
Safety valves

Part 1. Specification for safety valves for steam and hot water

Soupapes de sûreté

Partie 1. Soupapes de sûreté pour vapeur et eau chaude. Spécification

Sicherheitsventile

Teil 1. Dampf- und Warmwassersicherheitsventile

Contents	Page		Page
Foreword	Inside front cover	19. Tests to determine operating characteristics	9
Committees responsible	Back cover	20. Tests to determine flow characteristics	10
Specification		21. Determination of coefficient of discharge and certified discharge capacity	11
Section one. General		Section seven. Safety valves for boilers, superheaters, reheaters and economizers	
1. Scope	2	22. Boilers and superheaters	17
2. Definitions	2	23. Reheaters and superheaters separated from the boiler	17
Section two. Material requirements and limitations		24. Safety valves for economizers	17
3. Pressure containing components	3	25. Operating margins	17
4. Body seat faces and valve disk faces	4		
5. Safety valve springs	4	Appendices	
6. Bolting for pressure containing joints	4	A. Derivation of superheat correction factors	18
Section three. Design and construction		B. Guidance on safety valve mounting	18
7. General	4	C. Inspection and testing facilities	18
8. Scantlings	5		
9. Castings	5	Tables	
10. Forgings	5	1. Helical coil spring materials and mechanical properties	6
11. Springs	5	2. Minimum duration of hydraulic shell test	8
Section four. Production testing and inspection		3. Values of C relative to values of k	12
12. General	7	4. Capacity correction factors for back pressure (K_b)	14
13. Safety precautions	7	5. Superheat correction factor K_{Sh}	15
14. Test media	7		
15. Hydraulic test	8	Figures	
Section five. Marking		1. Illustration of area definitions	3
16. Body marking	8	2. Graph for value of constant K , the safety valve spring correction factor	7
17. Identification plate	8	3. Compression factor Z as a function of reduced pressure p_r and reduced temperature T_r	12
Section six. Performance testing			
18. Type testing of safety valves for operating and flow characteristics using water, steam, air or other gas	9		

Foreword

The preparation of this British Standard has been undertaken under the direction of the Pressure Vessel Standards Committee to incorporate such requirements as are necessitated by technical developments and to comply with the requirements of ISO 4126 'Safety valves, general requirements', published by the International Organization for Standardization.

The opportunity has been taken to bring together in one standard the requirements for safety valves. The standard will be published in three Parts as follows:

- Part 1. Specification for safety valves for steam and hot water
- Part 2. Specification for safety valves for compressed air and inert gases (in course of preparation)
- Part 3. Specification for safety valves for process fluids (in course of preparation)

Part 1 requires that safety valve designs shall be type tested for their operational and flow characteristics to the satisfaction of an independent authority. In order to give manufacturers a period of grace in which to align their products with this standard, BS 759 : Part 2 has been created by amendments to the 1975 edition of BS 759 which will be retained as an obsolescent standard until it is withdrawn in December 1987.

To assist manufacturers and inspecting authorities, a list of testing establishments, together with details of facilities available, has been compiled and is available on request from the Enquiry Section (London), British Standards Institution.

The hydraulic pressure testing requirements for components to this standard are in many cases equal to or greater than those for the boiler to which they may be fitted, but in any case it can be taken that any safety valve body will be capable of sustaining a hydraulic test pressure equal to 1.5

times the design pressure of the valve as specified to the valve supplier by the purchaser. For this purpose a safety valve is gagged or the seat blanked off as appropriate during the test.

Appendix A gives the derivation of the superheat correction factors listed in table 5 and which are used to calculate the certified discharge capacity of a safety valve discharging superheated steam.

Appendix B provides guidance on the mounting of safety valves and includes recommendations for discharge piping and drainage. The advice given in this appendix is intended to eliminate the detrimental effects on the performance of safety valves which may arise from influences associated with incorrect mounting.

It is recognized that clauses (reproduced in appendix C) regarding inspection facilities and testing facilities which have traditionally been incorporated into safety valve standards are a contractual matter. Nevertheless their importance is such that the purchaser in agreeing a contract should not overlook them.

This Part of this standard deals with the materials, construction, and testing of safety valves and associated capacity calculations, but is not intended to cover all details of their installation, for which additional reference should be made to the appropriate British Standard.

NOTE 1. In order to ensure the correct functioning of boiler safety valves, it is essential that suitable equipment be provided to enable the proper condition of the feedwater to the boiler and the water in the boiler to be maintained.

NOTE 2. Attention is directed to the recommendations contained in 'Guidance Note PM5' entitled 'Automatically controlled steam and hot water boilers' issued by the Health and Safety Executive.

Compliance with a British Standard does not of itself confer immunity from legal obligations.

British Standard

Safety valves

Part 1. Specification for safety valves for steam and hot water

Section one. General

1. Scope

This Part of this British Standard specifies requirements for safety valves for steam and hot water where the set pressure is greater than 1 bar gauge.

It includes requirements for safety valves for boilers, boiler installations and associated pipework systems where the steam pressure exceeds 1 bar gauge or, in the case of hot water boilers, where the rating is 44 kW and above, as well as for boilers pressurized by steam for use in hot water systems which are classified as steam boilers.

Requirements for testing safety valves for determination of their operating and flow characteristics are given.

Recommendations on safety valve mounting, discharge piping and drainage are given in appendix B.

This standard does not cover safety valves for boilers used in open vented hot water systems working at temperatures not exceeding 100 °C, nor safety valves for storage water heaters of the unvented type which normally operate at temperatures not exceeding 82 °C and at pressures not exceeding 10 bar*. For such boilers within the scope of BS 779 and BS 855 the requirements are incorporated in those standards.

NOTE. The titles of the publications referred to in this standard are listed on the inside back cover.

2. Definitions

For the purposes of this Part of BS 6759 the following definitions apply.

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

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

2.1.2 assisted safety valve. A direct loaded safety valve which, by means of a powered assistance mechanism, is 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 relevant requirements for safety valves given in this standard.

2.1.3 supplementary loaded safety valve. A safety valve which

(a) has, until the pressure at the inlet of the safety valve reaches set pressure, an additional force (supplementary load) to increase the sealing force, which may be provided by means of an extraneous power source which is reliably released when the pressure at the inlet of the safety valve reaches the set pressure, and

(b) attains its certified discharge capacity in the event of the supplementary loading not being released at an over-pressure not exceeding 115 % of the set pressure.

2.1.4 pilot operated safety valve (indirect loaded safety valve). A safety valve, the operation of which is initiated and controlled by the fluid discharged from a pilot valve which is itself a direct loaded safety valve.

2.2 blowdown of a safety valve†. The difference between the set pressure and the reseating pressure, normally stated as a percentage of set pressure, except for very low set pressure when the blowdown is then expressed in bar.

2.3 boiler operating pressure. In the case of fully-flooded hot water boilers, not externally pressurized, the maximum operating pressure in the hot water system, including any static head.

In the case of externally pressurized fully-flooded hot water boilers, the pressure at which the boiler operates.

2.4 built-up back pressure. The pressure existing at the outlet of the safety valve caused by flow through the valve and the discharge system.

2.5 certified discharge capacity. That portion of the measured capacity permitted to be used as a basis for the application of a safety valve.

NOTE. The certified discharge capacity is derived from either measured flow rate x derating factor or theoretical flow rate x coefficient of discharge x derating factor.

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

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

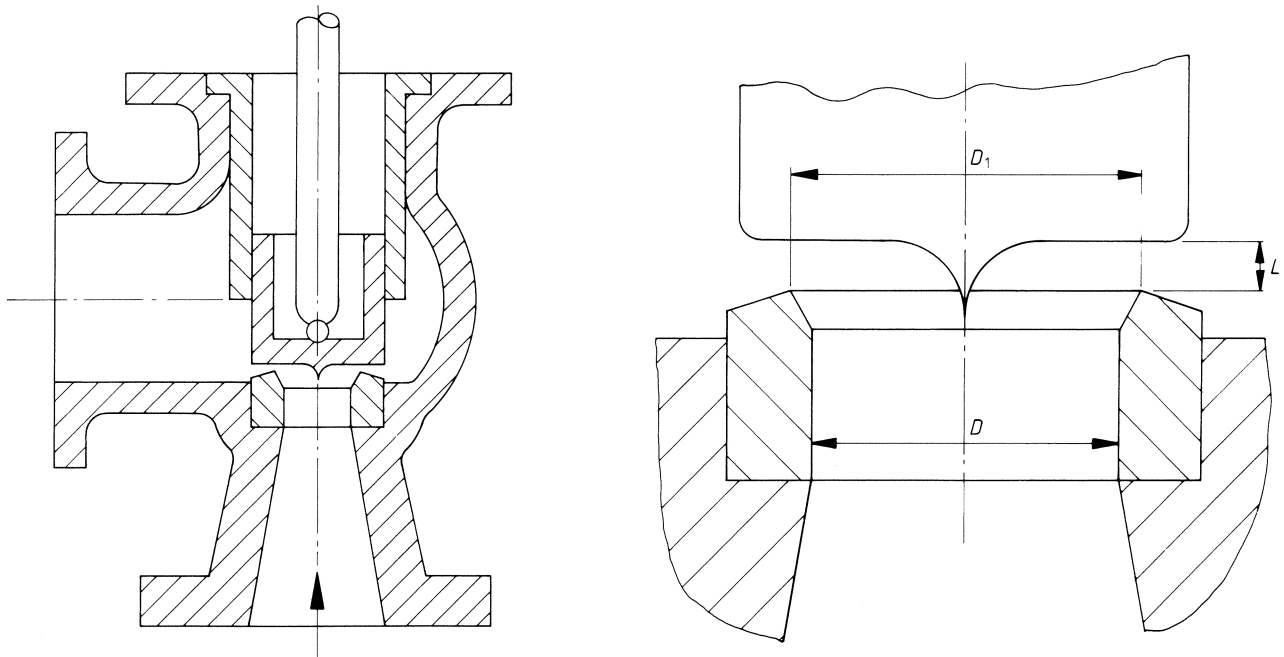
NOTE. Provision of such instrument facility only applies to valves under operating characteristics tests.

2.8 design pressure. The pressure used in calculating the thickness of a vessel or pipe system.

2.9 discharge area of a safety valve. The minimum cross-sectional area between inlet and seat, including the curtain

* 1 bar = 10⁵ N/m² = 100 kPa.

† The limits of blowdown are given in 19.1.



NOTE. The discharge area is the lesser of the curtain area ($\pi D_1 L$) or the flow area ($\frac{\pi}{4} D^2$), see 2.9 and 2.12.

Figure 1. Illustration of area definitions

area, which controls the flow of fluid through the safety valve when it is discharging its rated discharge capacity.

NOTE. See figure 1.

2.10 double safety valve. A safety valve with two body seats in one body.

2.11 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.

2.12 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 rate, with no deduction for any obstruction.

NOTE. See figure 1.

2.13 flow diameter. The diameter corresponding to the flow area.

2.14 independent authority. The competent independent authority which bears responsibility for all aspects of surveillance of tests, checking of calculations and certification of safety valve discharge capacities.

2.15 inspecting authority. The competent independent authority or association which verifies compliance with this standard.

2.16 lift. The travel of the disk away from the closed position.

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

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

2.19 relieving pressure (flow rating pressure). Set pressure plus overpressure.

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

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

2.22 single safety valve. A safety valve with one body seat only.

2.23 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.

Section two. Material requirements and limitations

3. Pressure containing components

3.1 Material specification. The materials used in the manufacture of bodies and bonnets of safety valves shall comply with whichever of the following is appropriate bearing in mind that fittings of the less ductile materials are more likely to fail under shock conditions.

(a) Cast carbon steel to BS 1504-161, grade 480.

NOTE. This material has a maximum carbon content of 0.30 %. For valves with butt welded ends less than 35 mm thick and intended for welding into pipelines subject to the requirements of BS 2633, the carbon content should be 0.25 % maximum. Alternatively, the material may be specified as BS 1504-161, grade 430.

(b) Cast carbon ½ % molybdenum steel to BS 1504-245.

- (c) Cast 1 ¼ % chromium ½ % molybdenum steel to BS 1504-621.
- (d) Cast 2¼ % chromium 1 % molybdenum steel to BS 1504-622.
- (e) Cast austenitic chromium nickel steel to BS 1504-347C17, or cast austenitic chromium nickel molybdenum steel to BS 1504-316C16.
- (f) Forged carbon steel to BS 970 : Part 1, 070M20.
- (g) Forged carbon steel to BS 1503 221-430.
- (h) Forged carbon ½ % molybdenum steel to BS 1503 245-420.
- (i) Forged 1 % chromium ½ % molybdenum steel to BS 1503 620-440.
- (j) Forged 1¼ % chromium ½ % molybdenum steel to BS 1503 621-460.
- (k) Forged 2¼ % chromium 1 % molybdenum steel to BS 1503 622-560.
- (l) Forged chromium molybdenum vanadium steel to BS 1503 660-460.
- (m) Forged austenitic chromium nickel steel to BS 1503 321S51-490 or BS 1503 347S51 or, forged austenitic chromium nickel molybdenum steel to BS 1503 316S51.
- (n) Cast iron with minimum mechanical properties equal to those specified in BS 1452 grade 220.
- (o) Cast copper alloy with minimum mechanical properties equal to those specified in BS 1400 for LG 2.
- (p) Other material having properties at least equal to those of the material to which it is an intended alternative, subject to the limitations given in 3.2 and to agreement between the manufacturer and the purchaser, such agreement being approved by the inspecting authority.

3.2 Pressure and/or temperature limitations

3.2.1 Cast iron. Cast iron shall not be used for the following:

- (a) temperatures above 220 °C;
- (b) pressures exceeding 13 bar gauge;
- (c) valves exceeding 200 mm nominal bore which are connected directly to the boiler.

3.2.2 Cast copper alloy. Cast copper alloy shall not be used for temperatures above 260 °C.

3.2.3 Steel

3.2.3.1 There are no pressure limitations on steel. Temperature limitations are given in 3.2.3.2 to 3.2.3.7 where the letters in parentheses refer to items listed in 3.1.

3.2.3.2 Cast carbon steel (a) and forged carbon steel (f) and (g) shall not be used at temperatures above 480 °C.

3.2.3.3 Cast carbon molybdenum steel (b) and forged carbon molybdenum steel (h) shall not be used at temperatures above 540 °C.

3.2.3.4 Cast chromium molybdenum steel (c) and forged chromium molybdenum steel (i) shall not be used at temperatures above 565 °C.

3.2.3.5 Cast chromium molybdenum steel (d) and forged chromium molybdenum steel (j) and (k) shall not be used at temperatures above 580 °C.

3.2.3.6 Forged chromium molybdenum vanadium steel (l) shall not be used at temperatures above 580 °C.

3.2.3.7 Cast austenitic chromium nickel steel and cast austenitic chromium nickel molybdenum steel (e) and

forged austenitic chromium nickel steel and forged austenitic chromium nickel molybdenum steel (m) shall not be used at temperatures above 700 °C.

NOTE. At temperatures above 680 °C it is generally accepted that the rate of oxidation or chemical attack begins to be important.

4. Body seat faces and valve disk faces

Body seat faces and valve disk faces shall be made from corrosion and erosion resistant material.

5. Safety valve springs

5.1 Helical coil

5.1.1 Material. Helical coil springs shall be made from circular section material complying with the requirements of one of the British Standards given in table 1. Table 1 also gives the temperature limits between which springs of the various materials shall be used.

NOTE. Recommended limiting sections for materials are also given in table 1.

5.1.2 Condition of material. Bars or wires used in the unmachined condition shall be in accordance with the relevant British Standard. Where the relevant standard does not specify the maximum depth of surface defects and decarburization, the surface defects shall be limited to 1 % of bar diameter or 0.25 mm whichever is the greater, and decarburization shall be limited to 2 % of bar diameter or 0.30 mm whichever is the greater. No more than one-third of the total affected depth shall be complete decarburization.

When bars are machined, prior to hot or cold coiling into helical springs, they shall be free from all surface defects, there shall be no complete decarburization and partial decarburization shall not exceed 0.13 mm in depth.

5.2 Torsion bar. Torsion bar springs shall be made from steel which has a tensile yield stress not less than 1350 N/mm².

When selecting the material from which the spring is manufactured, due account shall be taken of the additional deflection and hence increased stresses which apply when the valve is fully lifted.

6. Bolting for pressure containing joints

The dimensions and finish of bolting shall comply with the following British Standards as appropriate.

Metric	Inch
BS 3692	BS 1768 (below ½ in)
BS 4190	BS 1769
BS 4439	BS 2693 : Part 1
BS 4882	BS 2708
	BS 4882

Section three. Design and construction

7. General

7.1 Design lift. For safety valves that have a discharge area which is less than 80 % of the flow area, the overpressure at which the design lift is attained shall not exceed 10 % of the set pressure.

For safety valves that have a discharge area which is 80 % or more of the flow area, the overpressure at which the design lift is attained shall not exceed 5 % of the set pressure.

7.2 Bore. The bore of the body seat of each safety valve connected directly to a boiler shall be not less than 20 mm. The minimum area of the inlet connection of the safety valve shall be not less than the minimum area of the body seat or, in the case of double safety valves, it shall be not less than the sum of the minimum areas of the body seats.

7.3 Discharge. Safety valves shall be so constructed that breakage of any part or failure of any device will not obstruct free and full discharge through the safety valves.

In the particular case of pilot operated safety valves, at least two independent pilot device systems shall be provided for each main safety valve. The two systems shall be connected individually and arranged such that failure of any one pilot device system shall not prejudice the correct functioning of the other system in controlling the main safety valve.

7.4 Moving parts. The valve disks and spindles:

- (a) shall be guided efficiently, and
- (b) shall have sufficient clearance to ensure freedom of movement under all conditions of service, and
- (c) shall be prevented from lifting out of their seats.

Spindles shall not be fitted with stuffing boxes.

7.5 Body seats. Body seat faces shall be either:

- (a) flat and at right angles to the axis of the body seat; or
- (b) tapered, provided the included angle of the taper is not less than 90°.

Seats, other than those of integral design, shall be secured effectively.

7.6 Prevention of alteration to the set pressure. All safety valves shall be sealed by the manufacturer, his representative or a responsible authority. Unauthorized interference with the load on the spring, after the safety valve has been adjusted, shall be prevented by:

- (a) the fitting of a ferrule under the adjusting screw collar, or
- (b) the fitting of a compression ring under the adjusting screw collar, or
- (c) the locking of the adjusting screw.

NOTE. Alternations should only be made with the authority of the manufacturer and/or the inspecting authority.

7.7 Easing gear. Safety valves shall be so arranged that, when they are under normal working pressure, the mechanical load on the valve head can be eased by means of suitable gear.

7.8 Gaging device. When a gaging device is provided, due account shall be taken of the suitability of the valve spindle to accept additional compressive loading arising from its use.

8. Scantlings

The design of a safety valve body shall be such that the safety valve body is sufficiently robust to withstand reaction loads which will be imposed in service.

Steel valves manufactured in accordance with this Part of BS 6759 shall only be deemed to comply with this Part of BS 6759 if the design strength value does not exceed that given in table 2.3 of BS 5500 : 1982. Valves shall be designed for a life of 150 000 h except when contractual requirements, approved by the inspecting authority, specify a different design life.

Calculations of scantlings shall be based on the design pressure as defined in BS 806 and BS 2790 or, the calculation pressure as defined in BS 1113, as appropriate. End connections shall comply with one of the following standards:

- (a) flanges with BS 1560 : Part 2 or BS 4504;
- (b) screwed connections with BS 21;
- (c) weld preparation with an appropriate standard which has the approval of the inspecting authority.

9. Castings

All castings shall be smooth, sound, and free from cracks, significant flaws or other injurious defect. Variations in thickness shall be gradual, and substantial fillets shall be provided.

The welding of cast steel pressure containing components shall be in accordance with the procedures laid down in BS 4570 : Part 1, cognizance being taken of the requirements of clauses 18 and 19 of BS 1504 : 1976 dealing with rectification of castings and freedom from defects, respectively.

The welding of cast iron or copper alloy pressure containing components is prohibited.

10. Forgings

All forgings shall comply with BS 1503.

11. Springs

11.1 Helical coil

11.1.1 General. The spring manufacturer shall be in a position, if so requested, to supply a certificate stating that the spring or springs have been made from the prescribed material, and have been tested in accordance with the requirements of this British Standard.

11.1.2 Dimensions. The proportion of unloaded length to external diameter of the spring shall not exceed 4 to 1.

11.1.3 Stress. The shear stress, q , shall not exceed the value for that particular material given in column 4 of table 1, subject to the maximum shear stress when the spring is compressed coil to coil not exceeding the value given in column 5 of that table for the same material.

q shall be determined from the following equation.

$$q = \frac{8 W D K A}{\pi d^3} \quad (1)$$

where

q is the shear stress (in N/mm²);

W is the force at set pressure (in N);

D is the mean diameter of the coil (in mm);

d is the diameter of the section (in mm);

K is the safety valve spring correction factor (see figure 2)

$$= \frac{D/d + 0.2}{D/d - 1};$$

$$A = \frac{\delta_1 + \delta_2}{\delta_1} \quad (2)$$

where

δ_1 is the axial deflection due to force W (in mm);

δ_2 is the lift (in mm) of the valve at certified discharge capacity.