International Standard ISO 4126

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Safety valves — General requirements

Soupapes de sûreté — Prescriptions générales

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Foreword

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Draft International Standards adopted by the technical committees are circulated to the member bodies for approval before their acceptance as International Standards by the ISO Council.

International Standard ISO 4126 was developed by Technical Committee ISO/TC 153, *General purpose industrial valves.*

The first edition (ISO 4126-1979) had been approved by the member bodies of the following countries :

Australia	Germany, F.R.	Spain
Austria	India	Sweden
Brazil	Ireland	Switzerland
Canada	Italy	Turkey
Chile	Netherlands	United Kingdom
Denmark	Norway	USSR
Finland	Philippines	Yugoslavia
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The member bodies of the following countries had expressed disapproval of the document on technical grounds :

Belgium
Japan
South Africa, Rep. of

This second edition, which supersedes ISO 4126-1979, incorporates draft Addendum 1, which was circulated to the member bodies in July 1979, and which has been approved by the member bodies of the following countries :

Australia	Germany, F.R.	Romania
Austria	India	Spain
Belgium	Italy	Sweden
Brazil	Korea, Rep. of	Switzerland
Canada	Netherlands	United Kingdom
Finland	Norway	USA
France	Poland	USSR

The member body of the following country expressed disapproval of the document on technical grounds :

South Africa, Rep. of

Safety valves — General requirements

1 Scope and field of application

This International Standard specifies requirements for safety valves irrespective of the fluid for which they are designed.

It is applicable to valves having body seats of 9 mm bore and above, and is for use at pressures above 1 bar[1] up to 250 bar gauge. No limitation is placed on temperature.

2 References

ISO 7/1, *Pipe threads where pressure-tight joints are made on the threads — Part 1 : Designation, dimensions and tolerances.*[2]

ISO 2084, *Pipeline flanges for general use — Metric series — Mating dimensions.*

ISO 2229, *Equipment for the petroleum and natural gas industries — Steel pipe flanges, nominal sizes 1/2 to 24 in — Metric dimensions.*

ISO 2441, *Pipeline flanges for general use — Shapes and dimensions of pressure-tight surfaces.*

ASA B2.1, *Pipe threads (except dry seal).*

3 Definitions

3.1 safety valve : A valve which automatically, without the assistance of any energy other than that of the fluid concerned, discharges a certified quantity of the fluid so as to prevent a predetermined safe pressure being exceeded, and which is designed to reclose and prevent the further flow of fluid after normal pressure conditions of service have been restored.

The valve, when permitted by a national standard, may additionally be actuated by an energy source independent of the fluid energy.

3.1.1 direct loaded safety valve : A safety valve in which the loading due to the fluid pressure underneath the valve disk is opposed only by direct mechanical loading such as a weight, a lever and weight, or a spring.

3.1.2 assisted safety valve : A safety valve which, by means of a powered assistance mechanism, may additionally be lifted at a pressure below the unassisted set pressure and will, even in the event of failure of the assistance mechanism, comply with all the requirements for safety valves given in this International Standard.

3.1.3 supplementary loaded safety valve : A safety valve, which has, until the pressure at the inlet to the safety valve reaches the set pressure, an additional force which increases the sealing force. This additional force (supplementary load) which may be provided by means of an extraneous power source, shall be reliably released when the pressure at the inlet of the safety valve reaches the set pressure. The amount of supplementary loading shall be so arranged that if such supplementary loading is not released the safety valve shall attain its certified discharge capacity with a pressure at the inlet of the safety valve not greater than a percentage of set pressure as determined by national regulations.

3.1.4 pilot operated safety valve : A safety valve, the operation of which is initiated and controlled by the fluid discharged from a pilot valve which is itself a direct loaded safety valve subject to the requirements of this International Standard.

3.2 pressure

3.2.1 set pressure : The predetermined pressure at which a safety valve under operating conditions commences to lift. It is the gauge pressure measured at the valve inlet at which the pressure forces tending to open the valve for the specified service conditions are in equilibrium with the forces retaining the valve disk on its seat.

3.2.2 overpressure of a safety valve : A pressure increase over the set pressure of a safety valve, usually expressed as a percentage of set pressure.

3.2.3 re-seating pressure of a safety valve : The value of inlet static pressure at which the disk re-establishes contact with the seat or at which lift becomes zero.

1) 1 bar = 0,1 MPa

2) At present at the stage of draft. (Revision of ISO 7/1-1978.)

3.2.4 cold differential test pressure : The inlet static pressure at which a safety valve is set to commence to lift on the test stand. This test pressure includes corrections for service conditions of back pressure and/or temperature.

3.2.5 relieving pressure (flow rating pressure) : Set pressure plus overpressure.

NOTE — The limitations for relieving pressure are subject to national requirements.

3.2.6 built-up back pressure : The pressure existing at the outlet of the safety valve caused by flow through the valve into a discharge system.

3.2.7 superimposed back pressure : The static pressure existing at the outlet of a safety valve at the time the device is required to operate. It is the result of pressure in the discharge system from other sources.

3.2.8 blowdown of a safety valve : The difference between set and re-seating pressures, normally stated as a percentage of set pressure except for very low set pressure when the blowdown is then expressed in bars.

3.3 lift : The actual travel of the disk away from the closed position.

3.4 commencement of lift : Initial lift such as would cause the first indication of movement on a linear transducer or equivalent.

3.5 flow area : The minimum cross-sectional flow area (but not the curtain area) between inlet and seat which is used to calculate the theoretical flow capacity, with no deduction for any obstruction.

3.5.1 flow diameter : The diameter corresponding to the flow area.

3.6 discharge

3.6.1 theoretical flowing (discharge) capacity : The calculated capacity expressed in gravimetric or volumetric units of a theoretically perfect nozzle having a cross-sectional flow area equal to the flow area of a safety valve.

3.6.2 certified capacity : That portion of the measured capacity permitted to be used as a basis for the application of a safety valve, i.e. :

a) measured flow rate × derating factor, or

b) theoretical flow rate × coefficient of discharge × derating factor.

3.6.3 equivalent calculated capacity : The calculated capacity of the safety valve for conditions of pressure, temperature or nature of the fluid which differs from those for which certified capacities are available.

3.7 independent authority (in respect of safety valves) : That authority which, in the country concerned, bears responsibility for all aspects of surveillance of tests, checking of calculations and certification of safety valve discharge capacities.

3.8 nominal size DN : A numerical designation of size which is normally common to all components in a piping system. It is a convenient round number for reference purposes and it is normally only loosely related to manufacturing dimensions.

4 End connections

End connections of safety valves shall be in accordance with one of the following requirements :

a) flanges in accordance with ISO 2084 and ISO 2441;

b) flanges in accordance with ISO 2229;

c) *screwed connections in accordance with* ISO 7 *or* ASA B2.1;

d) welding preparation in accordance with an approved national welding code.

5 Integrity testing in works of all safety valves

5.1 Purpose

The purpose of these tests is to establish that each and every safety valve is adjusted to suit its operating requirements and is able to withstand the specified pressure and temperature.

5.2 General

All temporary pipes and connections and blanking devices shall be adequate to withstand the test pressure.

Any temporary welded-on attachments shall be carefully removed and the resulting weld scars shall be ground flush with the parent material. After grinding, all such scars shall be inspected by magnetic particle or fluid penetrant techniques.

All bourdon tube pressure gauges or other recognized pressure measuring devices fitted to test equipment shall be regularly tested and calibrated in accordance with the appropriate national standard, to ensure accuracy.

5.3 Hydraulic test

5.3.1 Application

The body seat of safety valves shall be blanked off and a test pressure of 1,5 times the maximum pressure for which the safety valve is designed shall be applied only to the part of the body at the inlet side of the seat.

Safety valves to be installed with a free discharge or where the only back pressure is built-up back pressure do not require a hydraulic test to be applied to that part of the valve on the discharge side of the seat. In the case where a safety valve is to be subjected to a superimposed back pressure or valves on closed discharge systems (closed bonnet valves) then a hydraulic test of 1,5 times the maximum back pressure on the valve shall be applied to those parts on the discharge side of the seat.

5.3.2 Duration of the hydraulic test

The test pressure shall be applied and maintained at the required pressure for a sufficient length of time to permit a visual examination to be made of all surfaces and joints, but in any case for not less than the times detailed in table 1. For tests on the discharge side of the seat the testing time shall be based on the pressure specified in 5.3.1 and the discharge size.

5.3.3 Safety requirements

Water of suitable purity shall normally be used as the test medium. Where other testing media are used, additional precautions may be necessary.

Valve bodies shall be properly vented to remove entrapped air.

If materials which are liable to failure by brittle fracture are incorporated in that part of the safety valve which is to be hydraulically tested, then both the safety valve, or part thereof, and the testing medium shall be at a sufficient temperature to prevent the possibility of such failure.

No valve or part thereof undergoing pressure testing shall be subjected to any form of shock loading, for example hammer testing.

5.4 Pneumatic test

5.4.1 Application

Pressure testing with air or other suitable gas should be avoided but may be carried out in place of the standard body hydraulic test with the agreement of all parties involved only in the following cases :

a) valves of such design and construction that is not practicable for them to be filled with liquid; and/or

b) valves that are to be used in service where even small traces of water cannot be tolerated.

The test pressure and method of application of this pressure shall be as required by 5.3.1.

5.4.2 Duration of pneumatic tests

The times and conditions of these tests shall be as indicated in 5.3.2.

Table 1 — Minimum duration of hydraulic test

Nominal valve size DN	Pressure rating		
	Up to and including 40 bar	Over 40 bar up to and including 64 bar	Over 64 bar
	Duration in minutes		
Up to and including 50	2	2	3
over 50 up to and including 65	2	2	4
over 65 up to and including 80	2	3	4
over 80 up to and including 100	2	4	5
over 100 up to and including 125	2	4	6
over 125 up to and including 150	2	5	7
over 150 up to and including 200	3	5	9
over 200 up to and including 250	3	6	11
over 250 up to and including 300	4	7	13
over 300 up to and including 350	4	8	15
over 350 up to and including 400	4	9	17
over 400 up to and including 450	4	9	19
over 450 up to and including 500	5	10	22
over 500 up to and including 600	5	12	24

Sizes larger than 600 shall have testing times pro rata.

5.4.3 Safety requirements

The hazards involved in pneumatic pressure testing shall be considered and adequate precautions taken. Attention is drawn to some relevant factors, namely :

If a major rupture of the valve should occur at some stage during the application of pressure, considerable energy will be released; hence no personnel should be in the immediate vicinity during pressure raising (for example a given volume of air contains 200 times the amount of energy that a similar volume of water contains, when both are the same pressure).

The risk of brittle failure under test conditions shall have been critically assessed at the design stage and the choice of materials for valves which are to be pneumatically tested shall be such as to avoid the risk of brittle failure during test. This necessitates provision of an adequate margin between the transition temperature of all parts and the metal temperature during testing.

Attention is drawn to the fact if the gas pressure is reduced to the valve under test from high pressure storage, the temperature will fall.

Valves undergoing pneumatic test should not be approached for close inspection until after the pressure raising has been completed.

No valve undergoing pneumatic test shall be subject to any form of shock loading.

Precautions shall be taken against pressures generated in excess of test pressure.

5.5 Adjustment of safety valve cold differential test pressure

It is not permissible to adjust the cold differential test pressure of a safety valve using air or other gas as the test medium unless the safety valve has previously been subjected to the standard integrity test in accordance with 5.3 or 5.4.

6 Operating and flow characteristics for safety valves tested on steam, air, water or other gas of known characteristics

6.1 General

6.1.1 Application

This clause applies to the types of safety valves defined in 3.1.

6.1.2 The carrying out of tests

The tests to determine the operating characteristics shall be in accordance with 6.2 and the tests to determine the flow characteristics shall be in accordance with 6.3.

When these tests are carried out separately, the parts of the valve which influence fluid flow shall be complete and installed in the valve.

6.1.3 Object of tests

To determine under specific operating conditions particular characteristics of the valves before opening, while discharging and at closing. The following characteristics are examples, there may be others :

a) set pressure;

b) reseating pressure;

c) blowdown;

d) reproducibility of valve performance;

e) mechanical characteristics of the valves determined by seeing or hearing such as :

— ability to re-seat satisfactorily;

— absence or presence of chatter, flutter, sticking and/or harmful vibration;

f) relieving pressure;

g) lift.

6.1.4 Procedure for testing

The purpose and manner of testing shall be such as to provide suitable data from which the operational and flow characteristics may be determined. To this end the following information shall be supplied to the independent authority, and shall be approved before testing is undertaken :

a) full particulars of the valves to be tested and the range of valves and springs which they represent;

b) details of the test rig(s) including proposed instrumentation test and calibration procedure;

c) proposed source, capacity, pressure, temperature and properties of the test fluid(s).

6.1.5 Results calculated from test

The theoretical flowing capacity is calculated (see 7.2, 7.3 or 7.4) and using this value together with the actual flowing capacity at relieving pressure the coefficient of discharge of the safety valve is calculated (see 7.1).

6.2 Tests to determine operating characteristics

6.2.1 The carrying out of tests

The set pressures at which the operating characteristics are determined shall be the minimum set pressures for which the spring used is designed. Valves for steam, air or other gas service shall be tested using steam, air or other gas of known characteristics except that valves for steam service should be tested on steam. Valves for liquid service shall be tested on water or liquids of known characteristics. The allowable tolerances or limits as applicable on these characteristics are as follows :

a) Set pressure below 5 bar ± 0,14 bar
5 bar and above : ± 3 %.

b) Lift : ± 5 % of the average for a given size of valve.

c) Limits of adjustable blowdown : 2,5 % of set pressure, minimum; 7 % of set pressure, maximum except for valves having :

— seat bore less than 15 mm when the maximum limit of blowdown shall be 15 % of set pressure;

— and for values of set pressure less than 3,0 bar when the blowdown shall be a maximum of 0,3 bar.

d) Limits for valves with non adjustable blowdown : maximum 15 % of set pressure.

e) Limits of blowdown for incompressible fluids : maximum 20 % of set pressure. For values of set pressure less than 3 bar, the blowdown shall be a maximum of 0,6 bar.

NOTE — Some countries have regulations limiting blowdown to smaller values than those stated above.

The independent authority may dispense with the operating characteristic test described previously in this clause when it has experience or documented independent evidence of lift and satisfactory performance of the specific design of safety valve.

6.2.2 Test equipment

The error of pressure measuring equipment used during the test shall not be more than 0,5 % of full scale reading, with the test pressure within the middle third of the instrument range.

6.2.3 Valves used in the test programme

The safety valves tested shall be representative of the design, pressure, and size range of valves for which operating characteristics are required. To be representative, the ratio of valve inlet to flow area and the ratio of flow area to valve outlet shall be taken into account.

Tests shall be carried out on three sizes unless the size range contains not more than six sizes, when the number tested may be reduced to two. When the range is extended from a number less than seven to a number equal to or in excess of seven, then tests on three sizes of valves are required.

When the range is extended so that the previously tested safety valves are no longer representative of the range, further tests shall be required.

6.2.4 Test procedure

The tests shall be carried out using three significantly different springs for each size of valve. Where three test pressures are required from one valve size this may be achieved by testing either one valve with three significantly different springs or three valves of the same size at three significantly different settings. Each test shall be carried out a minimum of three times in order to establish and confirm acceptable reproducibility of performance.

For the case of valves of either novel or special design, of which one size only at one pressure rating is being manufactured, tests at that set pressure are permitted by agreement with the independent authority.

For the case of valves of which one size only at various pressure ratings is being manufactured, tests shall be carried out using four different springs which shall cover the range of pressure for which the valve shall be used.

6.3 Test to determine flow characteristics

6.3.1 Carrying out of tests

For safety valves for steam service, after operational characteristics have been satisfactorily established using steam as the test fluid, it is acceptable to use steam, air, or other gas of known characteristics as the fluid for flow characteristic tests. Further, when discharged quantities are being assessed using fluids other than steam the valve disk shall be mechanically held at the same lift as that obtained with steam at the same overpressure.

6.3.2 Valves used in the test programme

The safety valves tested shall be representative of the design, pressure and size range of valves for which operating characteristics are required.

The valve configuration shall be the same as that used during the tests for operational characteristics. That is, the lift and, if a blowdown ring(s) is fitted, its position shall be the one(s) established for the particular size and overpressure during operational testing. Average values shall be used when the tolerances of 6.2.1 have been met.

In lieu of the above it is permissible to establish curves of capacity versus valve absolute inlet pressure as a function of lift and blowdown ring position. These curves may then be used to obtain the unique value desired based on the results of the operational testing.

6.3.3 Test procedure

The flow characteristic tests for determination of the coefficient of discharge shall be carried out at three different pressures for each of three sizes of a given valve design unless the size range contains not more than six sizes, when the number of sizes tested may be reduced to two.

When the range is extended from a number less than seven to a number equal to or in excess of seven, then tests on three sizes of valves (a total of nine tests) shall be required.

A curve may be established for the coefficient of discharge versus valve lift at a given inlet pressure and where applicable the appropriate blowdown ring(s) position. Coefficients of discharge for intermediate positions of lift may be interpolated from this curve. Tests shall be conducted to establish the variation of the coefficient of discharge with inlet pressure and relevant blowdown ring(s) position. If no variation occurs the curve may be used as described, however if variation is noted, tests shall be required by the independent authority to establish additional curves for these variables.

For the case of valves of either novel or special design of which one size only at various pressure ratings is being manufactured, tests shall be carried out at four different set pressures which shall cover the ranges of pressure for which the valve will be used or as determined by the limits of the test facility. The discharge capacities as determined by these four tests shall be plotted against the absolute inlet pressure and a straight line drawn through these four points and zero-zero. If all points do not lie within ± 5 % of this line, additional testing shall be required by the independent authority until the line is established without ambiguity. For liquids, the capacities determined by the four tests shall be plotted on log-log paper against the differential (inlet pressure minus back pressure) test pressure, and a straight line drawn through these four points.

In all cases the size and pressure range shall be representative of the design range within limits of the testing facility. In those cases where the size of the valve is greater than can be flow tested at the test facility, the independent authority shall, at its discretion, consider the feasibility and opportunity of requiring one confirmatory flow test at the location of the installation.

However three geometrically similar models of different sizes may be used to determine the coefficient of discharge. The proper function of at least one valve of the design to be certified shall be demonstrated by test.

In all the methods described for flow characteristics testing all final results must be within ± 5 % of the average, or additional testing shall be required by the independent authority, until this criterion is met.

6.3.4 Adjustments during test

No adjustment to the valve shall be made during the test. Following any change or deviation of the test conditions, a sufficient period of time shall be allowed to permit the rate of flow, temperature and pressure to reach stable conditions before readings are taken.

6.3.5 Records and test results

The test records shall include all observations, measurements, instrument readings and instrument calibration record (if required) for the objective(s) of the test. Original test records shall remain in the custody of the test establishment which conducted the test. Copies of all test records shall be furnished to each of the parties for the test. Corrections and corrected values shall be entered separately in the test record.

6.3.6 Flow test equipment

The test equipment shall be designed and operated such that the actual test flowing capacity measurement shall be accurate to within ± 2 %.

6.4 Coefficient of discharge

For the determination of the coefficient of discharge see clause 7.

6.5 Certification of valves

The certified capacity of the valve shall be 90 % of the capacity determined by test. For valves using the coefficient of discharge method the certified capacity shall be 90 % of the theoretical capacity times the coefficient of discharge.

It should be noted that the coefficient of discharge cannot be used to calculate the capacity at a lower overpressure than that at which the test (6.3) was carried out although it can be used to calculate the capacity at a higher overpressure.

7 Determination of coefficient of discharge

7.1 Coefficient of discharge, K_d

The coefficient of discharge, K_d, can be calculated from the following formula :

$$\text{Coefficient of discharge, } K_d, = \frac{\text{actual flowing capacity (from test)}}{\text{theoretical flowing capacity (from calculation)}}$$

7.2 Theoretical flowing (discharge) capacity using dry saturated steam as the test medium

For application up to and including 110 bar :

$$q_m = 0{,}525\, p \qquad \dots (1)$$

For application over 110 bar and up to 220 bar :

$$q_m = 0{,}525\, p \left(\frac{2{,}764\,4\, p - 1\,000}{3{,}324\,2\, p - 1\,061} \right) \qquad \dots (2)$$

where

q_m is the theoretical flowing capacity of dry saturated steam, in kilograms per hour per square millimetre of flow area;

p is the actual flowing (inlet) pressure, in bars, absolute.

7.3 Theoretical flowing (discharge) capacity using air or any true gases as the test medium

$$q_m = pC\sqrt{\frac{M}{ZT}} \qquad \dots (3)$$

where

q_m is the theoretical flowing capacity, in kilograms per hour per square millimetre of flow area;

C is a constant for the gas which is a function of the isentropic coefficient κ (for rounded figures, see table 2);

$$C = 3{,}949\sqrt{\kappa \left(\frac{2}{\kappa + 1} \right)^{\frac{\kappa + 1}{\kappa - 1}}} \qquad \dots (4)$$

p is the actual flowing (inlet) pressure, in bars, absolute;

M is the molecular mass of gas in kilograms per kilomole;

T is the absolute temperature at inlet, in kelvin;

Z is the compressibility factor. In many cases it is unity and may be neglected. For air under normal test conditions $Z = 1$. (See the figure.)

7.4 Theoretical flowing (discharge) capacity using a liquid as the test medium

$$q_m = \frac{\sqrt{\Delta p \varrho}}{0,621\ 1} \qquad \dots (5)$$

where

q_m is the theoretical flowing capacity related to the smallest flow area in kilograms per hour per square millimetre of flow area;

$\Delta p = p - p_a$ = pressure drop, in bars;

p is the actual flowing (inlet) pressure, in bars, absolute;

p_a is the back pressure, in bars, absolute;

ϱ is the volumetric mass in kilograms per cubic metre.

Table 2 — Values of κ and C

κ	Constant C	κ	Constant C	κ	Constant C
1,00	2,39	1,26	2,61	1,52	2,78
1,02	2,41	1,28	2,62	1,54	2,79
1,04	2,43	1,30	2,63	1,56	2,80
1,06	2,45	1,32	2,65	1,58	2,82
1,08	2,46	1,34	2,66	1,60	2,83
1,10	2,48	1,36	2,68	1,62	2,84
1,12	2,50	1,38	2,69	1,64	2,85
1,14	2,51	1,40	2,70	1,66	2,86
1,16	2,53	1,42	2,72	1,68	2,87
1,18	2,55	1,44	2,73	1,70	2,89
1,20	2,56	1,46	2,74	2,00	3,04
1,22	2,58	1,48	2,76	2,20	3,13
1,24	2,59	1,50	2,77		

8 Marking

8.1 On the body of the safety valve

The following minimum information shall be marked on the body of all safety valves. Marking on the body may be integral with the body or on a plate securely fixed to the body :

a) size designation (inlet) for example DN...;

b) material designation of the body;

c) manufacturer's name or trademark;

d) an arrow showing the direction of flow where the inlet and outlet connections have the same dimensions or the same pressure rating.

8.2 On an identification plate

The following minimum information, stating units, shall be on an identification plate securely fixed to the safety valve :

a) the limiting operating temperature(s); in degrees Celsius, for which the valve has been designed;

b) set pressure, in bars or pascals;

c) the number of this International Standard;

d) manufacturer's type reference;

e) coefficient of discharge or certified discharge capacity of reference fluid;

f) flow area, in square millimetres;

g) lift, in millimetres, and corresponding overpressure, expressed as a percentage.

8.3 Sealing of a safety valve

All safety valves shall be sealed by the manufacturer, his representative or a responsible authority.

9 Equivalent capacity

It is not permitted to calculate the capacity at a lower overpressure than that at which the test (see 6.3) was carried out although it is permissible to calculate the capacity at a higher overpressure.

9.1 Valves for gas or vapour relief

No distinction is made between substances commonly referred to as gases and those commonly referred to as vapours : the term "gas" is used to describe both states.

To calculate the capacity for any gas, the area and the coefficient of discharge shall be assumed constant and the theoretical equations of clause 7 shall be used.

Example :

$$\frac{q_{mcs}}{0,525\,p} \text{ (for steam)}$$

$$= \frac{q_{mcG}}{C_G p \left(\frac{M_G}{ZT}\right)^{1/2}} \text{ (for any true gas)} \qquad \dots (6)$$

or

$$\frac{q_{mc1}}{C_1 p \left(\frac{M_1}{Z_1 T_1}\right)^{1/2}} \text{ (for gas 1)}$$

$$= \frac{q_{mc2}}{C_2 p \left(\frac{M_2}{Z_2 T_2}\right)^{1/2}} \text{ (for gas 2)} \qquad \dots (7)$$