# TECHNICAL REPORT

# ISO TR 9824-2

First edition
1990-05-15

## Measurement of free surface flow in closed conduits —

## Part 2: Equipment



*Mesurage du débit des écoulements à surface dénoyée dans les conduites fermées —*

*Partie 2: Matériels*



Reference number
ISO/TR 9824-2:1990(E)

## Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

The main task of technical committees is to prepare International Standards, but in exceptional circumstances a technical committee may propose the publication of a Technical Report of one of the following types:



— type 1, when the required support cannot be obtained for the publication of an International Standard, despite repeated efforts;



— type 2, when the subject is still under technical development or where for any other reason there is the future but not immediate possibility of an agreement on an International Standard;

— type 3, when a technical committee has collected data of a different kind from that which is normally published as an International Standard ("state of the art", for example).

Technical Reports of types 1 and 2 are subject to review within three years of publication, to decide whether they can be transformed into International Standards. Technical Reports of type 3 do not necessarily have to be reviewed until the data they provide are considered to be no longer valid or useful.

ISO/TR 9824-2, which is a Technical Report of type 2, was prepared by Technical Committee ISO/TC 113, *Measurement of liquid flow in open channels*.

ISO/TR 9824 consists of the following parts, under the general title *Measurement of free surface flow in closed conduits* :

— *Part 1: Methods*

— *Part 2: Equipment*



International Organization for Standardization
Case Postale 56 • CH-1211 Genève 20 • Switzerland

Printed in Switzerland

Annex A of this part of ISO/TR 9824 is for information only.

## Introduction

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 equipment employed and on recent developments in this field.

Efficient and effective engineering design requires accurate and reliable flow information. The flows in closed conduits may vary from zero through a free surface flow condition to a surcharged pipe-full condition, and they may contain both floating and suspended solids as well as other contaminants which may be highly corrosive (e.g. contaminants resulting from industrial processes). The determination of flows in these conditions demands the design of specialized equipment. This part of ISO/TR 9824 sets out the performance specifications for such equipment.

# Measurement of free surface flow in closed conduits —

# Part 2:
Equipment

## 1 Scope

This part of ISO/TR 9824 specifies performance requirements of equipment for the determination of free surface flow in closed conduits. It identifies the conditions within which such equipment is required to operate and specifies the level of uncertainty and reliability of measurement which the equipment is expected to meet.

This part of ISO/TR 9824 is applicable to conduits having an internal cross-sectional area greater than 0,018 $m^2$ (e.g. circular conduits of diameter greater than 150 mm).

It is not applicable to the measurement of flows in closed conduits which normally operate under pressure as the result of pumping.

This part of ISO/TR 9824 should be used in conjunction with ISO/TR 9824-1.

## 2 Normative reference

The following standard contains provisions which, through reference in this text, constitute provisions of this part of ISO/TR 9824. At the time of publication, the edition indicated was valid. All standards are subject to revision, and parties to agreements based on this part of ISO/TR 9824 are encouraged to investigate the possibility of applying the most recent edition of the standard indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 772:1988, *Liquid flow measurement in open channels — Vocabulary and symbols.*

## 3 Definitions

For the purposes of this part of ISO/TR 9824, the definitions given in ISO 772 and the following definition apply.

**free surface flows in closed conduits:** Flows within closed conduits, under the influence of gravity only, and normally having a free surface.

NOTE 1 Where the total discharge exceeds the free surface capacity of the conduit, i.e. the conduit is surcharged, the free surface of the flow disappears.



## 4 Characteristics of the closed conduit system

### 4.1 Structure of the closed conduit system

The general configuration of a closed conduit system is shown in figure 1.

A closed conduit is typically located underground but in certain instances may be above the ground surface. Systems constructed underground typically incorporate means of access through a man-sized shaft (i.e. a manhole) which is sealed at the surface by a heavy but removable cover. For the purposes of this part of ISO/TR 9824, it is assumed that such access is available only at certain times.

Access shafts may be provided at frequent intervals along the length of the conduit at a spacing of perhaps 200 m to 400 m. It is normal practice to locate access shafts or other shafts at points of structural change in the conduit system, such as bends or junctions or where, for some reason, inspection or entry to the system may be required.

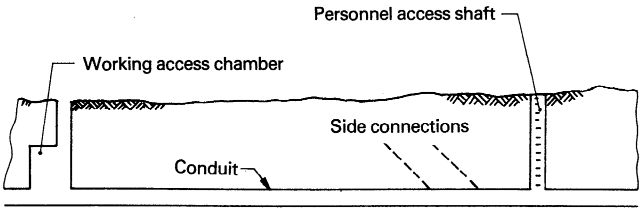


**Figure 1 — Closed conduit system**

## 4.2 Construction of the closed conduit

### 4.2.1 Cross-sectional shape

Closed conduits are most commonly circular or rectangular in cross-section, but they may be ovoid, horseshoe, squarebox or triangular.

### 4.2.2 Materials and surface characteristics

The conduit may be constructed in solid rock or of dry stone, brick, concrete, metal (e.g. steel), asbestos cement, earthenware, plastic, resin-bonded fibre, pitch fibre, or a combination of these materials. The surface of the conduit may be rough owing to deterioration, or organic growths or deposits, and may exhibit cracks, holes, nodules, wash-outs and other imperfections.

## 4.3 Flow conditions in the closed conduit

### 4.3.1 Hydraulics

Closed conduits are so designed and constructed to produce a self-cleaning velocity that prevents the deposition of solid matter in the invert. Thus flow is predominantly turbulent and subcritical.

### 4.3.2 Fluid properties

Flows in closed conduits may range from clear water, free from contaminants, to liquids containing both suspended and floating solid matter and other dissolved or immiscible corrosive chemicals. The fluid itself may be an admixture of several substances each with its own characteristic properties.

# 5 Environmental conditions within which equipment is required to operate

## 5.1 General

Equipment to be used for the determination of flows or levels in closed conduits is normally located within the confines of the closed conduit system (see figure 1). In such cases it shares the same environmental operating conditions as the flow itself. In most cases flow determination equipment comprises both sensing and indicating/recording elements. The indicating/recording element is often located outside the conduit system where it is to be expected that the environmental conditions are different from those within the conduit system.

The manufacturer should ensure that the equipment is so designed and manufactured that it can operate satisfactorily under a range of conditions or can be readily adapted to operate under different circumstances as specified by the user.

## 5.2 Environment within the conduit system

**5.2.1** The atmosphere within a conduit system may be assumed to be in equilibrium with the liquid in the conduit. If the atmosphere is of a toxic and/or corrosive nature appropriate precautions should be taken to protect equipment from its effects.

It is possible, in certain circumstances, that the atmosphere may be of a potentially explosive nature. In this case, the equipment should be intrinsically safe for operation in such an atmosphere (for example, the electrical circuits should be so constructed that they cannot cause ignition of the atmosphere).



**5.2.2** The extremes of the atmospheric environment within which the equipment is expected to operate should be specified by the user in terms of temperature, humidity and pressure. In addition, it should be noted that the atmosphere within the conduit system is likely to contain concentrations of gases such as $H_2S$, $SO_2$, CO, inflammable gases, chlorine and ammonia. The presence of all or any of these gases should be specified by the user.

## 5.3 Flow conditions within the conduit system

Discharges in closed conduit systems may vary over a wide range from zero to many cubic metres per second.

The depth of flow will normally be limited to the height of the conduit. Under abnormal conditions of flow when the conduit is surcharged, the depth of flow between the invert of the conduit and the level of the free surface may be equivalent to several conduit diameters. Equipment should not be damaged by the occurrence of such conditions. When ordering equipment, the user should specify the range of conditions under which the equipment is required to operate and to yield data in accordance with the uncertainty values given in clause 8.

Such a specification should include details of

a) the depth of flow (i.e. the operating range);

b) the head of flow (head under which equipment will not be damaged or leak);

c) the range of velocity;

d) whether supercritical flow is to be expected;

e) the water quality (including the presence of contaminants and the water temperature);

f) the nature, concentration, etc., of floating solids;

g) the bed load/saltation load;

h) the nature, concentration, etc. of suspended solids;

i) the atmospheric temperature, pressure, humidity and quality.

### 5.4 Environment outside the conduit system

Where elements of the equipment are situated outside the conduit system the user should specify the environmental conditions under which the elements are required to operate. Such a specification should include, for example, details of

a) the atmospheric temperature and relative humidity;

b) likelihood of electrical interference;

c) likelihood of mechanical shock.

## 6 Choice of measurement reach

In general, a measurement reach shall be chosen that is clear of hydraulic discontinuities throughout the flow determination range. This means that the reach selected shall be remote from bends, changes in cross-sectional shape or size, changes in gradient, junctions or bifurcations, access shafts or any other impediments to free smooth flow. It is recommended that the monitoring equipment is sited at least three or four conduit diameters upstream of such disturbances.

However, if dilution gauging is the selected method of measurement, irregularities in the conduit shape and flow disturbances will enhance mixing, allowing relatively short mixing lengths to be used (see ISO 555).

NOTE 2 The transition between free surface flow and flow under surcharged conditions may be very turbulent with large variations in air entrainment.

## 7 Functional requirements

**7.1** The equipment should be designed and manufactured, or able to be adapted, to operate in one or more of the following modes:

a) permanent installation — the equipment is required to measure flow or level over a long period of time (in excess of about 12 months);

b) temporary installation — the equipment is required to measure flow or level for a specific period of time (not more than about 12 months);

c) portable survey installation — the equipment is required to determine the flow for a short period of time, without permanent site fixture of any element of the measuring equipment.

**7.2** Equipment normally comprises three basic elements, i.e.

a) the sensor,

b) the transducer, and

c) the indicator/recorder.

All the elements may be installed within the conduit system or, alternatively, the sensor may be installed within the conduit system and the indicator/recorder installed outside, and possibly remote from, the conduit system.

**7.3** No element of the equipment should cause any significant interference with the flow itself and, in particular, should not present any edge or surface to which suspended or floating debris could attach itself. It is permissible under certain circumstances for sensors to be mounted within the wall of the conduit. If such an arrangement is required it should be specified by the user at the time of order, and the manufacturer should provide the appropriate installation arrangements.

**7.4** Once installed, the sensor should require a minimum of physical checking or other form of physical attention.

In the case of a permanent installation, the sensor should not require removal for off-site maintenance at intervals of less than 5 years. However, if frequent maintenance is required, then provision should be made at the outset for easy removal of the equipment from the conduit.

In the case of a temporary installation, the sensor should operate without attention for the whole of the measuring period.

For a portable survey device, the sensor should be installed and removed at the time of each measurement.

**7.5** The space available in most closed conduit systems is limited. The installation of equipment should be possible without interrupting the flow. In general, equipment should be installed so that it does not restrict movement within the access shaft. If, however, it is necessary to install the indicating/recording equipment in the access shaft, it should be able to be removed without interrupting the collection of data. Any other element of the equipment, including the flow sensor(s), should remain fixed in position until such time as removal becomes necessary for servicing, repair or renewal, or the abandonment of the site.

**7.6** For ease of transportation, it is desirable that no single item of equipment should exceed a maximum dimension of 2 m. The dimensions of the sensor, and of the measuring or recording equipment (if it is installed in the conduit system), should not exceed 0,5 m, which is commensurate with the minimum size of access shaft. The equipment should be portable either as a unit or in parts.

**7.7** Parts of the equipment which are to be operated below the surface of the liquid being monitored should be sealed to withstand pressures of at least five times the conduit diameter or its equivalent height, subject to a maximum head of 10 m.

**7.8** When the indicating/recording equipment is installed within the conduit system, the equipment should be sealed so that it can withstand immersion under a head of liquid of 1 m for a minimum period of 24 h without affecting its operation.

**7.9** The maximum distance between the sensor and the recorder should be commensurate with the specified site.

**7.10** The recording equipment should be capable of storing all data collected between attendance intervals.

## 8 Performance specification

### 8.1 Parameter value

**8.1.1** Equipment should be capable of measuring and, as appropriate, recording parameter values throughout the full range of operating conditions with an uncertainty level of ± 5 % to ± 10 % of the measured value of the parameter or ± 1 % of the full-range value, whichever is the smaller.

NOTE 3 In this context, "full-range" means the full range of the open channel flow conditions.

**8.1.2** The sensor should respond to changes in parameter values in less than 5 s.

**8.1.3** Equipment should incorporate facilities for damping short-period oscillations (of the order of 5 s) in the parameter value.



### 8.2 Timing device

Where a timing device is used for controlling sampling of parameter values at discrete time intervals, the frequency of sampling should be able to be regulated by the user. The operation of the equipment should be matched to the particular requirements of the user and related to the specific conditions of flow in the closed conduit.

## 9 Additional requirements

Any aspects of equipment specification not covered in this part of ISO/TR 9824 should be the subject of specific agreement between the user and the manufacturer.

# Annex A
(informative)

## Bibliography

[1] ISO 555-1:1973, *Liquid flow measurement in open channels — Dilution methods for measurement of steady flow — Part 1: Constant-rate injection method.*

[2] ISO 555-2:1987, *Liquid flow measurement in open channels — Dilution methods for the measurement of steady flow — Part 2: Integration method.*

[3] ISO 555-3:1982, *Liquid flow measurement in open channels — Dilution methods for measurement of steady flow — Part 3: Constant rate injection method and integration method using radioactive tracers.*

[4] ISO 555-4:—[1], *Liquid flow measurement in open channels — Dilution methods for the measurement of steady flow — Part 4: Chemical tracers.*

[5] ISO 555-5:—[1], *Liquid flow measurement in open channels — Dilution methods for the measurement of steady flow — Part 5: Fluorescent tracers.*

[6] ISO/TR 9824-1:1990[1], *Measurement of free surface flow in closed conduits — Part 1: Methods.*



1) To be published.