

Measurement of liquid flow in open channels —

**Part 11: Free surface flow in closed
conduits —**

Part 11A: Methods of measurement

Committees responsible for this British Standard

The preparation of this British Standard was entrusted by the Industrial-process Measurement and Control Standards Policy Committee (PCL/-) to Technical Committee PCL/3, upon which the following bodies were represented:

- Clyde River Purification Board
- Department of the Environment
- Department of the Environment for Northern Ireland
- Institute of Measurement and Control
- Institution of Water and Environmental Management
- National Rivers Authority
- Water Services Association of England and Wales
- Welsh Office

The following bodies were also represented in the drafting of the standard, through subcommittees and panels:

- British Hydrological Society
- British Water Industries Group
- GAMBICA (BEAMA) Ltd.
- Water Research Centre

This British Standard, having been prepared under the direction of the Industrial-process Measurement and Control Standards Policy Committee, was published under the authority of the Standards Board and comes into effect on 15 October 1992

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National foreword

This Part of BS 3680 has been prepared under the direction of the Industrial-process Measurement and Control Standards Policy Committee. It is identical with ISO/TR 9824-1:1990 *Measurement of free surface flow in closed conduits — Part 1: Methods*, published by the International Organization for Standardization (ISO).

This standard is one of a series of Parts of BS 3680-11 on the free surface flow in closed conduits. Part 11B describes the equipment for measurement of free surface flow in closed conduits, and Part 11C describes methods of measurement and equipment.

Cross-reference. The Technical Committee has reviewed the provisions of ISO 772:1988, to which normative reference is made in the text, and has decided that they are acceptable for use in conjunction with this standard. A related British Standard to ISO 772 is BS 3680-1:1983. BS 3680-1 has since been revised, and is now published as BS 3680-1:1991. A revision of ISO 772 is in preparation. The introduction to ISO/TR 9824-1 reads as follows.

“The measurement of fluid flow and level in partially filled closed conduits presents particularly difficult problems and is not fully documented. This part of ISO/TR 9824 has been prepared therefore to give guidance to users on the existing methods employed and on recent developments in this field.

The measurement of free surface flow in closed conduits is analogous to normal gauging in open channels, and thus open channel gauging techniques may be applied to free surface flows in closed conduits. Closed conduits may be classified as

- a) foul (sanitary), where only domestic and industrial waste are conveyed in the conduit,
- b) storm, where, following a rainstorm, run-off from impermeable areas is conveyed to the nearest watercourse,
- c) combined, where both domestic and industrial waste together with storm run-off are contained in one conduit, and
- d) culvert, where the watercourse is conveyed under a road, railway, etc.

The purpose of closed conduit systems types a), b) and c) is to remove waste products from urban areas to a site where treatment (mechanical, chemical and/or biological) can be undertaken. The cheapest way of conveying sewage in a conduit is by laying the conduit so that it follows the natural topography, while providing sufficient gradient where necessary so that sewage will not stagnate but will flow under gravity. In very flat areas conduits may have to be laid at great depths to attain a sufficient hydraulic gradient, or alternately, if they are laid at shallow depths, pumping/lifting stations may have to be incorporated.

At times of heavy rainfall, systems of type b) may become surcharged (i.e. full pipe flow). Therefore, overflows are constructed to convey the excess water to the nearest watercourse or storage area, thus relieving the surcharge and avoiding the chances of surface flooding.

Conduits may be constructed as closed or open, and may be made of various materials such as vitreous clayware, concrete, asbestos cement, cast iron, brick and, more recently, plastic and resin-bonded materials. They may range in diameter from 150 mm upwards, although it is rare, except in large cities, to have conduits greater than 3 m in diameter.

Sewage consists of floating and suspended solids and may contain effluents of a corrosive nature. In addition, the atmosphere within the closed conduit system may contain both inflammable and corrosive gases. Thus the total environment within the closed conduit system may be described as hostile.

A flow-meter will have to operate in these hostile conditions over a wide range of flows, from free surface open channel flow to conduit full pressure flow. The nature of urban drainage is such that steady flow conditions are rare except near the outfall from large catchment areas where flow attenuation has occurred. Non-uniform flow also occurs as a result of bends, junctions and displaced joints. The access to any closed conduit system is limited to the outfall or to specially built access points (i.e. manholes). Manholes are sited at irregular intervals where the sewer changes in direction or gradient or at a junction. These sites are hydraulically unsatisfactory for discharge measurement. Within the channel at a manhole an additional difficulty may be encountered when the depth of flow is above half-pipe full as the construction of the manhole frequently allows for benching to enable workmen to stand within the manhole. When the depth of flow rises above half-pipe full, the change in cross-sectional area of the closed conduit is discontinuous.

It is recommended that in deep conduits a platform or gallery be constructed at vertical intervals of 10 m. This is for safety reasons when ascending and descending into manholes. Thus, the sensing and recording elements need not be more than 10 m apart, but they must be capable of withstanding inundation."

Textual error. Since adopting the text of the International Standard, the textural error given below has been discovered. It has been reported to ISO in a proposal to amend the text of the International Standard.

In clause 4.2.2.2 the Colebrook-White formula is incorrect. Delete the equation as presented, and substitute the following.

$$\bar{v} = - \sqrt{32g_n R_h S} \log_{10} \left(\frac{k}{14,8R_h} + \frac{1,255\gamma}{R_h \sqrt{32g_n R_h S}} \right)$$

Where

- g_n is the acceleration due to gravity;
- k is the roughness height;
- R_h is the hydraulic radius;
- S is the energy gradient;
- $\bar{v}$ is the mean velocity;
- γ is the kinematic viscosity of the fluid.

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

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Summary of pages

This document comprises a front cover, an inside front cover, pages i and ii, pages 1 to 6, 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.