This is a preview of ISO 9300:2022. Click here to purchase the full version from the ANSI store.

Third edition
2022-06

Measurement of gas flow by means of critical flow nozzles

Mesurage de débit de gaz au moyen de tuyères en régime critique

Reference number
ISO 9300:2022(E)

© ISO 2022

This is a preview of ISO 9300:2022. Click here to purchase the full version from the ANSI store.



COPYRIGHT PROTECTED DOCUMENT

© ISO 2022

All rights reserved. Unless otherwise specified, or required in the context of its implementation, no part of this publication may be reproduced or utilized otherwise in any form or by any means, electronic or mechanical, including photocopying, or posting on the internet or an intranet, without prior written permission. Permission can be requested from either ISO at the address below or ISO's member body in the country of the requester.

ISO copyright office
CP 401 • Ch. de Blandonnet 8
CH-1214 Vernier, Geneva
Phone: +41 22 749 01 11
Email: copyright@iso.org
Website: www.iso.org

Published in Switzerland

© ISO 2022 – All rights reserved

This is a preview of ISO 9300:2022. Click here to purchase the full version from the ANSI store.

Contents

Page

Foreword v
1 Scope 1
2 Normative references 1
3 Terms and definitions 1
3.1 Pressure 1
3.2 Temperature 2
3.3 Nozzle 2
3.4 Flow 3
3.5 Flow rate 4
3.6 Gas 5
4 Symbols and abbreviations 6
5 Basic equations 9
5.1 Gas behaviour 9
5.1.1 Isentropic process 9
5.1.2 State equation 9
5.2 Isentropic flow of a perfect gas 9
5.2.1 Flowing area 9
5.2.2 Static pressure 9
5.2.3 Static temperature 10
5.3 Theoretical variables at the critical point 10
5.3.1 General 10
5.3.2 Critical pressure 10
5.3.3 Critical temperature 10
5.3.4 Critical density 10
5.3.5 Critical velocity 10
5.4 Theoretical mass flow rates 10
5.4.1 General 10
5.4.2 Theoretical mass flow rate of a perfect gas 10
5.4.3 Theoretical mass flow rate of real gas 11
5.5 Mass flow rate 11
6 General requirements 11
7 Applications for which the method is suitable 12
8 CFN 12
8.1 General requirements for both the standard CFN types 12
8.1.1 General 12
8.1.2 Materials 12
8.1.3 Contraction and throat 13
8.1.4 Diffuser 13
8.2 Requirements for each standard types of CFN 14
8.2.1 Standard CFNs ..... Error! Bookmark not defined.
8.2.2 Toroidal-throat CFN 15
8.2.3 Cylindrical-throat CFN 16
9 Installation requirements 18
9.1 General requirements for both the standard configurations 18
9.1.1 Standard configurations 18
9.1.2 Upstream pressure tapping 18
9.1.3 Downstream pressure tapping 19

© ISO 2022 – All rights reserved

This is a preview of ISO 9300:2022. Click here to purchase the full version from the ANSI store.

9.1.4 Temperature measurement 19
9.1.5 Density measurement 20
9.1.6 Drain hole 20
9.1.7 Downstream condition 20
9.2 Pipe configuration 21
9.2.1 General 21
9.2.2 Upstream pipe 21
9.2.3 Pressure measurement 22
9.2.4 Temperature measurement 22
9.3 Chamber configuration 23
9.3.1 General 23
9.3.2 Upstream chamber 23
9.3.3 Pressure measurement 23
9.3.4 Temperature measurement 23
9.3.5 Back-pressure ratio 23

10 Calculations 23
10.1 General 23
10.2 Calculation of mass flow rate, q_m 23
10.3 Calculation of discharge coefficient, C_d 24
10.4 Calculation of critical flow function, C^* or C^*_D 25
10.5 Conversion of measured pressure into stagnation pressure 25
10.6 Conversion of measured temperature into stagnation temperature 25
10.7 Calculation of viscosity 25

11 Estimation of critical back-pressure ratio 26
11.1 For a traditional diffuser at Reynolds numbers higher than 2×10^5 26
11.2 For any diffuser at low Reynolds numbers 27
11.3 For CFNs without diffuser or with very short diffuser 28

12 Uncertainties in the measurement of flow rate 28
12.1 General 28
12.2 Practical computation of uncertainty 29
12.3 Correlated uncertainty components 30

Annex A (informative) Discharge coefficient values 32

Annex B (informative) Critical flow function 34

Annex C (informative) Critical flow function values — Pure gases and air 37

Annex D (informative) Computation of critical mass flux for critical flow nozzles with high nozzle throat to upstream pipe diameter ratio, $\beta > 0{,}25$ 62

Annex E (informative) Diameter correction method 66

Annex F (informative) Adjustment of discharge coefficient curve on a data set 71

Annex G (informative) Discharge coefficient 79

Annex H (informative) Critical back pressure ratio 84

Annex I (informative) Viscosity values – Pure gases and air 92

Annex J (informative) Supplement 108

Bibliography 116

 © ISO 2022 – All rights reserved

This is a preview of ISO 9300:2022. Click here to purchase the full version from the ANSI store.

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 procedures used to develop this document and those intended for its further maintenance are described in the ISO/IEC Directives, Part 1. In particular, the different approval criteria needed for the different types of ISO documents should be noted. This document was drafted in accordance with the editorial rules of the ISO/IEC Directives, Part 2 (see www.iso.org/directives).

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights. Details of any patent rights identified during the development of the document will be in the Introduction and/or on the ISO list of patent declarations received (see www.iso.org/patents).

Any trade name used in this document is information given for the convenience of users and does not constitute an endorsement.

For an explanation of the voluntary nature of standards, the meaning of ISO specific terms and expressions related to conformity assessment, as well as information about ISO's adherence to the World Trade Organization (WTO) principles in the Technical Barriers to Trade (TBT), see www.iso.org/iso/foreword.html.

ISO 9300 was prepared by Technical Committee ISO/TC 30, *Measurement of fluid flow in closed conduits*, Subcommittee SC 2, *Pressure differential devices*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/SS F05, *Measuring instruments*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This third edition cancels and replaces the second edition (ISO 9300:2005), which has been technically revised.

The main changes are as follows:

— the discharge coefficient curve is given by a single equation each for the toroidal- and cylindrical-throat critical flow nozzles (CFNs) that covers both the laminar and turbulent boundary layer regimes;

— the discharge coefficient curve of the cylindrical-throat CFN is updated based on the recent experimental and theoretical data;

— the quadrant CFN and detachable diffuser are introduced;

— the basic equations used to measure the discharge coefficient are listed;

— the premature unchoking phenomenon is explained to give attention to the unpredictable unchoking at low Reynolds numbers;

— REFPROP is introduced for the calculations of critical flow function and viscosity as well as their fitted curves are given for some pure gases and air;

© ISO 2022 – All rights reserved

This is a preview of ISO 9300:2022. Click here to purchase the full version from the ANSI store.

— the diameter correction method is introduced to fit the experimental discharge coefficient data to a reference curve;

— the detailed method to match the discharge coefficient curve on an experimental data set is described;

— the background of the specifications is given.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

 © ISO 2022 – All rights reserved

This is a preview of ISO 9300:2022. Click here to purchase the full version from the ANSI store.

Measurement of gas flow by means of critical flow nozzles

1 Scope

This document specifies the geometry and method of use (installation in a system and operating conditions) of critical flow nozzles (CFNs) used to determine the mass flow rate of a gas flowing through a system basically without the need to calibrate the CFN. It also gives the information necessary for calculating the flow rate and its associated uncertainty.

This document is applicable to nozzles in which the gas flow accelerates to the critical velocity at the minimum flowing section, and only where there is steady flow of single-phase gas. When the critical velocity is attained in the nozzle, the mass flow rate of the gas flowing through the nozzle is the maximum possible for the existing inlet condition, while the CFN can only be used within specified limits, e.g. the CFN throat to inlet diameter ratio and Reynolds number. This document deals with the toroidal- and cylindrical-throat CFNs for which direct calibration experiments have been made in sufficient number to enable the resulting coefficients to be used with certain predictable limits of uncertainty.

2 Normative references

There are no normative references in this document.

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminology databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1 Pressure

3.1.1
static pressure
pressure of the flowing gas (see Annex J)

Note 1 to entry: The static pressure is measured through a *wall pressure tapping* (3.1.3).

3.1.2
stagnation pressure
pressure which would exist in a flowing gas stream if the stream were brought to rest by an isentropic process

© ISO 2022 – All rights reserved