ISO 9300:2022-06 (E)

Measurement of gas flow by means of critical flow nozzles

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
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