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ISO 4126-1

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Safety valves —

Part 1 :
General requirements

Soupapes de sûreté —

Partie 1 : Prescriptions générales

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Contents

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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.

Draft International Standards adopted by the technical committees are circulated to the member bodies for voting. Publication as an International Standard requires approval by at least 75 % of the member bodies casting a vote.

International Standard ISO 4126-1 was prepared by Technical Committee ISO/TC 185, *Safety devices for protection against excessive pressure.*

This first edition of ISO 4126-1 cancels and replaces ISO 4126 : 1981, of which it constitutes a technical revision.

ISO 4126 will consist of the following parts under the general title *Safety valves*:

— *Part 1: General requirements*

— *Part 2: Controlled safety pressure-relief systems*

Annexes A, B, C, D and E of this part of ISO 4126 are for information only.

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Safety valves —

Part 1 :
General requirements

1 Scope

This part of ISO 4126 specifies general requirements for safety valves irrespective of the fluid for which they are designed.

It is applicable to safety valves having a flow diameter of 9 mm and above, which are for use at set pressures of 1 bar gauge (0,1 MPa) and above. No limitation is placed on temperature.

2 Normative references

The following standards contain provisions which, through reference in this text, constitute provisions of this part of ISO 4126. At the time of publication, the editions indicated were valid. All standards are subject to revision, and parties to agreements based on this part of ISO 4126 are encouraged to investigate the possibility of applying the most recent editions of the standards indicated below. Members of IEC and ISO maintain registers of currently valid International Standards.

ISO 7-1 : 1982, *Pipe threads where pressure-tight joints are made on the threads — Part 1 : Designation, dimensions and tolerances.*

ANSI/ASME B1.20.1 : 1983, *Pipe threads, general purpose (inch).*

3 Definitions

For the purposes of this part of ISO 4126, the following definitions apply.

3.1 safety valve: 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.

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

3.1.2 assisted safety valve: 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 part of ISO 4126.

3.1.3 supplementary loaded safety valve: 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, is reliably released when the pressure at the inlet of the safety valve reaches the set pressure. The amount of supplementary loading is so arranged that if such supplementary loading is not released, the safety valve attains 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: 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 part of ISO 4126.

3.2 pressure

3.2.1 set pressure: The predetermined pressure at which a safety valve under operating conditions commences to open. 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 disc 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 disc re-establishes contact with the seat or at which lift becomes zero.

3.2.4 cold differential test pressure: The inlet static pressure at which a safety valve is set to commence to open 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 and the discharge system.

3.2.7 superimposed back pressure : The static pressure existing at the outlet of a safety valve at the time when 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 pressures of less than 3 bar when the blowdown is then expressed in bar.

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

3.4 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 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 (discharge) capacity : That portion of the measured capacity permitted to be used as a basis for the application of a safety valve. It may be, for example, equal to

a) the measured flow rate times the derating factor, or

b) the theoretical flow rate times the coefficient of discharge times the derating factor, or

c) the theoretical flow rate times the derated coefficient of discharge.

3.6.3 equivalent calculated capacity : The calculated capacity of the safety valve for conditions of pressure, temperature or nature of the fluid which differ 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 inspection authority: The competent authority or association, which may or may not be the same as the independent authority, which verifies compliance with this part of ISO 4126.

3.9 nominal size (DN): A numerical designation of size which is common to all components in a piping system other than components designated by outside diameters or by thread size. It is a convenient round number for reference purposes and is only loosely related to manufacturing dimensions.

NOTE — It is designated by DN followed by a number.

[Extract from ISO 6708 : 1980, *Pipe components — Definition of nominal size.*]

4 Design, materials and construction

4.1 General

4.1.1 The design shall incorporate guiding arrangements necessary to ensure consistent operation and seat-tightness.

4.1.2 The body seat of a safety valve other than where it is an integral part of the valve body shall be fastened securely to prevent the seat becoming loose in service.

4.1.3 Means shall be provided to lock and/or to seal all external adjustments in such a manner so as to prevent or reveal unauthorized adjustments of the safety valve.

4.1.4 Safety valves for toxic or flammable fluids shall be of the closed-bonnet type to prevent leakage to the atmosphere.

4.1.5 The safety valve shall be provided with a drain connection at the lowest point where liquid can collect unless other provisions for draining are provided.

4.1.6 The design stress of load-carrying parts shall not exceed that specified in the appropriate national standard.

4.2 End connections

4.2.1 Types

End connections of safety valves shall be in accordance with an appropriate International Standard, national standard, industry standard or national welding code. (For screwed connections, see ISO 7-1 and ANSI/ASME B1.20.1.)

4.2.2 Design

The design of end connections, whatever their type, shall be such that the area of the bore of the external pipe or stub connection is at least equal to that of the safety valve inlet (see figure 1).

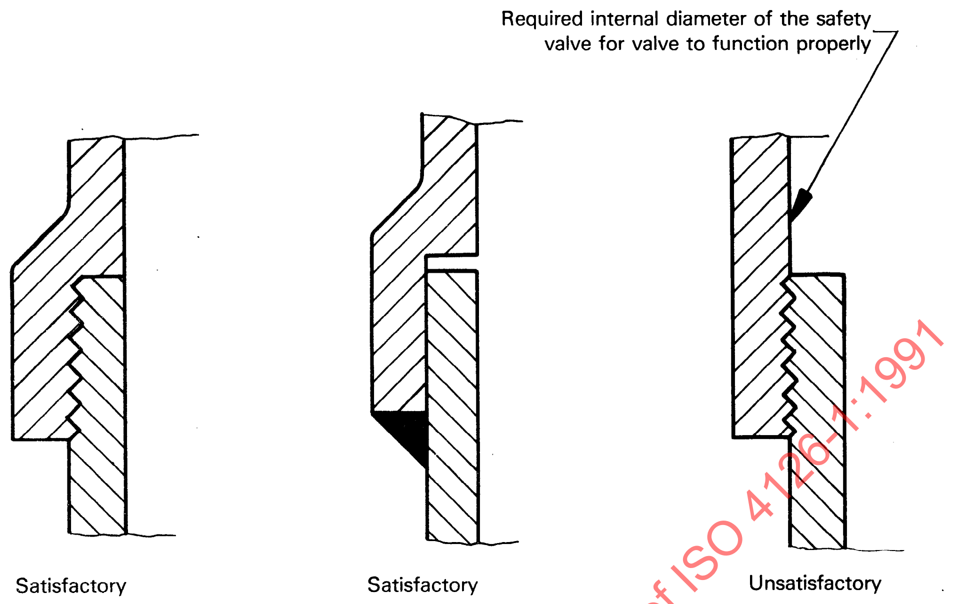


Figure 1 — Design of end connections

4.3 Minimum requirements for safety valve springs

4.3.1 Materials

Safety valve springs shall be made from materials complying with the requirements of an appropriate national standard or International Standard and shall be suitable for the intended service conditions.

4.3.2 Marking

Identification marking of springs which involves metal stamping or etching shall be confined to the inactive coils.

When springs are made of wire of less than 6 mm diameter, identification may alternatively be achieved by means of a metal tag or other suitable method.

4.3.3 Certification

The spring manufacturer shall supply a certificate, if required to do so, stating that the spring(s) has(have) been manufactured and tested in accordance with the requirements of the safety valve manufacturer's specification.

4.3.4 Allowable stresses

The allowable stresses shall be determined on the basis of previous satisfactory experience and the current understanding of the behaviour of spring materials. The service temperature of the spring, and the environment in which it operates, shall be taken into consideration.

4.3.5 Coil spacing

The pitch of the coils shall be regular. The spacing of the coils shall be such that when the safety valve disc is at the lift corresponding to its certified discharge capacity, the minimum space between the coils or the minimum sum of these spaces complies with the appropriate national standard.

4.3.6 Inspection, testing and tolerances

The quality of manufacture, testing and tolerances shall be such as to ensure that the spring is suitable for its intended duty.

All springs shall be tested for permanent set. The permanent set of the spring is defined as the change in the spring's free length as a result of a series of compression cycles to solid in accordance with the safety valve manufacturer's specification or other appropriate standard. The spring should be compressed to solid at least three times before determining the initial free length. The spring is then compressed to solid three more times before measuring the final free length. The permanent set shall not exceed 0,5 % of the initial free length.

4.4 Materials for safety valves

4.4.1 The materials of construction shall be compatible with the process fluid, the adjoining components and the environment in which the safety valve is to be used.

4.4.2 The material of guiding surfaces shall be corrosion resistant and shall be selected to minimize the possibility of galling or seizure.

4.4.3 Materials used for the pressure-retaining components shall be controlled by the manufacturer of the safety valve on the basis of a specification which ensures a control of the quality, chemical properties and mechanical properties at least equivalent to that specified by an appropriate national standard.

5 Integrity testing in the factory of all safety valves

5.1 Purpose

The purpose of these tests is to ensure that each and every safety valve meets the requirements for which it has been designed without exhibiting any form of leakage from pressure retaining components or joints. Each and every safety valve will also be adjusted to suit its designated operating conditions.

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 using magnetic particle or fluid penetrant techniques.

All 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.

In the case where a safety valve is to be subjected to a superimposed back pressure or for valves on closed discharge systems (closed-bonnet valves), then a hydraulic test pressure of 1,5 times the maximum back pressure on the valve shall be applied to those parts on the discharge 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.

5.3.2 Duration

The test pressure shall be applied and maintained at the required magnitude 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.

Table 1 — Minimum duration of hydraulic test

Nominal valve size [1] DN	Pressure rating		
	⩽ 40 bar (4 MPa)	> 40 bar (4 MPa) ⩽ 64 bar (6,4 MPa)	> 64 bar (6,4 MPa)
	Minimum duration min		
DN ⩽ 50	2	2	3
50 < DN ⩽ 65	2	2	4
65 < DN ⩽ 80	2	3	4
80 < DN ⩽ 100	2	4	5
100 < DN ⩽ 125	2	4	6
125 < DN ⩽ 150	2	5	7
150 < DN ⩽ 200	3	5	9
200 < DN ⩽ 250	3	6	11
250 < DN ⩽ 300	4	7	13
300 < DN ⩽ 350	4	8	15
350 < DN ⩽ 400	4	9	17
400 < DN ⩽ 450	4	9	19
450 < DN ⩽ 500	5	10	22
500 < DN ⩽ 600	5	12	24

1) Sizes larger than DN 600 shall have testing times *pro rata*.

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 (5.3) with the agreement of all parties involved in the following cases:

a) valves of such design and construction that it 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 specified in 5.3.1.

5.4.2 Duration

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

5.4.3 Safety requirements

The hazards involved in pneumatic pressure testing shall be considered and adequate precautions taken.

Particular attention is drawn to some relevant factors as follows.

a) 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 at the same pressure.)

b) 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.

c) Attention is drawn to the fact that if there is a reduction in gas pressure between the high pressure storage and the valve under test, the temperature will decrease.

Valves undergoing pneumatic test should not be approached for close inspection until after the pressure increase 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 a 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 gases or liquids of known characteristics

6.1 General

The operating and flow characteristics of safety valves shall be determined by type tests in conformity with this clause. For the quality assurance of these valves, see clause 10.

6.1.1 Application

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

6.1.2 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

The object of the tests is 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) re-seating pressure;

c) blowdown;

d) reproducibility of valve performance;

e) mechanical characteristics of the valves determined by sight 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 procedure and calibration procedure;

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

6.1.5 Results calculated from tests

The theoretical flowing capacity is calculated (see 7.2, 7.3 or 7.5, and 7.4 if applicable) 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).

6.1.6 Design changes

When changes are made in the design of a safety valve in such a manner as to affect the flow path, lift or performance characteristics of the valve, new tests shall be carried out in accordance with clause 6.

6.2 Tests to determine operating characteristics

6.2.1 Test requirements

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 air or other gas service shall be tested using steam, air or other gas of known characteristics. Valves for steam service shall 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 the operating characteristics are as follows:

a) set pressure: ± 3 % of set pressure or ± 0,15 bar (0,015 MPa), whichever is the greater;

b) lift: not lower than the value stated by the manufacturer;

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

— a flow diameter less than 15 mm when the maximum limit of blowdown shall be 15 % of set pressure;

— values of set pressure less than 3 bar gauge (0,3 MPa) when the blowdown shall be a maximum of 0,3 bar (0,03 MPa);

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 gauge (0,3 MPa), the blowdown shall be a maximum of 0,6 bar (0,06 MPa).

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

The independent authority may dispense with the operating characteristic tests 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 be not more than 0,5 % of the 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. The ratio of valve inlet area to flow area and the ratio of flow area to valve outlet area shall be taken into account.

For size ranges containing seven or more sizes, tests shall be carried out on three sizes. If the size range contains not more than six sizes, the number of sizes tested may be reduced to two.

When a size range is extended so that the safety valves tested previously are no longer representative of the range, further tests on the appropriate number of sizes shall be carried out.

6.2.4 Test procedure

The tests shall be carried out using three significantly different springs for each size of valve tested. 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 is to be used.

6.3 Tests to determine flow characteristics

6.3.1 Test requirements

For safety valves for steam service, after the 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 disc shall be mechanically held at the same lift as that obtained with steam.

6.3.2 Valves used in the test programme

The safety valves tested shall be the same as or identical to those used for the operational tests (see 6.2.3).

The valve configuration shall be the same as that used during the tests for operational characteristics, i.e. the lift and the position(s) of the blowdown ring(s), when such a ring or rings is(are) fitted, shall be the same as those established for the particular size and overpressure during operational testing. Average values shall be used when the tolerances specified in 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(s) position. These curves may then be used to obtain the unique value desired on the basis of the results of the operational testing.

6.3.3 Test procedure

The tests 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 a size range is extended from one containing less than seven sizes to one containing seven or more sizes, then tests on three sizes of valves (a total of nine tests) shall be carried out.

A curve may be established for the coefficient of discharge versus valve lift at a given inlet pressure and, where applicable, the appropriate position(s) of the blowdown ring(s). Coefficients of discharge for intermediate positions of lift may be interpolated from this curve. Tests shall be conducted to establish the variation in the coefficient of discharge with inlet pressure and relevant position(s) of the blowdown ring(s). 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 the 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 size 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 shall be within ± 5 % of the arithmetic 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 tests. Following any change or deviation in 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 records (if required) for the objective(s) of the tests. Original test records shall remain in the custody of the test establishment which conducted the tests. Copies of all test records shall be furnished to each of the parties concerned with the tests. 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 Determination of the coefficient of discharge

For the determination of the coefficient of discharge see 7.1.

6.5 Certification of valves

The certified capacity of the valve shall be not greater than 90 % of the capacity determined by test. Where the coefficient of discharge method is used the certified capacity shall be calculated as

a) the theoretical capacity times the coefficient of discharge times 0,9, or

b) the theoretical capacity times the derated coefficient of discharge.

It should be noted that neither the coefficient of discharge nor the derated coefficient of discharge can be used to calculate the capacity at a lower overpressure than that at which the tests to determine flow characteristics (6.3) were carried out although they can be used to calculate the capacity at a higher overpressure.

7 Determination of safety valve performance

7.1 Determination of coefficient of discharge

7.1.1 Coefficient of discharge, K_d

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

$$K_d = \frac{q'_m}{q_m}$$

where

q'_m is the actual flowing capacity (from test);

q_m is the theoretical flowing capacity (from calculation).

7.1.2 Derated coefficient of discharge, K_{dr}

The derated coefficient of discharge, K_{dr}, is calculated from the coefficient of discharge as follows:

$$K_{dr} = K_d \times 0,9$$

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

7.2.1 Dry saturated steam

Dry saturated steam in this context refers to steam with a minimum dryness fraction of 98 % or a maximum degree of superheat of 10 °C.

For applications from 1 bar gauge (0,1 MPa) up to and including 110 bar gauge (11 MPa)

$$q_{ms} = 0,525\,p \qquad \ldots (1)$$

and for applications over 110 bar gauge (11 MPa) and up to 220 bar gauge (22 MPa)

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

where

p is the actual relieving pressure, in bar absolute;

q_{ms} is the theoretical flowing capacity, in kilograms per hour per square millimetre of flow area.

7.2.2 Superheated steam

Superheated steam in this context refers to steam with a degree of superheat greater than 10 °C.

For applications from 1 bar gauge (0,1 MPa) up to and including 110 bar gauge (11 MPa)

$$q_{mSh} = 0,525\,p\,K_{Sh} \qquad \ldots (3)$$

and for applications over 110 bar gauge (11 MPa) and up to 220 bar gauge (22 MPa)

$$q_{mSh} = 0,525\,p \left(\frac{2,764\,4\,p - 1\,000}{3,324\,2\,p - 1\,061}\right) K_{Sh} \qquad \ldots (4)$$

where

K_{Sh} is the superheat correction factor (for rounded figures, see table 2);

p is the actual relieving pressure, in bar absolute;

q_{mSh} is the theoretical flowing capacity, in kilograms per hour per square millimetre of flow area.

7.2.3 Alternative

The theoretical flowing capacity q_m for dry saturated steam and for superheated steam without pressure limitation may also be calculated as follows:

$$q_m = 0,288\,3\,C \sqrt{\frac{p}{v}} \qquad \ldots (5)$$

where

C is a function of the isentropic exponent κ [see equation (6), or for rounded figures, see table 3]

$$C = 3,948 \sqrt{\kappa \left(\frac{2}{\kappa + 1}\right)^{\frac{\kappa + 1}{\kappa - 1}}} \qquad \ldots (6)$$

where κ is the isentropic exponent at the relieving inlet conditions; if the value of κ is not available at these conditions the value at 1,013 bar (0,101 3 MPa) and 15 °C shall be used;

The value of κ used to determine C shall be based on the actual flowing conditions at the safety valve inlet and shall be determined from figure B.2.

p is the actual relieving pressure, in bar absolute;

v is the specific volume at the actual relieving pressure and the actual relieving temperature, in cubic metres per kilogram.

NOTE — The results obtained from equations (3) and (4) are not necessarily identical with those obtained from equation (5) owing to the differing derivations, but the differences are minimal.

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

7.3.1 Critical and subcritical flow

The flow of gas or vapour through an orifice, such as the flow area through a safety valve, increases as the downstream pressure is decreased until critical flow is achieved. Further decrease in the downstream pressure will not result in any further increase in flow.

Critical flow occurs when

$$\frac{p_b}{p} \leqslant \left(\frac{2}{\kappa + 1}\right)^{\frac{\kappa}{\kappa - 1}}$$

and subcritical flow occurs when

$$\frac{p_b}{p} > \left(\frac{2}{\kappa + 1}\right)^{\frac{\kappa}{\kappa - 1}}$$

where the validity of Rankine's law is assumed and where

p is the actual relieving pressure, in bar absolute;

p_b is the back pressure, in bar absolute;

κ is the isentropic exponent at the relieving inlet conditions (for an ideal gas, κ is equal to the ratio of the specific heat capacities).

7.3.2 Discharge capacity at critical flow

$$q_{mg} = pC\sqrt{\frac{M}{ZT}} = 0{,}288\,3\,C\sqrt{\frac{p}{v}} \qquad \ldots (7)$$

where the validity of Rankine's law is assumed and where

C is a function of the isentropic coefficient κ [for rounded figures, see table 3; see also equation (6) for the derivation];

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

p is the actual relieving pressure, in bar absolute;

q_{mg} is the theoretical flowing capacity, in kilograms per hour per square millimetre of flow area;

T is the actual relieving temperature, in kelvin;

v is the specific volume at the actual relieving pressure and the actual relieving temperature, in cubic metres per kilogram;

Z is the compressibility factor; in many cases Z is unity and may be neglected (see figure B.1).

7.3.3 Discharge capacity at subcritical flow

$$q_{mg} = pCK_b\sqrt{\frac{M}{ZT}} = 0{,}288\,3\,CK_b\sqrt{\frac{p}{v}} \qquad \ldots (8)$$

where

C is a function of the isentropic exponent κ [for rounded figures, see table 3; see also equation (6) for the derivation];

K_b is the theoretical capacity correction factor for subcritical flow (for rounded figures, see table 4);

$$K_b = \sqrt{\frac{\dfrac{2\kappa}{\kappa - 1}\left[\left(\dfrac{p_b}{p}\right)^{\frac{2}{\kappa}} - \left(\dfrac{p_b}{p}\right)^{\frac{\kappa + 1}{\kappa}}\right]}{\kappa\left(\dfrac{2}{\kappa + 1}\right)^{\frac{\kappa + 1}{\kappa - 1}}}} \qquad \ldots (9)$$

where

p_b is the back pressure, in bar absolute;

κ is the isentropic exponent at the relieving inlet conditions;

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

p is the actual relieving pressure, in bar absolute;

q_{mg} is the theoretical flowing capacity, in kilograms per hour per square millimetre of flow area;

T is the actual relieving temperature, in kelvin;

v is the specific volume at the actual relieving pressure and the actual relieving temperature, in cubic metres per kilogram;

Z is the compressibility factor; in many cases Z is unity and may be neglected (see figure B.1).

Table 2 — Superheat

(For derivation of these

Pressure bar absolute	Saturation temperature °C	Inlet																					
		150	160	170	180	190	200	210	220	230	240	250	260	270	280	290	300	310	320	330	340	350	360
		Superheat correction																					
2	120	1,00	1,00	1,00	1,00	1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,89	0,88	0,87	0,86	0,86	0,85
3	133	1,00	1,00	1,00	1,00	1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,89	0,88	0,87	0,86	0,86	0,85
4	144	1,00	1,00	1,00	1,00	1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,90	0,89	0,88	0,87	0,86	0,86	0,85
5	152	1,00	1,00	1,00	1,00	1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,90	0,89	0,88	0,87	0,87	0,86	0,85
6	159		1,00	1,00	1,00	1,00	0,99	0,99	0,98	0,96	0,95	0,94	0,93	0,92	0,92	0,91	0,90	0,89	0,88	0,87	0,87	0,86	0,85
7	165			1,00	1,00	1,00	0,99	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,92	0,90	0,89	0,88	0,87	0,87	0,86	0,85
8	170			1,00	1,00	1,00	1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,92	0,90	0,89	0,88	0,88	0,87	0,86	0,85
9	175				1,00	1,00	1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,92	0,90	0,89	0,88	0,88	0,87	0,86	0,85
10	180				1,00	1,00	1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,92	0,90	0,89	0,88	0,88	0,87	0,86	0,85
11	184					1,00	1,00	0,99	0,99	0,97	0,96	0,95	0,94	0,93	0,92	0,92	0,90	0,89	0,89	0,88	0,87	0,86	0,85
12	188					1,00	1,00	0,99	0,99	0,98	0,97	0,95	0,94	0,93	0,92	0,92	0,90	0,90	0,89	0,88	0,87	0,86	0,85
13	192						1,00	1,00	0,99	0,98	0,97	0,96	0,94	0,93	0,92	0,92	0,91	0,90	0,89	0,88	0,87	0,86	0,86
14	195						1,00	1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,87	0,86	0,86
15	198						1,00	1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,87	0,86	0,86
16	201						1,00	1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,88	0,87	0,86
17	204							1,00	0,99	0,99	0,98	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,88	0,87	0,86
18	207							1,00	1,00	0,99	0,98	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,88	0,87	0,86
19	210							1,00	1,00	0,99	0,98	0,97	0,95	0,95	0,93	0,92	0,91	0,90	0,89	0,88	0,88	0,87	0,86
20	212								1,00	0,99	0,98	0,97	0,96	0,95	0,93	0,92	0,91	0,90	0,89	0,89	0,88	0,87	0,86
21	215								1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,92	0,91	0,90	0,90	0,89	0,88	0,87	0,86
22	217								1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,87	0,86
23	220								1,00	0,99	0,98	0,97	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,87	0,86
24	222									1,00	0,99	0,98	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,87	0,86
26	226									1,00	0,99	0,98	0,97	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,87	0,87
28	230									1,00	0,99	0,99	0,97	0,96	0,95	0,93	0,92	0,91	0,90	0,89	0,88	0,87	0,87
30	234										0,99	0,99	0,98	0,96	0,95	0,94	0,93	0,91	0,90	0,90	0,89	0,88	0,87
32	237										1,00	0,99	0,98	0,96	0,95	0,94	0,93	0,92	0,91	0,90	0,89	0,88	0,87
34	241										1,00	0,99	0,98	0,97	0,95	0,95	0,93	0,92	0,91	0,90	0,89	0,88	0,87
36	244											1,00	0,98	0,97	0,96	0,95	0,93	0,92	0,91	0,90	0,90	0,88	0,87
38	247											1,00	0,99	0,97	0,96	0,95	0,94	0,93	0,91	0,90	0,90	0,88	0,87
40	250											1,00	0,99	0,98	0,97	0,95	0,94	0,93	0,92	0,90	0,90	0,89	0,88
42	253												0,99	0,98	0,97	0,96	0,94	0,93	0,92	0,91	0,90	0,89	0,88
44	256												0,99	0,98	0,97	0,96	0,94	0,93	0,92	0,91	0,90	0,89	0,88
46	259												1,00	0,99	0,97	0,96	0,95	0,94	0,92	0,91	0,90	0,89	0,88
48	261												1,00	0,99	0,98	0,97	0,95	0,94	0,93	0,92	0,90	0,89	0,88
50	264													0,99	0,98	0,97	0,95	0,94	0,93	0,92	0,91	0,89	0,88
52	266													0,99	0,98	0,97	0,96	0,94	0,93	0,92	0,91	0,90	0,88
54	269													1,00	0,99	0,97	0,96	0,95	0,93	0,92	0,91	0,90	0,89
56	271													1,00	0,99	0,98	0,96	0,95	0,94	0,92	0,91	0,90	0,89
58	273														0,99	0,98	0,96	0,95	0,94	0,93	0,91	0,90	0,89
60	276														0,99	0,98	0,97	0,95	0,94	0,93	0,92	0,90	0,89
62	278														0,99	0,99	0,97	0,96	0,94	0,93	0,92	0,91	0,90
64	280														1,00	0,99	0,97	0,96	0,95	0,94	0,92	0,91	0,90
66	282															0,99	0,97	0,96	0,95	0,94	0,92	0,91	0,90
68	284															0,99	0,98	0,96	0,95	0,94	0,93	0,91	0,90
70	286															0,99	0,98	0,97	0,95	0,94	0,94	0,92	0,90
75	290															1,00	0,99	0,97	0,96	0,95	0,94	0,92	0,91
80	295																0,99	0,98	0,96	0,96	0,94	0,93	0,91
85	299																1,00	0,98	0,97	0,96	0,95	0,93	0,92
90	303																	0,99	0,98	0,97	0,96	0,94	0,93
95	307																	0,99	0,98	0,97	0,97	0,95	0,93
100	311																	1,00	0,99	0,97	0,97	0,96	0,94
105	314																		0,99	0,98	0,97	0,97	0,95
110	318																		1,00	0,98	0,98	0,97	0,95
115	321																		1,00	0,98	0,98	0,97	0,96
120	324																			0,99	0,98	0,97	0,96
125	327																			0,99	0,98	0,97	0,97
130	331																			1,00	0,98	0,97	0,97
135	333																				0,99	0,97	0,96
140	336																				0,99	0,97	0,96
145	339																				1,00	0,98	0,96
150	342																				1,00	0,98	0,96
155	344																					0,99	0,97
160	347																					1,00	0,97
165	350																						0,97
170	352																						0,97
175	354																						0,98
180	357																						0,99
185	359																						1,00
190	361																						1,00
195	364																						
200	366																						
205	368																						
210	370																						
215	372																						
220	374																						

correction factors, K_{Sh}
factors, see annex A)

temperature, °C

370	380	390	400	410	420	430	440	450	460	470	480	490	500	510	520	530	540	550	560	570	580	590	600	610	620	630	640
factors, K_{Sh}																											
0,84	0,83	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,79	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,73	0,72	0,72	0,71	0,71	0,70	0,70
0,84	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,73	0,72	0,72	0,71	0,71	0,70	0,70
0,84	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,73	0,72	0,72	0,71	0,71	0,70	0,70
0,84	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,70	0,70
0,84	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,70	0,70
0,84	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,79	0,78	0,78	0,77	0,76	0,76	0,76	0,75	0,74	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,70	0,70
0,85	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,70	0,70
0,85	0,84	0,83	0,83	0,82	0,81	0,80	0,80	0,79	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,70	0,70
0,85	0,84	0,83	0,83	0,82	0,81	0,80	0,80	0,79	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,71	0,70
0,85	0,84	0,83	0,83	0,82	0,81	0,80	0,80	0,79	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,71	0,70
0,85	0,84	0,83	0,83	0,82	0,81	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,71	0,70
0,85	0,84	0,83	0,83	0,82	0,81	0,81	0,80	0,80	0,78	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,71	0,70
0,85	0,84	0,83	0,83	0,82	0,81	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,71	0,70
0,85	0,84	0,84	0,83	0,82	0,81	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,71	0,70
0,85	0,84	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,71	0,70
0,85	0,84	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,71	0,70
0,85	0,84	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,72	0,71	0,71	0,70
0,85	0,85	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,72	0,71	0,71	0,70
0,85	0,85	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,72	0,71	0,71	0,70
0,85	0,85	0,84	0,83	0,82	0,82	0,82	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,72	0,71	0,71	0,70
0,85	0,85	0,84	0,83	0,83	0,82	0,82	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,72	0,71	0,71	0,70
0,86	0,85	0,84	0,84	0,83	0,82	0,82	0,80	0,80	0,79	0,79	0,78	0,77	0,77	0,77	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,72	0,71	0,71	0,70
0,86	0,85	0,84	0,84	0,83	0,82	0,82	0,80	0,80	0,79	0,79	0,78	0,77	0,77	0,77	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,72	0,71	0,71	0,70
0,86	0,85	0,84	0,84	0,83	0,82	0,82	0,81	0,80	0,79	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,74	0,74	0,73	0,73	0,73	0,72	0,72	0,71	0,71	0,70
0,86	0,85	0,84	0,84	0,83	0,82	0,82	0,81	0,80	0,79	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,73	0,73	0,73	0,72	0,72	0,71	0,71	0,70
0,86	0,85	0,84	0,84	0,83	0,82	0,82	0,81	0,80	0,79	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,73	0,73	0,73	0,72	0,72	0,71	0,71	0,70
0,86	0,85	0,84	0,84	0,83	0,82	0,82	0,81	0,80	0,79	0,79	0,79	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,70
0,86	0,85	0,84	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,79	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,70
0,86	0,86	0,84	0,84	0,83	0,83	0,82	0,81	0,81	0,80	0,79	0,79	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,70
0,87	0,86	0,85	0,84	0,83	0,83	0,82	0,81	0,81	0,80	0,79	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,70
0,87	0,86	0,85	0,84	0,83	0,83	0,82	0,81	0,81	0,80	0,79	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,70
0,87	0,86	0,85	0,84	0,84	0,83	0,82	0,81	0,81	0,80	0,79	0,79	0,78	0,78	0,77	0,77	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,71
0,87	0,86	0,85	0,84	0,84	0,83	0,82	0,81	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,72	0,71	0,71
0,87	0,86	0,85	0,85	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,72	0,71	0,71
0,87	0,86	0,86	0,85	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71
0,87	0,87	0,86	0,85	0,84	0,83	0,83	0,82	0,81	0,80	0,80	0,79	0,79	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71
0,88	0,87	0,86	0,85	0,84	0,83	0,83	0,82	0,81	0,81	0,80	0,79	0,79	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71
0,88	0,87	0,86	0,85	0,84	0,84	0,83	0,82	0,81	0,81	0,80	0,79	0,79	0,78	0,77	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71
0,88	0,87	0,86	0,85	0,84	0,84	0,83	0,82	0,81	0,81	0,80	0,79	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71
0,88	0,87	0,86	0,85	0,85	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71
0,88	0,87	0,86	0,85	0,85	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71
0,88	0,88	0,87	0,86	0,85	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71
0,89	0,88	0,87	0,86	0,85	0,84	0,83	0,83	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71
0,89	0,88	0,87	0,86	0,85	0,84	0,84	0,83	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71
0,89	0,88	0,87	0,86	0,85	0,84	0,84	0,83	0,82	0,81	0,81	0,80	0,79	0,79	0,78	0,77	0,77	0,76	0,76	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71
0,89	0,88	0,87	0,86	0,85	0,84	0,84	0,83	0,82	0,81	0,81	0,80	0,79	0,79	0,78	0,77	0,77	0,76	0,76	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71	0,71
0,90	0,89	0,88	0,87	0,85	0,85	0,84	0,83	0,82	0,81	0,81	0,80	0,79	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71
0,91	0,89	0,88	0,87	0,86	0,85	0,84	0,83	0,83	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71
0,91	0,90	0,88	0,87	0,86	0,85	0,84	0,83	0,83	0,82	0,81	0,81	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71
0,91	0,90	0,89	0,88	0,87	0,86	0,84	0,84	0,83	0,82	0,81	0,81	0,80	0,79	0,79	0,78	0,77	0,77	0,76	0,76	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71
0,92	0,90	0,89	0,88	0,87	0,86	0,85	0,84	0,83	0,82	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,75	0,75	0,73	0,73	0,72	0,72	0,71
0,92	0,91	0,90	0,88	0,87	0,86	0,85	0,85	0,84	0,83	0,82	0,81	0,80	0,80	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,75	0,75	0,74	0,73	0,73	0,72	0,71
0,93	0,92	0,90	0,89	0,88	0,87	0,86	0,85	0,84	0,83	0,82	0,81	0,81	0,80	0,79	0,78	0,78	0,77	0,77	0,76	0,75	0,75	0,75	0,74	0,73	0,73	0,72	0,72
0,94	0,92	0,91	0,89	0,88	0,87	0,86	0,85	0,84	0,83	0,82	0,81	0,81	0,80	0,79	0,79	0,78	0,77	0,77	0,76	0,75	0,75	0,75	0,74	0,73	0,72	0,72	0,72
0,94	0,92	0,91	0,89	0,88	0,87	0,86	0,85	0,84	0,83	0,82	0,81	0,81	0,80	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,75	0,75	0,74	0,73	0,72	0,72	0,71
0,94	0,92	0,91	0,89	0,88	0,87	0,86	0,85	0,84	0,83	0,82	0,81	0,81	0,80	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,74	0,74	0,73	0,73	0,72	0,72	0,71
0,95	0,93	0,91	0,90	0,88	0,87	0,86	0,85	0,84	0,83	0,82	0,81	0,80	0,80	0,79	0,78	0,77	0,77	0,76	0,75	0,75	0,74	0,74	0,73	0,73	0,72	0,71	0,71
0,95	0,93	0,91	0,90	0,88	0,87	0,86	0,85	0,84	0,83	0,82	0,81	0,80	0,79	0,79	0,78	0,77	0,76	0,76	0,75	0,75	0,74	0,74	0,73	0,72	0,72	0,71	0,71
0,95	0,93	0,91	0,90	0,88	0,87	0,86	0,85	0,84	0,83	0,82	0,81	0,80	0,79	0,78	0,78	0,77	0,76	0,76	0,75	0,74	0,74	0,74	0,73	0,72	0,71	0,71	0,70
0,96	0,93	0,91	0,90	0,88	0,87	0,86	0,85	0,83	0,82	0,82	0,81	0,80	0,79	0,78	0,77	0,77	0,76	0,75	0,75	0,74	0,73	0,73	0,72	0,72	0,71	0,71	0,70
0,96	0,94	0,92	0,90	0,88	0,87	0,86	0,84	0,83	0,82	0,81	0,80	0,80	0,79	0,78	0,77	0,76	0,76	0,75	0,74	0,74	0,73	0,73	0,72	0,71	0,71	0,70	0,70
0,96	0,94	0,92	0,90	0,88	0,87	0,86	0,84	0,83	0,82	0,81	0,80	0,79	0,78	0,78	0,77	0,76	0,75	0,75	0,74	0,73	0,73	0,73	0,72	0,71	0,71	0,70	0,70
0,96	0,94	0,92	0,90	0,88	0,87	0,86	0,84	0,83	0,82	0,81	0,80	0,79	0,78	0,77	0,77	0,76	0,75	0,74	0,74	0,73	0,73	0,73	0,71	0,71	0,70	0,70	0,69
0,95	0,95	0,92	0,90	0,88	0,87	0,86	0,84	0,83	0,82	0,81	0,80	0,79	0,78	0,77	0,76	0,76	0,75	0,74	0,73	0,73	0,72	0,72	0,71	0,70	0,70	0,69	0,69
0,95	0,95	0,92	0,90	0,88	0,87	0,86	0,84	0,83	0,82	0,80	0,79	0,78	0,78	0,77	0,76	0,75	0,74	0,74	0,73	0,72	0,72	0,72	0,71	0,70	0,70	0,69	0,68
0,95	0,95	0,92	0,90	0,88	0,86	0,86	0,84	0,82	0,81	0,80	0,79	0,78	0,77	0,76	0,76	0,75	0,74	0,73	0,73	0,72	0,71	0,71	0,70	0,70	0,69	0,69	0,68
0,95	0,94	0,93	0,90	0,88	0,86	0,86	0,83	0,82	0,81	0,80	0,79	0,78	0,77	0,76	0,75	0,74	0,74	0,73	0,72	0,72	0,71	0,71	0,70	0,69	0,69	0,68	0,68
0,95	0,94	0,93	0,90	0,88	0,86	0,86	0,83	0,82	0,80	0,79	0,78	0,77	0,76	0,76	0,75	0,74	0,73	0,73	0,72	0,71	0,71	0,71	0,69	0,69	0,68	0,68	0,67
0,96	0,94	0,93	0,90	0,88	0,86	0,85	0,83	0,81	0,80	0,79	0,78	0,77	0,76	0,75	0,74	0,74	0,73	0,72	0,71	0,71	0,70	0,70	0,69	0,68	0,68	0,67	0,67
0,96	0,94	0,93	0,90	0,88	0,86	0,84	0,82	0,81	0,80	0,79	0,78	0,77	0,76	0,75	0,74	0,73	0,73	0,72	0,71	0,70	0,70	0,70	0,68	0,68	0,67	0,67	0,66
0,96	0,94	0,92	0,90	0,87	0,85	0,83	0,82	0,80	0,79	0,79	0,77	0,76	0,75	0,74	0,73	0,72	0,72	0,71	0,70	0,70	0,69	0,69	0,68	0,67	0,67	0,66	0,65
0,97	0,93	0,92	0,90	0,87	0,85	0,83	0,81	0,80	0,79	0,78	0,76	0,75	0,74	0,74	0,73	0,72	0,72	0,70	0,70	0,69	0,68	0,68	0,67	0,67	0,66	0,65	0,65
0,98	0,93	0,92	0,90	0,87	0,85	0,83	0,81	0,79	0,78	0,77	0,76	0,75	0,74	0,73	0,72	0,71	0,71	0,70	0,69	0,68	0,68	0,68	0,66	0,66	0,66	0,65	0,64
1,00	0,93	0,91	0,90	0,87	0,84	0,82	0,80	0,79	0,78	0,76	0,75	0,74	0,73	0,72	0,71	0,70	0,70	0,69	0,68	0,68	0,67	0,67	0,66	0,65	0,65	0,64	0,64
	0,94	0,91	0,89	0,86	0,84	0,82	0,80	0,78	0,77	0,76	0,74	0,73	0,72	0,71	0,71	0,70	0,69	0,68	0,67	0,67	0,66	0,66	0,65	0,64	0,64	0,63	0,63
	0,94	0,90	0,89	0,86	0,83	0,81	0,79	0,78	0,76	0,75	0,74	0,73	0,72	0,71	0,70	0,69	0,68	0,67	0,67	0,66	0,65	0,65	0,64	0,64	0,63	0,62	0,62

Table 3 — Values of C as a function of κ

κ	C	κ	C	κ	C
0,40	1,65	1,02	2,41	1,42	2,72
0,45	1,73	1,04	2,43	1,44	2,73
0,50	1,81	1,06	2,45	1,46	2,74
0,55	1,89	1,08	2,46	1,48	2,76
0,60	1,96	1,10	2,48	1,50	2,77
0,65	2,02	1,12	2,50	1,52	2,78
0,70	2,08	1,14	2,51	1,54	2,79
0,75	2,14	1,16	2,53	1,56	2,80
0,80	2,20	1,18	2,55	1,58	2,82
0,82	2,22	1,20	2,56	1,60	2,83
0,84	2,24	1,22	2,58	1,62	2,84
0,86	2,26	1,24	2,59	1,64	2,85
0,88	2,28	1,26	2,61	1,66	2,86
0,90	2,30	1,28	2,62	1,68	2,87
0,92	2,32	1,30	2,63	1,70	2,89
0,94	2,34	1,32	2,65	1,80	2,94
0,96	2,36	1,34	2,66	1,90	2,99
0,98	2,38	1,36	2,68	2,00	3,04
0,99	2,39	1,38	2,69	2,10	3,09
1,001	2,40	1,40	2,70	2,20	3,13

7.4 Capacity correction for the effect of back pressure

If the capacity of the valve ceases to be independent of the back pressure, i.e. if subcritical flow occurs, even if the lift remains constant, a capacity correction shall be applied to allow for the decrease in capacity.

For valves where the lift is a function of back pressure, the manufacturer shall be asked to supply specific information, as verified by the independent authority, where applicable.

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

$$q_{ml} = 1{,}61 \sqrt{\varrho \, \Delta p} \qquad \ldots (10)$$

where

$\Delta p = p - p_b$ is the pressure drop, in bar;

where

p is the actual relieving pressure, in bar absolute;

p_b is the back pressure, in bar absolute;

q_{ml} is the theoretical flowing capacity, in kilograms per hour per square millimetre of flow area;

ϱ is the volumetric mass, in kilograms per cubic metre.

Table 4 — Theoretical capacity correction factors for subcritical flow, K_b

p_b/p	Isentropic exponent, κ																		
	0,4	0,5	0,6	0,7	0,8	0,9	1,001	1,1	1,2	1,3	1,4	1,5	1,6	1,7	1,8	1,9	2,0	2,1	2,2
	Capacity correction factors for subcritical flow, K_b																		
0,45																	1,00	0,999	0,999
0,50												1,000	1,000	0,999	0,999	0,996	0,994	0,992	0,989
0,55									0,999	1,000	0,999	0,997	0,994	0,991	0,987	0,983	0,979	0,975	0,971
0,60							1,000	0,999	0,997	0,993	0,989	0,983	0,978	0,972	0,967	0,961	0,955	0,950	0,945
0,65						0,999	0,995	0,989	0,982	0,974	0,967	0,959	0,951	0,944	0,936	0,929	0,922	0,915	0,909
0,70			0,999	0,999	0,993	0,985	0,975	0,964	0,953	0,943	0,932	0,922	0,913	0,903	0,895	0,886	0,879	0,871	0,864
0,75		1,000	0,995	0,983	0,968	0,953	0,938	0,923	0,909	0,896	0,884	0,872	0,861	0,851	0,841	0,832	0,824	0,815	0,808
0,80	0,999	0,985	0,965	0,942	0,921	0,900	0,881	0,864	0,847	0,833	0,819	0,806	0,794	0,783	0,773	0,764	0,755	0,747	0,739
0,82	0,992	0,970	0,944	0,918	0,894	0,872	0,852	0,833	0,817	0,801	0,787	0,774	0,763	0,752	0,741	0,732	0,723	0,715	0,707
0,84	0,979	0,948	0,917	0,888	0,862	0,839	0,818	0,799	0,782	0,766	0,752	0,739	0,727	0,716	0,706	0,697	0,668	0,680	0,672
0,86	0,957	0,919	0,884	0,852	0,800	0,779	0,769	0,742	0,727	0,712	0,700	0,688	0,677	0,667	0,687	0,658	0,649	0,641	0,634
0,88	0,924	0,881	0,842	0,809	0,780	0,755	0,733	0,714	0,697	0,682	0,668	0,655	0,644	0,633	0,624	0,615	0,606	0,599	0,592
0,90	0,880	0,831	0,791	0,757	0,728	0,703	0,681	0,662	0,645	0,631	0,617	0,605	0,594	0,584	0,575	0,566	0,558	0,551	0,544
0,92	0,820	0,769	0,727	0,693	0,664	0,640	0,619	0,601	0,585	0,571	0,559	0,547	0,537	0,527	0,519	0,511	0,504	0,497	0,490
0,94	0,739	0,687	0,647	0,614	0,587	0,565	0,545	0,528	0,514	0,501	0,489	0,479	0,470	0,461	0,453	0,446	0,440	0,434	0,428
0,96	0,628	0,579	0,542	0,513	0,489	0,469	0,452	0,438	0,425	0,414	0,404	0,395	0,387	0,380	0,373	0,367	0,362	0,357	0,352
0,98	0,462	0,422	0,393	0,371	0,353	0,337	0,325	0,314	0,305	0,296	0,289	0,282	0,277	0,271	0,266	0,262	0,258	0,254	0,251
1,00	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000	0,000

7.6 Viscosity correction factors for liquids

See annex D.

7.7 Alternative method of calculation for the theoretical flowing capacity for any fluid

See annex E.

8 Equivalent capacity

It is not permitted to calculate the equivalent capacity at a lower overpressure than that at which the tests to determine flow characteristics (see 6.3) were carried out although it is permissible to calculate the equivalent capacity at a higher overpressure.

Valves having a certified coefficient of discharge established on critical flow at the test back pressure may not have the same coefficient of discharge at a higher back pressure. Calculations for equivalent capacities for subcritical flow will result in a theoretical capacity equivalence only. Actual capacity for a back pressure above the test back pressure condition and subcritical flow shall only be established by test.

Attention is drawn to the fact that the identification plate (see 9.2) gives information relating to the condition of the fluid used for certification, not to the equivalent calculated capacity.

8.1 Valves for gas or vapour relief

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

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

8.2 Calculation of equivalent capacity

The equation to be applied depends on the reference fluid used to establish the certified capacity (see clause 7) of the safety valve under consideration.

Examples of equivalent capacity equations are given in 8.2.1 to 8.2.4.

8.2.1 Reference fluid — Dry saturated steam

8.2.1.1 Equivalent capacity for superheated steam

$$q_{m\text{Sh}} = q_{m\text{cs}} \times K_{\text{Sh}} \qquad \ldots (11)$$

where

K_{Sh} is the superheat correction factor (for rounded figures, see table 2);

$q_{m\text{cs}}$ is the certified capacity for dry saturated steam, in kilograms per hour per square millimetre of flow area;

$q_{m\text{Sh}}$ is the authorized equivalent capacity of superheated steam, in kilograms per hour per square millimetre of flow area.

8.2.1.2 Equivalent capacity for wet steam

The following equation is applicable only to homogeneous wet steam of dryness fraction 90 % and over.

$$q_{m\text{w}} = \frac{q_{m\text{cs}}}{x} \qquad \ldots (12)$$

where

$q_{m\text{cs}}$ is the certified capacity for dry saturated steam, in kilograms per hour per square millimetre of flow area;

$q_{m\text{w}}$ is the authorized equivalent capacity of wet steam, in kilograms per hour per square millimetre of flow area;

x is the dryness fraction of wet steam at the valve inlet.

8.2.1.3 Equivalent capacity for a gas

a) At a pressure from 1 bar gauge (0,1 MPa) up to and including 110 bar gauge (11 MPa)

$$\frac{q_{m\text{cs}}}{0{,}525\,p} = \frac{q_{m\text{g}}}{pC_{\text{g}}\sqrt{\dfrac{M_{\text{g}}}{Z_{\text{g}}T_{\text{g}}}}} \qquad \ldots (13)$$

for any gas, designated by the subscript g and where

C_{g} is a function of the isentropic exponent κ [for rounded figures see table 3; see also equation (6) for the derivation];

M_{g} is the molecular mass of the gas, in kilograms per kilomole;

p is the actual relieving pressure, in bar absolute;

$q_{m\text{cs}}$ is the certified capacity for dry saturated steam, in kilograms per hour per square millimetre of flow area;

$q_{m\text{g}}$ is the authorized equivalent capacity of a gas, in kilograms per hour per square millimetre of flow area;

T_{g} is the actual relieving temperature, in kelvin;

Z_{g} is the compressibility factor; in many cases Z_{g} is unity and may be neglected (see figure B.1).

b) At a pressure over 110 bar (11 MPa) and up to 220 bar (22 MPa)

$$\frac{q_{m\text{cs}}}{0{,}525\,p\dfrac{(2{,}764\,4\,p - 1\,000)}{(3{,}324\,2\,p - 1\,061)}} = \frac{q_{m\text{g}}}{pC_{\text{g}}\sqrt{\dfrac{M_{\text{g}}}{Z_{\text{g}}T_{\text{g}}}}} \qquad \ldots (14)$$

for any gas designated by the subscript g, and where the symbols have the same meaning as given in equation (13).

8.2.2 Reference fluid — Superheated steam

8.2.2.1 Equivalent capacity for dry saturated steam

a) At a pressure from 1 bar gauge (0,1 MPa) up to and including 110 bar gauge (11 MPa)

$$\frac{q_{mcSh}}{0{,}288\,3\,C\sqrt{\frac{p}{v}}} = \frac{q_{ms}}{0{,}525\,p} \qquad \ldots (15)$$

where

C is a function of the isentropic exponent κ [for rounded figures see table 3; see also equation (6) for the derivation];

p is the actual relieving pressure, in bar absolute;

q_{mcSh} is the certified capacity for superheated steam, in kilograms per hour per square millimetre of flow area;

q_{ms} is the authorized equivalent capacity of dry saturated steam, in kilograms per hour per square millimetre of flow area;

v is the specific volume at the actual relieving pressure and the actual relieving temperature, in cubic metres per kilogram.

b) At a pressure over 110 bar gauge (11 MPa) and up to 220 bar gauge (22 MPa)

$$\frac{q_{mcSh}}{0{,}288\,3\,C\sqrt{\frac{p}{v}}} = \frac{q_{ms}}{0{,}525\,p\,\frac{(2{,}764\,4\,p - 1\,000)}{(3{,}324\,2\,p - 1\,061)}} \qquad \ldots (16)$$

where the symbols have the same meaning as given in equation (15).

8.2.2.2 Equivalent capacity for a gas

By virtue of the relationship between saturated and superheated steam as stated in equation (11), one can write

a) at a pressure from 1 bar gauge (0,1 MPa) up to and including 110 bar gauge (11 MPa)

$$\frac{q_{mcSh}}{0{,}525\,p\,K_{Sh}} = \frac{q_{mg}}{pC_g\sqrt{\frac{M_g}{Z_gT_g}}} \qquad \ldots (17)$$

for any gas, designated by the subscript g, and

b) at a pressure over 110 bar gauge (11 MPa) and up to 220 bar gauge (22 MPa)

$$\frac{q_{mcSh}}{0{,}525\,p\,\frac{(2{,}764\,4\,p - 1\,000)}{(3{,}324\,2\,p - 1\,061)}K_{Sh}} = \frac{q_{mg}}{pC_g\sqrt{\frac{M_g}{Z_gT_g}}} \qquad \ldots (18)$$

for any gas, designated by the subscript g, and where

C_g is a function of the isentropic exponent κ [for rounded figures see table 3; see also equation (6) for the derivation];

K_{Sh} is the superheat correction factor (for rounded figures see table 2);

M_g is the molecular mass of the gas, in kilograms per kilomole;

p is the actual relieving pressure, in bar absolute;

q_{mcSh} is the certified capacity for superheated steam, in kilograms per hour per square millimetre of flow area;

q_{mg} is the authorized equivalent capacity of a gas, in kilograms per hour per square millimetre of flow area;

T_g is the actual relieving temperature, in kelvin;

Z_g is the compressibility factor; in many cases Z_g is unity and may be neglected (see figure B.1).

Alternatively to a) and b) above, one has

c) without any pressure limitations

$$\frac{q_{mcSh}}{0{,}288\,3\,C\sqrt{\frac{p}{v}}} = \frac{q_{mg}}{pC_g\sqrt{\frac{M_g}{Z_gT_g}}} \qquad \ldots (19)$$

for any gas designated by the subscript g, and where the symbols have the same meaning as given in equations (17) and (18), and

v is the specific volume at the actual relieving pressure and the actual relieving temperature, in cubic metres per kilogram.

NOTE — The results obtained from equations (17) and (18) are not necessarily identical with the results obtained from equation (19) owing to differing derivations, but the differences are minimal.

8.2.3 Reference fluid — A gas (designated 1) of known characteristics

The equivalent capacity for a gas (designated 2) is

$$\frac{q_{mcg1}}{pC_{g1}\sqrt{\frac{M_{g1}}{Z_{g1}T_{g1}}}} = \frac{q_{mg2}}{pC_{g2}\sqrt{\frac{M_{g2}}{Z_{g2}T_{g2}}}} \qquad \ldots (20)$$

where

C_g is a function of the isentropic exponent κ [for rounded figures see table 3; see also equation (6) for the derivation];

M_g is the molecular mass of the gas, in kilograms per kilomole;

p is the actual relieving pressure, in bar absolute;

q_{mcg1} is the certified capacity for a gas (designated 1), in kilograms per hour per square millimetre of flow area;

q_{mg2} is the authorized equivalent capacity of a gas (designated 2), in kilograms per hour per square millimetre of flow area;

T_g is the actual relieving temperature, in kelvin;

Z_g is the compressibility factor; in many cases Z_g is unity and may be neglected (see figure B.1).

NOTE — Subscripts 1 and 2, associated with the appropriate symbols above, respectively indicate the reference fluid and the fluid for which the equivalent capacity is required.

8.2.4 Reference fluid — A liquid (designated 1) of known characteristics

(See also 7.6 and annex D.)

Only equivalent capacities for liquids may be calculated from the certified capacity using a reference liquid. Certified liquid capacities shall not be used to calculate equivalent capacities for steam, gas or flashing liquids.

The equivalent capacity for a liquid (designated 2) is

$$q_{ml2} = q_{mcl1} \sqrt{\frac{\varrho_{l2}\,\Delta p_{l2}}{\varrho_{l1}\,\Delta p_{l1}}} \quad \ldots (21)$$

where

Δp_{l1} is the pressure drop for a liquid designated 1, in bar;

Δp_{l2} is the pressure drop for a liquid designated 2, in bar;

q_{mcl1} is the certified capacity for a liquid designated 1, in kilograms per hour per square millimetre of flow area;

q_{ml2} is the authorized equivalent capacity of a liquid designated 2, in kilograms per hour per square millimetre of flow area;

ϱ_{l1} is the volumetric mass for a liquid designated 1, in kilograms per cubic metre;

ϱ_{l2} is the volumetric mass for a liquid designated 2, in kilograms per cubic metre.

9 Marking and sealing

9.1 Marking on the body of the safety valve

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

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

b) material designation of the body;

c) manufacturer's name or trade-mark;

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

9.2 Marking on an identification plate

The following minimum information shall be given 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 (stating units), in bar or pascals;

c) the number of this part of ISO 4126 (ISO 4126-1);

d) manufacturer's type reference;

e) derated coefficient of discharge or certified discharge capacity (stating units) indicating reference fluid: G for gas, S for steam and L for liquid. The designation of the fluid may be placed either before or after the derated coefficient of discharge or certified discharge capacity, e.g. G-0.815 or G-100 000 kg/h;

f) flow area, in square millimetres;

g) minimum lift, in millimetres, and corresponding overpressure, expressed as a percentage of set pressure.

9.3 Sealing of a safety valve

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

10 Quality assurance system

10.1 The manufacturer shall establish and maintain a quality assurance system which will ensure that all the requirements of this part of ISO 4126 are satisfied. This system shall also ensure that all safety valves will perform in a similar manner to those representative valves subjected to original testing for determination of the operating and flow characteristics.

10.2 A written description of the system the manufacturer will use shall be available for review and acceptance by the inspection authority.

NOTE — Annex C provides a typical outline of subjects for inclusion in the quality assurance system.

10.3 The system may include provisions for satisfying any requirements in addition to those specified in 10.1. The manufacturer may make changes to these additional provisions of the system without securing prior acceptance by the inspection authority.

11 Installation of safety valves

11.1 Environmental conditions

Due consideration shall be taken of climatic, process or other conditions which might adversely affect the performance of a safety valve.

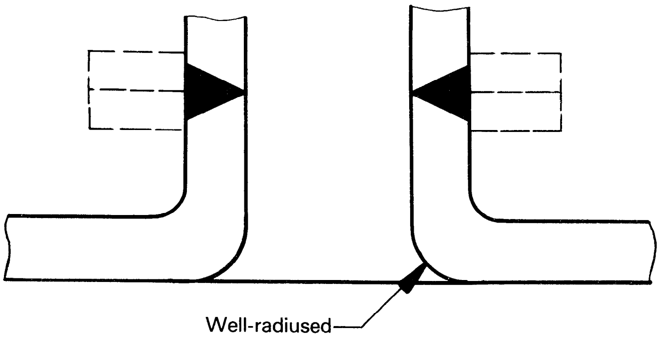
11.2 Mounting

11.2.1 In order to minimize the risks of reduced flow rate or damage to seating faces and others parts of the valve as a result of chattering or hammering, the following points shall be taken into consideration when mounting the safety valve.

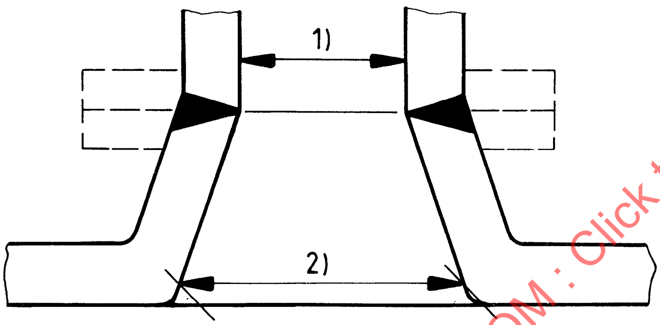
11.2.2 The manufacturer's approval shall be obtained if it is intended to mount the safety valve in any other position than the vertically upright position, and care shall be taken that any arrow indicating the direction of flow, as required by 9.1 d), is pointing in the correct direction.

11.2.3 It is essential that the minimum area through the inlet branch on which the safety valve is mounted shall be not less than the area at the safety valve inlet (see 4.2.2).

11.2.4 Safety valves shall be mounted as close as possible to the protected system and the inlet branch shall be short and straight. However, for high pressure and/or high capacity applications, the inlet branch should have either a well-radiused inlet or a taper bore, with the inlet area of the taper approximately twice the area A of the outlet as shown in figure 2.



a) Well-radiused inlet



1) Area, A

2) Area, $2A$

b) Taper bore

Figure 2 — Safety valve inlet branches

11.2.5 A safety valve inlet branch shall never be installed in a position directly opposite a branch line.

NOTE — Change-over valves or "Y" connections are not considered to be branches in this context.

11.3 Inlet piping

11.3.1 The pressure drop in the inlet branch or between the protected equipment and the safety valve shall not exceed 3 % of the set pressure or one-third of the maximum allowable blowdown, whichever is the least at actual flow.

11.3.2 Pipelines or vessels on which safety valves are mounted shall be adequately supported to ensure that vibrations are not transmitted to the safety valve.

11.3.3 All associated pipework shall be installed in such a way that it will not impose unacceptable stresses on the safety valve which result in distortion and leakage.

11.3.4 Any installation of isolating devices on the inlet of safety valves shall not contravene national, legal or code requirements.

11.4 Discharge piping

11.4.1 The discharge piping associated with a safety valve shall be so designed and installed that it will not affect the discharge capacity.

11.4.2 The cross-sectional area of the discharge piping shall be not less than the area of the safety valve outlet. Where safety valves are discharging into a manifold, its cross-sectional area shall be calculated such that it can accept the discharge capacity of all the safety valves which can simultaneously discharge into the manifold. In this context, note should also be taken of the requirement given in 11.4.3.

11.4.3 Back pressure (built-up and/or superimposed) on the outlet side of a safety valve that affects set pressure and/or mass flow shall be considered.

11.4.4 Safety valve discharges and drains shall be to a safe place; particular attention shall be given to the discharge or draining of hazardous fluids.

11.4.5 Any condition that could lead to blockages of the discharge piping system shall be avoided. Where appropriate, drainage lines shall be provided.

11.4.6 Any installation of isolating devices on the outlet of safety valves shall not contravene national, legal or code requirements.

11.5 Access to safety valves

Safety valves shall be accessible for purposes of functional testing and maintenance.

12 Adjustment, maintenance and repair of safety valves

12.1 Adjustment, maintenance and repair of safety valves, including changes in set pressure, should be performed only by the manufacturer of the safety valve, or the manufacturer's authorized representative, or an agency authorized by the inspection authority or appropriate national organization.

12.2 Critical spare parts used in repair of the safety valve should be either the original manufacturer's parts or, if manufactured by an authorized agency, be produced to meet the specification of the original part. The term "critical parts" refers to those components whose design configuration is critical to ensure proper valve performance and includes as a minimum the nozzle, the disc, disc holder, disc insert, the guide, spindle or spindle assembly control rings (adjusting ring, etc.) and the spring.

12.3 If the set pressure of a safety valve is to be changed, the manufacturer shall be consulted concerning valve design compatibility for the revised service conditions. The manufacturer shall determine whether a change of spring is necessary. Only springs conforming to the manufacturer's standard shall be used. A nameplate shall be attached by the agency making such a change which indicates the change in set pressure and any other affected variable. The original markings which are changed shall be scored out but shall remain legible.

12.4 The safety valve shall, as a minimum, be tested to confirm the set pressure and seat tightness.

12.5 A nameplate identifying the repair agency shall be permanently attached to the safety valve (preferably adjacent to the manufacturer's identification plate if the repair agency is other than the manufacturer). All external adjustments shall be sealed by the repair organization following satisfactory testing.

Annex A
(informative)

Derivation of superheat correction factor, K_{Sh}

A.1 The superheat correction factor K_{Sh} (see table 2) is the ratio of the maximum unit isentropic nozzle flow q_{mShmax} for a given superheat inlet condition to the Napier flow q_{ms} for the dry saturated condition at the same inlet pressure. That is

$$K_{Sh} = \frac{q_{mShmax}}{q_{ms}} \qquad \ldots (A.1)$$

A.2 The determination of the maximum unit isentropic flow at superheat conditions, q_{mShmax}, is carried out by iteration of successive isentropic unit area flows q_{mSh} until convergence to the maximum unit flow q_{mShmax} occurs. The term q_{mSh}, expressed in kilograms per hour per square millimetre of flow area, is calculated as follows:

$$q_{mSh} = \frac{u}{v} \times 3{,}6 \times 10^{-3} \qquad \ldots (A.2)$$

where

u is the throat velocity, in metres per second, of an ideal converging nozzle

$$u = \sqrt{2(h - h_t)} \qquad \ldots (A.3)$$

where

h is the inlet specific enthalpy, in joules per kilogram;

h_t is the throat specific enthalpy, in joules per kilogram;

v is the throat specific volume, in cubic metres per kilogram.

Annex B
(informative)

Derivation of compressibility factor, Z

B.1 Determination

The compressibility factor Z at relieving conditions may be obtained from accurate data for the gas using the following equation:

$$Z = 10^5 pvM/RT \qquad \text{(B.1)}$$

where

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

p is the actual relieving pressure, in bar absolute;

R is the universal gas constant [= 8 314 N·m/(kmol·K)];

T is the actual relieving temperature, in kelvin;

v is the specific volume at the actual relieving pressure and the actual relieving temperature, in cubic metres per kilogram.

In the absence of accurate data, the compressibility factor may be obtained from the reduced temperature $T_r = T/T_c$ and the reduced pressure $p_r = p/p_c$ of the gas given in figure B.1,

where T_c and p_c are the critical temperature and the critical pressure of the pure gas.

B.2 Example

The value of Z for ammonia gas relieving through a safety valve set at a gauge pressure of 15 bar gauge (1,5 MPa), at 60 °C with 10 % overpressure, is determined using figure B.1 as follows:

— relieving pressure p = 15 + 1,5 + 1 = 17,5 bar absolute (1,75 MPa absolute)

— relieving temperature T = 60 + 273 = 333 K

— critical pressure p_c = 114,6 bar (11,46 MPa)

— critical temperature T_c = 405,6 K

$$p_r = \frac{p}{p_c} = \frac{17,5}{114,6} = 0,153$$

$$T_r = \frac{T}{T_c} = \frac{333}{405,6} = 0,82$$

From figure B.1, Z = 0,89.

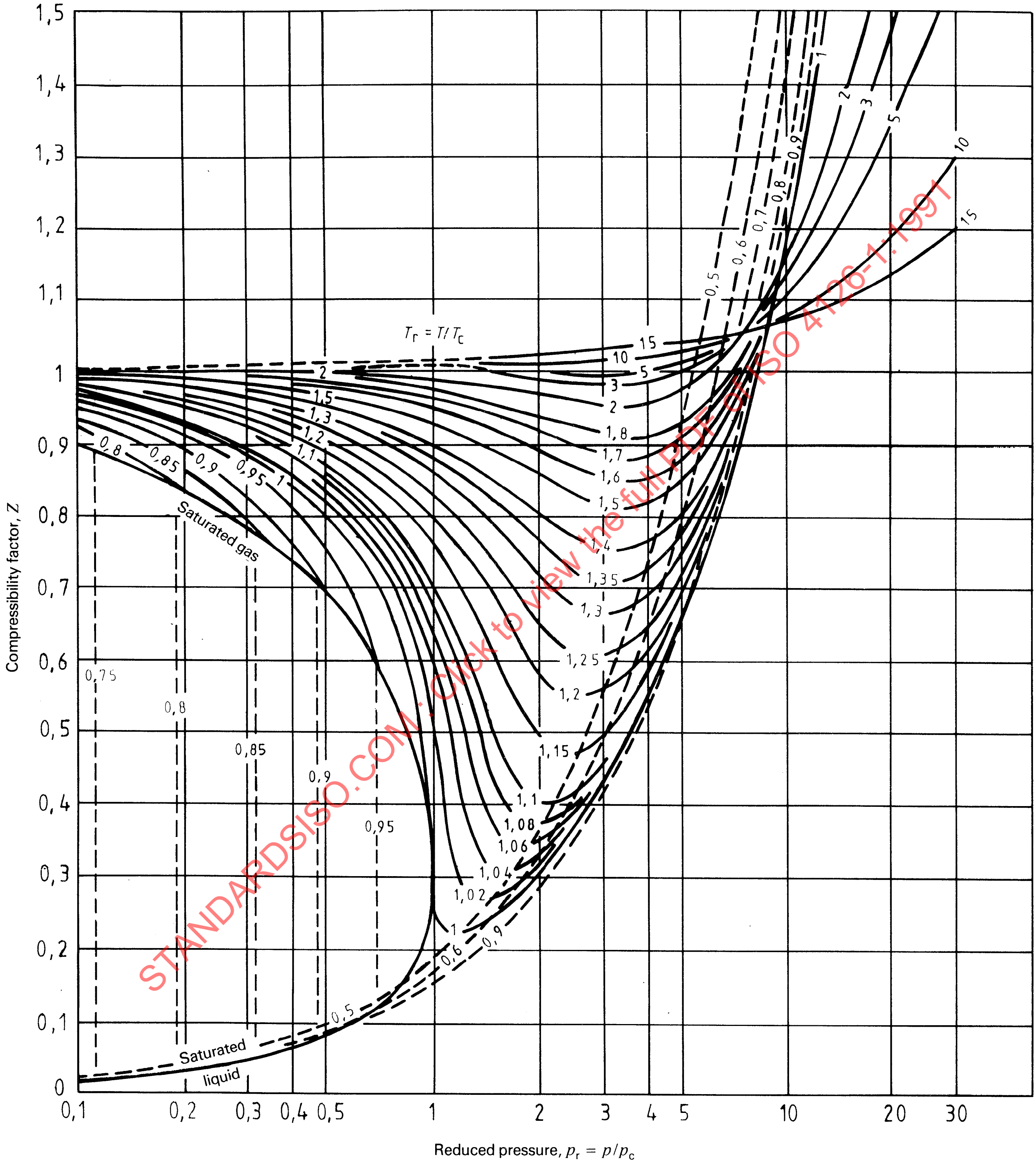
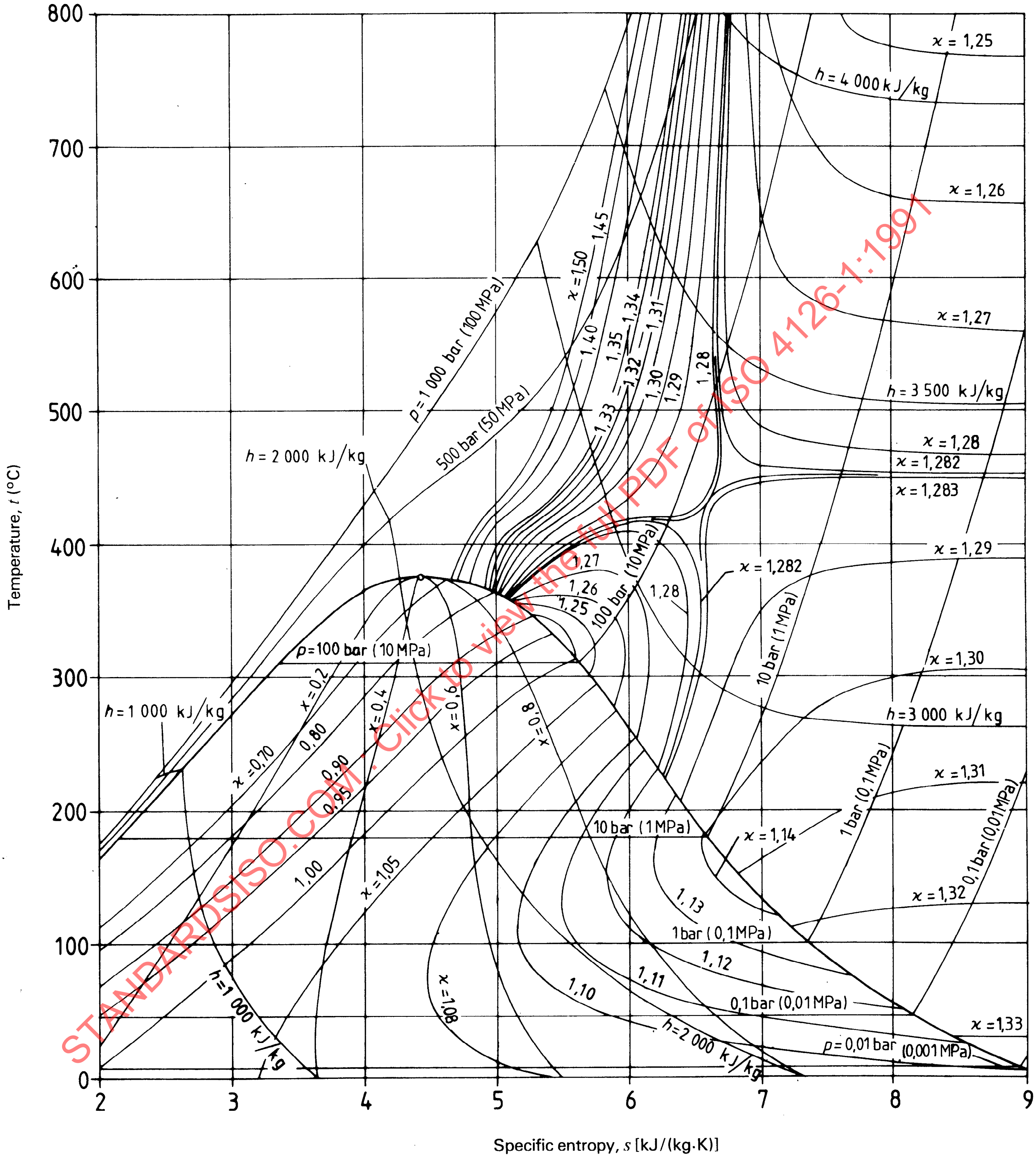


Figure B.1 — Compressibility factor Z as a function of reduced pressure $p_r = p/p_c$ and reduced temperature $T_r = T/T_c$



The isentropic exponent κ is defined by the equation $\kappa = -\frac{V}{p}\left(\frac{\partial p}{\partial V}\right)_S$

Figure B.2 — Isentropic exponent for steam