

Measurement of fluid flow in closed conduits —

Part 1: Pressure differential devices —

Section 1.2 Specification for square-edged orifice plates and nozzles (with drain holes, in pipes below 50 mm diameter, as inlet and outlet devices) and other orifice plates

UDC 532.542:532.575.52

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/2, upon which the following bodies were represented:

- British Compressed Air Society
- British Gas plc
- Department of Energy (Gas and Oil Measurement Branch)
- Department of Trade and Industry (National Engineering Laboratory)
- Electricity Supply Industry in England and Wales
- Energy Industries Council
- GAMBICA (BEAMA Ltd.)
- Institute of Measurement and Control
- Institute of Petroleum
- Institute of Trading Standards Administration
- Institution of Gas Engineers
- Institution of Mechanical Engineers
- Water Authorities' Association

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

- Engineering Equipment and Materials Users' Association
- Institution of Water and Environmental Management (IWEM)
- United Kingdom Offshore Operators' Association

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 Board of BSI and comes into effect on 29 September 1989

© BSI 01-2000

First published as part of BS 1042-1 February 1943
First revision September 1964
First published as BS 1042-1.2 March 1984
First revision September 1989

The following BSI references relate to the work on this standard:
Committee reference PCL/2
Draft for comment 87/21719 DC

ISBN 0 580 17415 8

Amendments issued since publication

Amd. No.	Date of issue	Comments
8191	July 1994	Indicated by a sideline in the margin

Contents

	Page
Committees responsible	Inside front cover
Foreword	ii
Section 1. General	
1 Scope	1
2 Symbols	1
3 Principle of the method of measurement and computation	1
Section 2. Square-edged orifice plates and nozzles with drain holes, in pipes below 50 mm diameter and as inlet and outlet devices	
4 Drain holes through the upstream face of the square-edged orifice plate or nozzle	2
5 Square-edged orifice plates installed in pipes of diameter $25 \text{ mm} \leq D < 50 \text{ mm}$	2
6 No upstream or downstream pipeline	3
Section 3. Orifice plates (except square-edged)	
7 Conical entrance orifice plates	5
8 Quarter circle orifice plates	6
9 Eccentric orifice plates	8
Figure 1 — Conical entrance orifice plate	12
Figure 2 — Quarter circle orifice plate	13
Figure 3 — Eccentric orifice plate	14
Table 1 — Symbols	1
Table 2 — Minimum internal diameter of upstream pipe for conical entrance orifice plates	5
Table 3 — Minimum internal diameter of upstream pipe for quarter circle orifice plates	7
Table 4 — Discharge coefficients for quarter circle orifice plates	8
Table 5 — Discharge coefficients for eccentric orifice plates	10
Table 6 — Roughness correction factor F_E for eccentric orifice plates	11
Publications referred to	Inside back cover

Foreword

This revision of BS 1042-1.2:1984 has been prepared under the direction of the Industrial-process Measurement and Control Standards Policy Committee. It supersedes BS 1042-1.2:1984 which is withdrawn. It has the objective of introducing updated data and correcting and improving the text.

This is Section 1.2 of a series of Sections of BS 1042 on pressure differential devices as follows:

- *Section 1.1: Specification for square-edged orifice plates, nozzles and venturi tubes inserted in circular cross section conduits running full;*
- *Section 1.2: Specification for square-edged orifice plates and nozzles (with drain holes, in pipes below 50 mm diameter, as inlet and outlet devices) and other orifice plates;*
- *Section 1.3: Method of use of critical flow venturi nozzles inserted in a closed conduit and calculation of critical flowrates and their associated uncertainties¹⁾;*
- *Section 1.4: Guide to the use of devices specified in Sections 1.1 and 1.2;*
- *Section 1.5: Guide to the effect of departure from the conditions specified in Section 1.1.*

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.

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 14, 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 Section of BS 1042-1.2 specifies the geometry and method of use for conical entrance orifice plates, quarter circle orifice plates and eccentric orifice plates. Requirements are also specified for square-edged orifice plates and nozzles under conditions outside the scope of BS 1042-1.1.

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

2 Symbols

The symbols used in this standard are given in Table 1.

3 Principle of the method of measurement and computation

The principle of the method of measurement and computation is as specified in clause 5 of BS 1042-1.1:1992.

NOTE Sample calculations, physical data and other additional information on using pressure differential devices are given in BS 1042-1.4.

Table 1 — Symbols

Symbols	Represented quantity	Dimensions M: mass L: length T: time	SI unit
a	Pressure tapping hole diameter	L	m
C	Discharge coefficient	dimensionless	
d	Diameter of orifice or throat of primary device at operating conditions	L	m
D	Upstream internal pipe diameter at operating conditions	L	m
e	Thickness of bore	L	m
E, E_1	Thickness of orifice plate	L	m
F_E	Correction factor	dimensionless	
k	Uniform equivalent roughness	L	m
p	Static pressure of the fluid	$ML^{-1}T^{-2}$	Pa
q_m	Mass rate of flow	MT^{-1}	kg/s
r	Radius of profile	L	m
R_a	Roughness criterion	L	m
Re	Reynolds number	dimensionless	
Re_D Re_d	Reynolds number referred to D or d	dimensionless	
β	Diameter ratio, $\beta = \frac{d}{D}$	dimensionless	
Δp	Differential pressure	$ML^{-1}T^{-2}$	Pa
ϵ	Expansibility (expansion) factor	dimensionless	
κ	Isentropic exponent	dimensionless	
ρ	Mass density of the fluid	ML^{-3}	kg/m ³
τ	Pressure ratio, $\tau = \frac{P_2}{P_1}$	dimensionless	
NOTE 1 Other symbols used in this standard are defined at their place of use.			
NOTE 2 Some of the symbols used in this standard are different from those used in BS 1042-1.1.			
NOTE 3 Subscript 1 refers to the cross section at the plane of the upstream pressure tapping. Subscript 2 refers to the cross section at the plane of the downstream pressure tapping.			

Section 2. Square-edged orifice plates and nozzles with drain holes, in pipes below 50 mm diameter and as inlet and outlet devices

4 Drain holes through the upstream face of the square-edged orifice plate or nozzle

4.1 General

Square-edged orifice plates and nozzles with drain holes shall be used, installed, and manufactured in accordance with clauses 6, 7, 8, 9 and 10 of BS 1042-1.1:1992.

4.2 Square-edged orifice plates

If a drain hole is drilled through the orifice plate the coefficient values specified in BS 1042-1.1 shall not be used unless the following conditions are observed.

- The pipe diameter shall be larger than 100 mm.
- The diameter of the drain hole shall not exceed $0.1d$ and no part of the hole shall lie within a circle, concentric with the orifice, of diameter $(D - 0.2d)$. The outer edge of the drain hole shall be as close to the pipe wall as practicable.
- The drain hole shall be deburred and the upstream edge shall be sharp.
- Single pressure tapplings shall be orientated so that they are between 90° and 180° to the position of the drain hole.
- The measured orifice diameter, d_m , shall be corrected to allow for the additional orifice area represented by the drain hole of diameter d_k as shown in the following equations.

$$d \approx d_m \left\{ 1 + 0.55 \left(\frac{d_k}{d_m} \right)^2 \right\}$$

$$d_m \approx d \left\{ 1 - 0.55 \left(\frac{d_k}{d} \right)^2 \right\}$$

NOTE These equations are based on the assumption that the value for $C\epsilon(1 - \beta^4)^{-0.5}$ for flow through the drain hole is 10 % greater than the value for flow through the orifice.

An additional uncertainty equivalent to 100 % of the drain hole correction shall be added arithmetically to the discharge coefficient uncertainty when estimating the overall uncertainty of the flow measurement.

4.3 ISA 1932 nozzles

If a drain hole is drilled through the nozzle upstream face, the coefficient values specified in BS 1042-1.1 shall not be used unless the following conditions are observed.

- The value of β shall be less than 0.625.
- The diameter of the drain hole shall not exceed $0.1d$ and no part of the hole shall lie within a circle, concentric with the throat, of diameter $(D - 0.2d)$.
- The length of the drain hole shall not exceed $0.1D$.
- The drain hole shall be deburred and the upstream edge shall be sharp.
- Single pressure tapplings shall be orientated so that they are between 90° and 180° to the position of the drain hole.
- The measured diameter, d_m , shall be corrected to allow for the additional throat area represented by the drain hole of diameter d_k as shown in the following equations.

$$d \approx d_m \left\{ 1 + 0.40 \left(\frac{d_k}{d_m} \right)^2 \right\}$$

$$d_m \approx d \left\{ 1 - 0.40 \left(\frac{d_k}{d} \right)^2 \right\}$$

NOTE These equations are based on the assumption that the value for $C\epsilon(1 - \beta^4)^{-0.5}$ for flow through the drain hole is 10 % greater than the value for flow through the throat of the nozzle.

An additional uncertainty equivalent to 100 % of the drain hole correction shall be added arithmetically to the discharge coefficient uncertainty when estimating the overall uncertainty of the flow measurement.

4.4 Long radius nozzles

Drain holes through these primary elements shall not be used.

5 Square-edged orifice plates installed in pipes of diameter $25 \text{ mm} \leq D < 50 \text{ mm}$

5.1 General

Orifice plates shall be installed and manufactured in accordance with clauses 6, 7 and 8 of BS 1042-1.1:1992.