguard against excessive pressure a bypass is often provided between delivery and suction. This should be combined with a pressure relief valve. An alternative is to relieve the discharge to the suction well.

A reciprocating pump requires a slow speed drive; this is provided through gearing between the prime mover and the pump. A steady rated discharge is maintained over a wide variation in head. Discharge is altered by varying the speed.

5.4 Pneumatic pumps

The pneumatic ejector, whether of the automatically filled vessel or the air lift type, is suitable where reliability and ease of maintenance are of greater importance than overall efficiency, and where a small quantity of sewage is to be pumped against a relatively small head.

The installation usually comprises an ejector together with an automatic self-starting air compressor, with provision for air storage. In special situations two ejectors should be provided to facilitate repairs; where breakdown would have serious results, a second air compressor should be provided. It is possible to serve several ejector stations from one central air compressing station if the distances are not too great.

5.5 Archimedean screw pumps

Archimedean screw pumps are basically screws revolving at a fixed speed. They provide a steady rate of pumping and high efficiency over a wide range of flows and are also effective in pumping varying flows. They are suitable for lifting large volumes of unscreened sewage or storm water against low heads.

The actual volume lifted for any particular diameter is dependent on the speed of rotation and on the angle of inclination; the greater the angle the less the rate of discharge. The angle of inclination varies from a minimum of 27° to the horizontal to a maximum of 40°. The preferred angle is 38°.

Archimedean screw pumps are in two main groups, namely open-screw and encased-screw. Neither group requires a deep sump. While the open-screw types are virtually unchokeable, in certain applications it is advantageous to install a coarse bar screen at the inlet to prevent large objects, such as baulks of timber, from entering the screw. A higher degree of protection is required for the encased-screw pumps.

Capacities of Archimedean screw pumps cover a very wide range varying, depending on diameter and inclination, from 7 L/s up to about 10 000 L/s.

6 Prime movers and drives

6.1 General

The prime movers normally employed for driving sewage pumping plant are electric motors and internal combustion engines (diesel, dual fuel or petrol). They should be suitable for the types of pumps selected and rated for operational conditions. The choice may depend upon the availability of electricity or a fuel supply. Due consideration should be given to capital, running and maintenance costs in selecting either electricity or fuel, together with the effect of possible interruption of supply from outside influences such as shortage, mechanical breakdown and supply difficulties.

Where necessary, explosion-proof units should be used. Fire detection and alarm systems in all buildings should comply with BS 5839-1.

Electricity is normally adopted as the cleanest and most convenient form of motive power. In the UK 415 V 3-phase supply is normal for motors up to about 150 kW to 200 kW, whilst 3.3 kV or higher voltage is often used for larger motors. Direct current (d.c.) drive is occasionally adopted, either by rectifying from the a.c. grid supply or by local generation from internal combustion engines.

Standby electricity supply in case of breakdown is frequently provided by a second feeder from a different substation or by switching to diesel generating plant situated locally or mounted on a vehicle.

6.2 Electric motors

The electric motor is a convenient, cheap and reliable prime mover for all types of sewage pumping. Varieties of electric motor are available to suit the particular conditions of duty to be performed.

As automatic controls have been developed to a high degree of reliability, an electric motor is particularly suitable for an unattended automatically operated station.

The following are the more usual types of electric motor used for sewage pumping.

a) *Squirrel cage induction motor*. This type of motor is the simplest and most robust in design for use on alternating current (a.c.) supplies. It is commonly used for single speed applications but can be wound for multi-speed operation, dual speed windings being fairly common. Other motor speed variations are available.

Starting the motor direct on line demands a high starting current from the supply, and other methods of starting such as star-delta, autotransformer, or electronic soft start, may have to be considered in order to reduce the high starting current from the supply (and its cost) and satisfy the requirements of the supply authority.

Care should be taken when selecting reduced current methods of starting that the motor accelerating torque matches the pump characteristics.

This type of motor is suitable for electronic methods of speed control.

Many types of power electronic drive equipment are available to enable the squirrel cage induction motor to be considered as an alternative to motors under items b), c) and d).

The main types are as follows:

- 1) voltage controlled invertors;
- 2) current controlled invertors;
- 3) pulse width modulated invertors;
- 4) variable voltage at constant frequency.

b) *Wound rotor induction motor*. This type of motor has a wound rotor and can have a lower starting current than the squirrel cage motor. It is suitable for speed control by means of external resistors, usually contained in the control equipment. It is normally only used where the speed control is small and applied for short periods. The motor efficiency is less at reduced speeds.

c) *Synchronous induction motor*. This type of motor runs at a fixed speed independent of the load, the speed being determined by the frequency of the supply and the number of poles in the motor.

Normally it has good efficiency and power factor and may attract favourable terms from the supply authority. However, a separate d.c. supply is required for exciting windings and the starting performance is poor.

d) *Direct current motor*. The d.c. motor may be used with advantage for variable speed applications. Starting methods are simple and it has a good starting performance and high efficiency over a wide range of duties. However, maintenance and prime cost are more expensive than with a.c. motors.

Where a wide range of pumping duties is required, it may be more economical in respect of capital and/or energy costs to use motors with two (or possibly three) speeds or a larger number of constant speed pumping units controlled in an optimum sequence depending on flow or level control strategy.

6.3 Internal combustion engine

The following are the more usual types of internal combustion engine.

a) *Diesel engine*. The diesel engine is a reliable, efficient type of prime mover. The medium and slow speed units generally have longer lives and are heavy; they require heavy foundations and relatively more space. The high speed units are efficient, compact and light but generally have a shorter life; they are not so expensive (in capital costs), nor do they require heavy foundations. High speed units are, however, often noisy.

The slow and medium speed units can be operated automatically but they usually need the regular attendance of a skilled staff. High speed units are suitable for automatic operation, but need more highly skilled maintenance to ensure reliability.

b) *Dual fuel engine*. Sewage gas, a by-product of sewage purification, is an economical fuel for dual fuel engines. These engines can also be operated efficiently on diesel.

c) *Petrol engine*. The petrol engine is rarely adopted as a form of prime mover at a permanent sewage pumping station owing to the comparatively high cost of fuel and maintenance. Portable pumps are sometimes powered by petrol engines.

Suitable arrangements should be made for the safe handling of flammable liquids and for the safe ventilation of combustion products, particularly where mobile plant is involved.

6.4 Drives

Electric motors (either horizontally or vertically mounted) and internal combustion engines can be arranged to drive most types of pumps, by one of the following means.