INTERNATIONAL STANDARD

ISO 4126-5

Second edition
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Safety devices for protection against excessive pressure —

Part 5: Controlled safety pressure relief systems (CSPRS)

Dispositifs de sécurité pour protection contre les pressions excessives —

Partie 5: Dispositifs de sécurité asservis (CSPRS)

Reference number
ISO 4126-5:2013(E)

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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.

International Standards are drafted in accordance with the rules given in the ISO/IEC Directives, Part 2.

The main task of technical committees is to prepare International Standards. 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.

Attention is drawn to the possibility that some of the elements of this document may be the subject of patent rights. ISO shall not be held responsible for identifying any or all such patent rights.

ISO 4126-5 was prepared by Technical Committee ISO/TC 185, *Safety devices for protection against excessive pressure*.

This second edition cancels and replaces the first edition (ISO 4126-5:2004), which has been technically revised. It also incorporates the Technical Corrigenda ISO 4126-5:2004/Cor 1:2006 and ISO 4126-5:2004/Cor 2:2007.

ISO 4126 consists of the following parts, under the general title *Safety devices for protection against excessive pressure*:

— *Part 1: Safety valves*

— *Part 2: Bursting disc safety devices*

— *Part 3: Safety valves and bursting disc safety devices in combination*

— *Part 4: Pilot operated safety valves*

— *Part 5: Controlled safety pressure relief systems (CSPRS)*

— *Part 6: Application, selection and installation of bursting disc safety devices*

— *Part 7: Common data*

— *Part 9: Application and installation of safety devices excluding stand-alone bursting disc safety devices*

— *Part 10: Sizing of safety valves for gas/liquid two-phase flow*

— *Part 11: Performance testing*[1)]

Part 7 contains data that is common to more than one of the parts of ISO 4126 to avoid unnecessary repetition.

1) Under development.

Safety devices for protection against excessive pressure —

Part 5:
Controlled safety pressure relief systems (CSPRS)

1 Scope

This part of ISO 4126 specifies the requirements for controlled safety pressure relief systems (CSPRS) irrespective of the fluid for which they are designed.

It is applicable for main valves having a flow diameter of 4 mm and above which are for use at pressures of 0,1 bar gauge and above. No limitation is placed on temperature.

This is a product standard and is not applicable to applications.

2 Normative references

The following referenced documents are indispensable for the application of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 4126-7:2013, *Safety devices for protection against excessive pressure — Part 7: Common data*

3 Terms and definitions

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

3.1
controlled safety pressure relief system
CSPRS
system consisting of a main valve in combination with a control unit

Note 1 to entry: See Figure 1 for the components of a CSPRS.

Note 2 to entry: On reaching the set pressure, the operating forces on the main valve are by means of the control unit automatically applied, released or so reduced that a main valve discharges a specified quantity of the fluid so as to prevent the predetermined pressure being exceeded. The system is so designed that the main valve re-closes and prevents a further flow of fluid after normal pressure conditions of service have been restored.

Note 3 to entry: Specific types of CSPRS are installed to protect the downstream system by preventing further fluid input (safety shut-off valve). In this case the closing function shall meet the same requirements as the opening function of the relief valve (see 5.1.5).

3.2
main valve
valve consisting of the parts of a CSPRS through which the discharge capacity is achieved, and the actuator

3.3
relieving principle
principle in which a main valve opens when the operating force is released or reduced, and in which the main valve closes when the operating force is re-applied

Note 1 to entry: See Figure 2, Type 1.

3.4
loading principle
principle in which a main valve opens when the operating force is applied, and in which the main valve closes when the operating force is removed

Note 1 to entry: See Figure 2, Type 2.

3.5
control unit
unit which establishes the opening and closing of the main valve

Note 1 to entry: The arrangement shall consist of redundant individual control paths in operation (see 5.1.13 and 5.1.15). The individual control path may consist of pressure tapping line, pressure sensor, sensing line, control module and control line [see Figures 1 a), 1 b) and 1 c), principle for two control paths].

3.6
pressure tapping line
line to the pressure sensor

3.7
sensing line
line between the pressure sensor and control module

3.8
control line
line between the control module and the main valve

3.9
pressure sensor
comparator in which a predetermined adjustable value of pressure is compared with the actual system pressure

Note 1 to entry: On reaching the predetermined pressure, a signal is transmitted to the control unit. The signal to the control unit is removed when the system pressure has been lowered to a predetermined pressure.

3.10
control module
module which transforms the signal from the pressure sensor into a force to operate the actuator of the main valve

3.11
closed circuit principle
principle characterized by the fact that on failure of the external control energy, the control unit effects the loading or relief of the main valve

3.12
open circuit principle
principle characterized by the fact that on failure of the external control energy the control unit does not change the loading or relief of the main valve

3.13
operating force
force which causes the main valve to operate

3.14
set pressure of a CSPRS
predetermined pressure at which a main valve disc under operating conditions commences to open

Note 1 to entry: It is the gauge pressure measured at the main valve inlet at which the pressure forces tending to open the main valve for specified service conditions are in equilibrium with the forces retaining the main valve disc on its seat.

3.15
maximum allowable pressure
PS
maximum pressure for which the protected equipment is designed

3.16
overpressure
pressure increase over the set pressure, usually expressed as a percentage of the set pressure

3.17
reseating pressure
value of the inlet static pressure at which the main valve disc re-establishes contact with the seat or at which the lift becomes zero

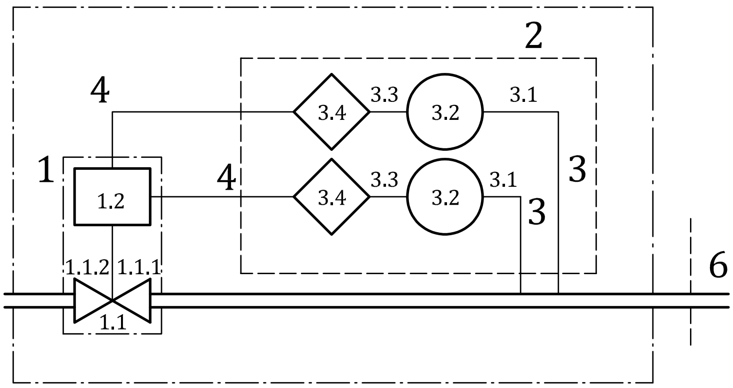
3.18
cold differential test pressure
inlet static pressure at which the main valve is set to commence to open on the test bench

Note 1 to entry: This test pressure includes corrections for service conditions, e.g. back pressure and/or temperature.

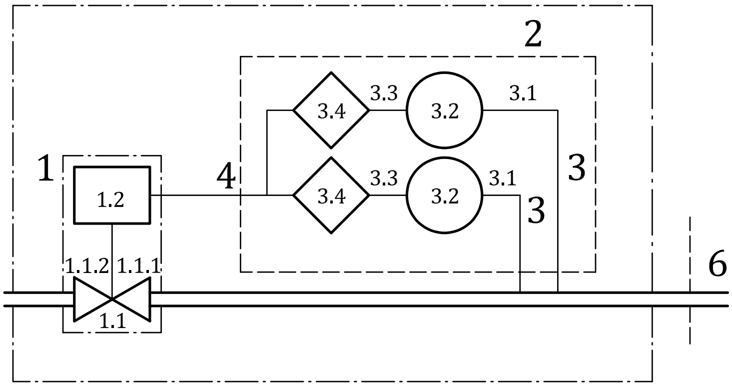
3.19
relieving pressure
pressure used for the sizing of a CSPRS which is greater than or equal to the set pressure plus overpressure

3.20
blowdown
difference between set and reseating pressures, normally stated as a percentage of set pressure except for pressures of less than 3 bar when the blowdown is expressed in bar

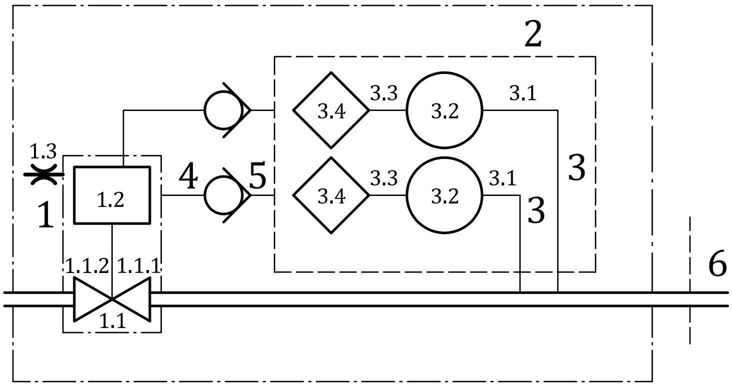
3.21
opening sensing pressure
predetermined pressure which activates the pressure sensor



a) Two control lines, relieving principle



b) One control line, relieving principle

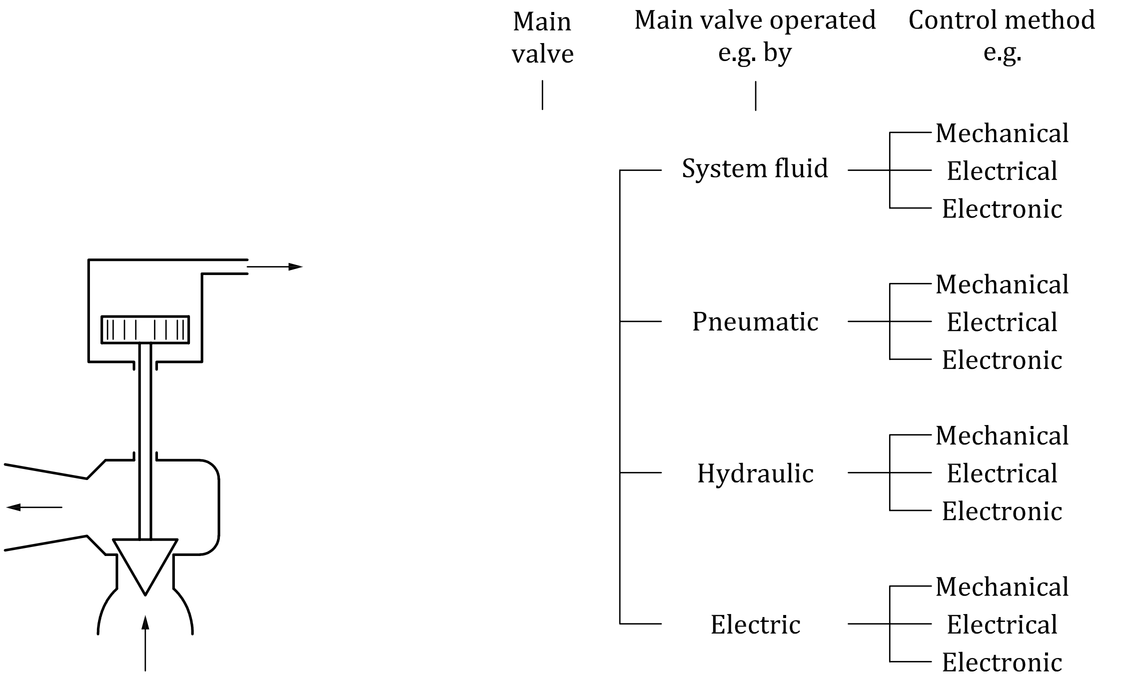


c) Two control lines, loading principle

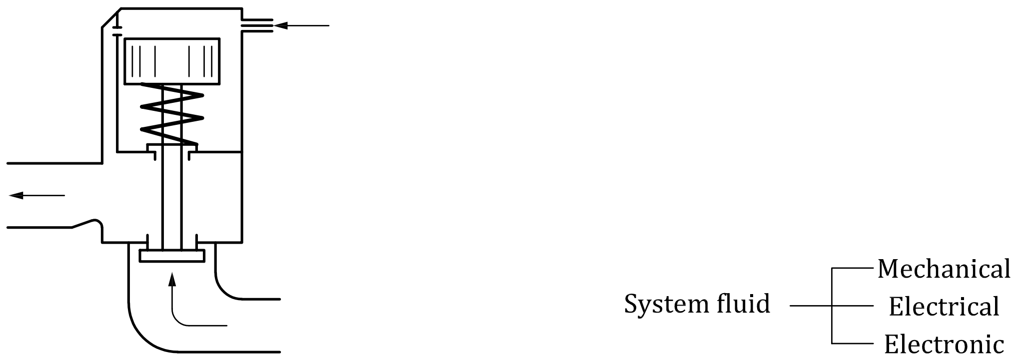
Key

1 main valve
1.1 body
1.1.1 inlet port
1.1.2 outlet port
1.2 actuator
1.3 vent
2 control unit
3 individual control path
3.1 pressure tapping line
3.2 pressure sensor
3.3 sensing line
3.4 control module
4 control line
5 check valve
6 protected system

Figure 1 — Typical examples of redundancy for two individual control paths



a) Type 1: Relieving principle



b) Type 2: Loading principle

Figure 2 — Operating principle of the main valve

3.22
closing sensing pressure
predetermined pressure which deactivates the pressure sensor

3.23
back pressure
pressure that exists at the outlet of a safety valve as a result of the pressure in the discharge system

Note 1 to entry: The back pressure is the sum of the superimposed and built-up back pressures.

3.24
built-up back pressure
pressure existing at the outlet of the main valve caused by flow through the main valve and the discharge system

3.25
superimposed back pressure
pressure existing at the outlet of the main valve at the time when the device is required to operate

Note 1 to entry: It is the result of pressure in the discharge system from other sources.

3.26
balanced bellows
bellows device which minimizes the effect of superimposed back pressure on the set pressure of a safety valve

3.27
lift
actual travel of the main valve disc away from the closed position

3.28
flow area
minimum cross-sectional flow area (but not the smallest area between seat and disc) between inlet and seat which is used to calculate the theoretical flow capacity, with no deduction for any obstruction

3.29
flow diameter
diameter corresponding to the flow area

3.30
theoretical discharge capacity
calculated capacity of a theoretically perfect nozzle having a cross-sectional flow area equal to the flow area of the main valve

Note 1 to entry: Expressed in mass or volumetric units.

3.31
coefficient of discharge
value of actual flowing capacity (from tests) divided by the theoretical flowing capacity (from calculation)

3.32
certified (discharge) capacity
that portion of the measured capacity permitted to be used as a basis for the application of the CSPRS

Note 1 to entry: It may, for example, equal: a) the measured capacity times the de-rating factor; or b) the theoretical capacity times the coefficient of discharge times the de-rating factor; or c) the theoretical capacity times the certified de-rated coefficient of discharge.

3.33
DN (nominal size)
alphanumeric designation of size that is common for components used in a piping system, used for reference purposes, comprising the letters DN followed by a dimensionless number having an indirect correspondence to the physical size of the bore or outside diameter of the component end connection

Note 1 to entry: The dimensionless number does not represent a measurable value and is not used for calculation purposes.

Note 2 to entry: Prefix DN usage is applicable to components bearing PN designations according to ISO 7268.

Note 3 to entry: Adapted from ISO 6708:1995, definition 2.1.

3.34
opening time
time interval for the main valve disc to move from the closed to the fully open position

3.35
reseating time
time interval for the main valve disc to move from the fully open to the closed position

3.36
opening dead time
time interval from the detection of the opening sensing pressure and the commencement of the opening of the main valve

3.37
reseating dead time
time interval from the detection of the closing sensing pressure and the commencement of the closing of the main valve

4 Symbols and units

Table 1 — Symbols and their descriptions

Symbol	Description	Unit
A	Flow area of a safety valve (not smallest area between seat and disc)	mm^2
K_d	Coefficient of discharge[a]	—
K_{dr}	Certified de-rated coefficient of discharge (K_d × 0,9)[a]	—
n	Number of tests	—
q_m	Theoretical specific discharge capacity	$kg/(h{\cdot}mm^2)$
q'_m	Specific discharge capacity determined by tests	$kg/(h{\cdot}mm^2)$

[a] K_d and K_{dr} are expressed as 0,xxx.

5 Design

5.1 General

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

5.1.2 The seat of any valve in the system, other than where it is an integral part of the valve shell, shall be fastened securely to prevent the seat becoming loose in service.

5.1.3 All external adjustments shall be locked and/or sealed in such a manner so as to prevent or reveal unauthorized adjustments of the CSPRS.

5.1.4 In the case of main valves with restricted lift, the lift restricting device shall limit the main valve lift but shall not otherwise interfere with the operation of the main valve. The lift restricting device shall be designed so that, if adjustable, the adjustable feature can be mechanically locked and sealed. The lift restricting device shall be installed and sealed in accordance with the design of the manufacturer.

The valve lift shall not be restricted to a value less than 30 % of the unrestricted lift or 1 mm, whichever is greater.

5.1.5 For CSPRS working as safety shut-off valves it has to be assumed that the main valve cannot be closed completely as a result of particles in the fluid. Upstream of the main valves, devices such as perforated discs or strainers shall be installed. With the size of these bores or perforations, the leakage rate of the main valve shall be determined.

5.1.6 Any CSPRS for toxic or flammable fluids shall be so designed to prevent leakage to atmosphere or if vented it shall be disposed of in a safe place.

5.1.7 The main valve shall be provided with a drain connection at the lowest point where liquid could collect unless other provisions for draining are provided.

5.1.8 The design stress of pressure-retaining shells shall not exceed that specified in the appropriate standards.

NOTE For example, EN 12516 or ANSI/ASME B 16.34 may be used as reference.

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

5.1.10 Seat and disc of CSPRS shall be made of suitable material in order to avoid increasing set pressure, e.g. cold welding or sticking.

5.1.11 The main valve opens without the assistance of any energy other than that of the fluid to be relieved under the principle of 3.3 or 3.4 (see Figure 2). The design of the main valve shall not be of gate or rotating disc valve type.

5.1.12 Operating forces other than those created by the fluid itself can only be used for closing the main valve. They can be mechanical, e.g. springs or weight, hydraulic, pneumatic or electrical [see Figure 2a)].

For main valves and valves used as control module where the system pressure or control medium acts on the valve disc in the direction of closing, the opening force shall be rated such that the valve opens completely with twice the system pressure.

The internal functional reserve of safety-related components in the control paths shall be ensured by rating operating forces to be at least twice the force necessary for opening the main valve. The opening forces of main valves not in accordance with ISO 4126-1 shall be rated at least twice the necessary forces.

5.1.13 Each individual control path shall be so designed that the relevant main valve will operate reliably in case of failure of the other individual control paths. At least three control paths, each independent of each other, shall be in operation. At least two control paths shall be in accordance with the closed circuit principle.

NOTE Installations with two main valves each covering the required capacity, two installed control paths per main valve comply with this part of ISO 4126-5.

5.1.14 For test purposes it shall be possible to operate the main valve.

5.1.15 It is permissible to operate more than one main valve from a single control unit subject to its application. Redundancy of individual control systems shall be in accordance with this part of ISO 4126. If one control path has to be made inactive for performance testing during operation, two shall stay active.

5.1.16 When operating the main valve other than by electrical means, there shall be two control lines. These lines shall not be installed in near proximity to each other in order to avoid simultaneous damage. The only exception is as described in 5.1.17.

5.1.17 With a CSPRS operating under the relieving principle and with filtered control fluid, which is not the system fluid, it is permissible to use only one control line [see Figure 1 b)] providing that:

a) the pipe is at least 15 mm bore to avoid the risk of blockage;

b) the pipe is of sufficient thickness to ensure that if it is crushed the remaining flow area is at least 20 % of the original flow area;

c) this area of 20 % of the original flow area is sufficient to ensure that the specified maximum opening time of the main valve is not to be exceeded;

d) the opening time is determined by test.

5.1.18 When operating the main valve under the loading principle each control line shall be fitted with a check valve close to the actuator [see Figure 1 c)].

5.1.19 It shall be possible to test at any time the functionality of all the control paths of a CSPRS to verify the performance of the main valve and the functionality of the individual control paths. Values and procedures determined in 7.1.1 shall be verified for functionality and predictive maintenance.

For tests under operating conditions, a locking system is necessary which ensures that according to 3.5 at least two individual control paths stay in operation.

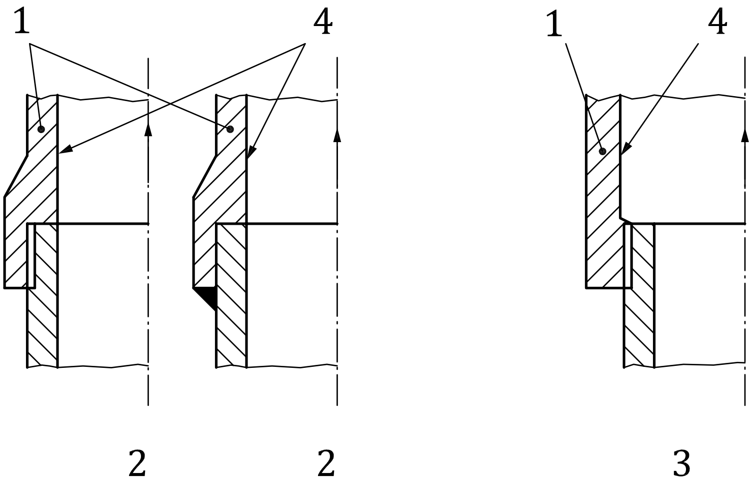
5.1.20 Only non-corrosive fluids shall be used in the control unit. In the event that the system fluid is not clean or is corrosive then a suitable "barrier" (e.g. siphon, diaphragm) shall be provided to ensure that the control unit can function reliably. The formation of condensate in any gaseous fluid or vapour shall not be allowed if it affects the functionality of the control unit.

5.2 Valve end connections

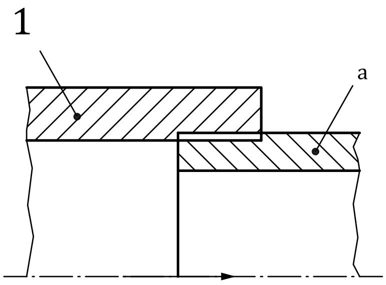
The inlet design of valve end connections, regardless of type, shall be such that the internal area of the external pipe or stub connection at the main valve inlet is at least equal to that of the valve inlet connection [see Figure 3 a)].

The outlet design of valve end connections, regardless of type, shall be such that the internal area of the external pipe connection at the main valve outlet is at least equal to that of the valve outlet, except those valves with female threaded outlet connections [according to Figure 3 b)].

NOTE See Clause 7 regarding type testing.



a) Inlet



b) Outlet

Key

1 main valve

2 satisfactory

3 unsatisfactory

4 required internal diameter of the main valve for the CSPRS to function properly

a If the nominal diameter of the pipe is not equal to the nominal diameter of the main valve outlet as shown in b), then a suitable pipe shall be fitted during testing as specified in 7.1.3.

Figure 3 — Design of end connections

5.3 Minimum requirements for springs

Pressure setting springs, as applicable, shall be in accordance with ISO 4126-7.

5.4 Materials

5.4.1 All materials shall be compatible with the system fluid, the adjoining components and the environment in which the CSPRS is to be used. Temperature variations shall be considered.

5.4.2 Only approved materials shall be used for pressure-retaining shells.

NOTE For example, EN 12516 or any other published national or international material standards (e.g. ASME, ASTM, JIS, etc.) may be used as reference.

These materials and their temperature limitations shall be suitable for pressure-containing function.

6 Production testing

6.1 Purpose

The purpose of these tests is to ensure that each and every CSPRS meets the requirement for which it has been designed without exhibiting any form of leakage of pressure-retaining components or joints.

6.2 General

It is permissible to test the main valve independently from the control unit. All temporary pipes, 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.

6.3 Hydrostatic testing

6.3.1 Application

The portion of the main valve shell exposed to the inlet pressure shall be tested to a pressure 1,5 times the manufacturer's stated maximum pressure for which the valve is designed.

The portion of the main valve shell on the discharge side of the seat shall be tested to 1,5 times the manufacturer's stated maximum back pressure for which the valve is designed. This pressure can be lower than that given by the outlet flange rating.

6.3.2 Duration

The test pressure shall be applied and maintained at the required magnitude for a sufficient length of time to permit a visual examination of all surfaces and joints to be made, but in any case for not less than the times given in Table 2. For tests on the discharge side of the seat, the testing time shall be based on the pressure specified in 6.3.1 and discharge size.

Table 2 — Minimum duration of hydrostatic test

Nominal size DN	Minimum duration in seconds
DN ≤ 50	15
65 ≤ DN ≤ 200	60
DN ≥ 250	180

6.3.3 Acceptance criteria

No leakage from tested parts as defined in 6.3.1 is accepted.

6.3.4 Safety requirements

Water of suitable purity shall normally be used as the test medium. Where other liquids 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 valve which is to be hydrostatically tested, then both the 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.

6.4 Pneumatic testing

6.4.1 Application and duration of test

Pressure testing with air or other suitable gas may be carried out in place of the standard shell hydrostatic test 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 portions of the valve to be tested, test pressure and duration of application shall be as specified in 6.3.

6.4.2 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 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 that 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.

6.5 Adjustment of set or cold differential test pressure

Each CSPRS shall be adjusted to its designated set or, if applicable, cold differential test pressure.

It is not permissible to adjust the set or cold differential test pressure of a CSPRS using air or other gas as the test medium unless the pressure-retaining parts have previously been subjected to a test in accordance with 6.3 or 6.4.

6.6 Seat leakage test

The seat leakage test of a main valve shall be carried out after the adjustment of the set or the cold differential test pressure. The test procedure and leakage rate shall be agreed between the manufacturer and the purchaser.

NOTE For example, API 527 can be used.

6.7 Pressure seals

All pressure seals between valve, loading/unloading line and sensing line shall be leak tested. If appropriate, hold for 1 min at 10 % or 0,35 bar, whichever is the greater below set pressure, using air or nitrogen. Leakage is not acceptable.

7 Type testing

7.1 General

7.1.1 Application

The operating and flow characteristics of a CSPRS shall be determined by type tests in conformity with this clause. For CSPRS, working as safety shut-off valve testing of flow characteristics is not applicable.

The design shall be verified according to the requirements in 5.1

Values and procedures for testing the internal functional reserve according to 5.1.12 of safety-related elements of the control paths shall be defined and documented, e.g. in the operation manual of the CSPRS.

These shall be used for tests according to 5.1.19.

7.1.2 Tests

The tests to determine the operating characteristics shall be in accordance with 7.2 and the tests to determine the flow characteristics shall be in accordance with 7.3.

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

The testing procedure, test rig and equipment shall be such that the operability and capacity at the relieving pressure can be established.

7.1.3 Objectives of tests

The objective of the tests is to determine, under specific operating conditions, the particular characteristics of the CSPRS. The following characteristics are examples and there may be others:

a) set pressure;

b) overpressure;

c) functional times as applicable, e.g. opening dead time, opening time;

d) relieving pressure;

e) reseating pressure;

f) blowdown;

g) reproducibility of CSPRS performance;

h) mechanical characteristics of the CSPRS such as:

- ability to reseat satisfactorily;
- absence or presence of chatter, flutter, sticking and/or vibration.

i) lift at overpressure;

j) actual mass flow rate.

7.1.4 Procedure for testing

The tests shall provide suitable data from which the operational and flow characteristics may be determined. For valves with internally screwed connections on the outlet with a configuration as shown in Figure 3 b), a pipe, of appropriate thickness, at least five diameters long shall be fitted during the test.

7.1.5 Results calculated from tests

The theoretical flowing capacity is calculated in accordance with ISO 4126-7 as applicable, and, using this value together with the actual flowing capacity at relieving pressure, the coefficient of discharge of the main valve is calculated in accordance with ISO 4126-7.

7.1.6 Design changes

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

7.2 Tests to determine operating characteristics

7.2.1 General requirements

Valves for air or other gas service shall be tested using air or any other gas of known characteristics or superheated steam with a minimum of 10 °C of superheat. Valves for steam service shall be tested on steam, air or other gas of known characteristics. Valves for liquid service shall be tested on water or other 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 ± 0,1 bar, whichever is the greater.

If the pilot is to be adjusted separately from the main valve, the pressure to which the pilot is adjusted may not be the same as the set pressure. The opening sensing pressure shall be specified by the manufacturer. It shall be demonstrated that the pilot is adjusted in such a way that the above tolerance on set pressure is maintained;

b) overpressure: the value stated by the manufacturer but not exceeding 10 % of set pressure or 0,1 bar, whichever is greater;

c) lift at overpressure: not less than the value stated by the manufacturer;

d) blowdown: not greater than the value stated by the manufacturer, but within the following limits:

 — compressible fluids: minimum: 2,0 % (not applicable for the pilot operated safety valves with modulating action),

 maximum: 15 % or 0,3 bar, whichever is greater;

 — incompressible fluids: minimum: 2,5 % (not applicable for the pilot operated safety valves with modulating action),

 maximum: 20 % or 0,6 bar, whichever is greater;

e) overpressure and blowdown of restricted lift pilot operated safety valves shall have the same tolerances or limits as the unrestricted lift valves;

f) overpressure and blowdown of pilot operated safety valves with modulating action shall be verified and be stable for various lifts between the minimum and maximum stated by the manufacturer.

7.2.2 Test equipment

The uncertainty of pressure measurement shall be within ± 0,5.

7.2.3 CSPRS used in the test programme

The CSPRS tested shall be representative of the design, pressure, and main valve size range of CSPRS for which operating characteristics are determined within the capability of the test laboratory.

For main valve 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 main valves tested previously are no longer representative of the range, further tests on the appropriate number of sizes shall be carried out.

The same control unit may be used for a number of main valve tests.

The tests shall be carried out using three significantly different set pressures for each size of the main valve. This may be achieved by testing either one valve with three significantly different pressures or three valves of the same size with three significantly different pressures. Each test shall be carried out a minimum of three times in order to establish and confirm acceptable reproducibility of performance. Tests at the minimum design set pressure shall be carried out.

In the case of a main valve or a control unit of either novel or special design, of which one size only at one pressure rating is being manufactured, tests at a single set pressure are permitted by agreement.

In the case of a main valve or control unit of which one size only at various pressure ratings is being manufactured, tests shall be carried out using four different set pressures, which shall cover the range of pressure for which the CSPRS shall be used.

Where the size range cannot be adequately covered then scale models shall be used having a minimum flow-diameter of 40 mm.

All dimensions of the flow path in the model shall be strictly to scale with the corresponding dimensions of the actual valve.

All dimensions of the parts which can affect the overall thrust exercised by the medium on the moving parts shall be to scale.

In the case of balanced bellows, it is permitted that the effective area be only to scale.

NOTE Effective area is the area of the balanced bellows from which end loads are calculated (piston area).

The overall spring rate of spring plus bellows, if any, of the model shall be to scale with the overall rate of the actual valve.

The roughness of all surfaces of the flow path of the model shall not be less than that of the corresponding surfaces of the actual valve.

Before tests are carried out, it shall be verified that the model complies with the above.

7.3 Tests to determine flow characteristics

7.3.1 Test requirements

After the operational characteristics (see 7.2) have been satisfactorily established, it is acceptable to use steam, air or other gas of known characteristics as the fluid for flow characteristics tests except for CSPRS designed for liquid service. CSPRS for use with liquids shall be tested with water or other liquid of known characteristics. When flow characteristics are determined independently from operating characteristics, the valve disc shall be held at the lift as determined by the operating characteristics tests.

7.3.2 CSPRS used in the test programme

The CSPRS shall be the same as, or identical to, those used for the tests operating characteristics tests (see 7.2.3).

7.3.3 Test procedure

7.3.3.1 Test conditions

The testing procedure, test rig and equipment shall be approved before testing is undertaken.

The testing procedure, test rig and equipment shall be such that the capacity at the overpressure can be established.

The lift shall be the same as determined during the operational testing.

Tests shall be conducted at various pressures to establish that no variation of the coefficient of discharge with the relevant position(s) of the adjusting ring(s), if any, occurs.

7.3.3.2 Flowing capacity for control unit

The discharge capacity (if any) through a control unit shall not be taken into account unless it represents more than 25 % of the total flow.

7.3.3.3 Number of valves

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

When a size range is extended from one containing fewer 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.

In the case of valves of either novel or special design of which only one size at various pressure ratings is being manufactured, tests shall be carried out at four different set pressures which shall cover the range of pressures for which the valves will be used, or as determined by the limits of the test facility.

7.3.3.4 Restricted lift valves

For restricted lift valves the capacity at restricted lift may be determined immediately following the tests to determine flow characteristics at full lift or determined later.

For restricted lift designs, a curve of coefficient of discharge versus lift may be established. Tests shall be performed at minimum lift, maximum lift and at least three lifts between minimum and maximum lift using a minimum of three test pressures at each lift. This curve may be used to establish the coefficient of discharge for any lift between minimum and maximum lift.

7.3.3.5 Value of test pressure

Three tests shall be carried out on each safety valve size at test pressures whereby the ratio of absolute back pressure to absolute relieving pressure is less than 0,25.

These tests shall be carried out with atmospheric back pressure.

In all cases of a single main valve design, tests shall be carried out at four different pressures.

For compressible fluids, when the ratio of absolute back pressure versus absolute relieving pressure exceeds the value of 0,25, the coefficient of discharge can be largely dependent upon this ratio. Then tests shall be conducted at ratios between the pressure ratio of 0,25 and the maximum pressure ratio required to obtain curves or tables of coefficient of discharge K_d versus the ratio of absolute back pressure and absolute relieving pressure. This curve may be extended to cover the tests with pressure ratios less than 0,25.

For incompressible fluids the coefficient of discharge does not depend on the ratio of absolute back pressure to absolute relieving pressure.

7.3.3.6 Flow testing acceptance tolerance

In all the methods described for flow characteristic testing, all final results shall be within ± 5 % of the arithmetic average to certify one common discharge coefficient.

Where these tolerances are not achieved when testing, to produce the curve of coefficient of discharge versus the ratio of absolute back pressure to absolute relieving pressure greater than 0,25, the curve illustrating the lowest coefficient of discharge versus this ratio shall be accepted for the range of valves tested.

7.3.4 Adjustment during test

No adjustment to the CSPRS shall be made during the test. Following any changes 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.

7.3.5 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 test. Copies of all test records shall be supplied to each of the parties concerned with the test. Corrections and corrected values shall be entered separately in the test record.

The manufacturer or his authorized representative shall keep a copy of the test records and their additions for a period of 10 years after the last of the safety valves has been manufactured.

7.3.6 Flow test equipment

The test equipment shall be designed and operated such that the uncertainty of the actual test flowing capacity measurements shall be within ± 2 %.

7.4 Determination of the coefficient of discharge

The coefficient of discharge K_d is calculated using Formula (1):

$$K_d = \frac{\sum_{1}^{n} \left(\frac{q'_m}{q_m} \right)}{n} \quad (1)$$

7.5 Certification of coefficient of discharge

The certified de-rated coefficient of discharge K_{dr} of the main valve shall be not greater than 90 % of the coefficient of discharge K_d determined by Formula (2):

$$K_{dr} = 0{,}9\, K_d \quad (2)$$

Neither the coefficient of discharge nor the certified de-rated coefficient of discharge can be used to calculate the capacity at a lower relieving pressure than that at which the tests to determine the flow characteristics (see 7.3) were carried out although they can be used to calculate the capacity at any higher relieving pressure.

7.6 Certification of CSPRS

When the main valve and the control unit, whether manufactured by the same company or not, are combined, the system shall meet the requirements of 7.1.3 and the CSPRS shall be certified in accordance with the derated coefficient of discharge of the main valve.

8 Determination of CSPRS performance

Refer to ISO 4126-7.

9 Sizing of CSPRS

Refer to ISO 4126-7.

10 Marking and sealing

10.1 Marking

10.1.1 Marking on the shell of the main valve

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

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

b) material designation of the shell;

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.

10.1.2 Marking on an identification plate

10.1.2.1 Main valve

The following information shall be given on an identification plate securely fixed to the main valve:

a) set pressure, in bar gauge or any other internationally recognized unit;

b) reference to this part of ISO 4126, i.e. ISO 4126-5:2013;

c) manufacturer’s type reference;

d) certified de-rated coefficient of discharge indicating reference fluid:

“G” for gas, “S” for steam and “L” for liquid;

NOTE The designation of the fluid may be placed either before or after the certified de-rated coefficient of discharge, e.g. G-0,815.

e) flow area, in square millimetres or any other internationally recognized unit;

f) minimum value of the lift, in millimetres or any other internationally recognized unit, and corresponding overpressure, expressed as, for example, a percentage of set pressure;

g) manufacturer’s type reference for identifying the accompanying control unit;

h) serial number or alternative coding to indicate year of manufacture.

10.1.2.2 Control unit

The following minimum information shall be given on an identification plate securely fixed to the control unit or parts thereof if the parts are out of the control unit enclosure:

a) manufacturer’s type reference;

b) reference to this part of ISO 4126, i.e. ISO 4126-5:2013;

c) sign for identifying the accompanying main valve;

d) set pressure, in bar gauge or other internationally recognized unit;

e) serial number or alternative coding to indicate year of manufacture.

10.2 Sealing of a CSPRS

All external adjustments of main valves and control units shall be sealed.

Bibliography

[1] ISO 6708:1995, *Pipework components — Definition and selection of DN (nominal size)*

[2] ISO 4126-1, *Safety devices for protection against excessive pressure — Part 1: Safety valves*

[3] ISO 7268, *Pipe components — Definition of nominal pressure*

[4] ANSI/ASME B 16.34, *Valves — Flanged, threaded, and welding end*

[5] API 527, *Seat tightness of pressure relief valves*

[6] EN 12516 (all parts), *Industrial valves — Shell design strength*

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