

Safety valves —

Part 3: Specification for safety valves for process fluids

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Committees responsible for this British Standard

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- Associated Offices Technical Committee
- Association of Shell Boilermakers
- BEAMA Ltd.
- British Compressed Air Society
- British Compressed Gases Association
- British Valve Manufacturers' Association Ltd.
- Combustion Engineering Association
- Department of Transport (Marine Directorate)
- Electricity Supply Industry in England and Wales
- Energy Industries Council
- Engineering Equipment and Materials Users' Association
- GAMBICA (BEAMA Ltd.)
- Health and Safety Executive
- Institution of Chemical Engineers
- Institution of Mechanical Engineers
- Liquified Petroleum Gas Industry Technical Association (UK)
- Process Plant Association
- Spring Research and Manufacturers' Association
- Water-tube Boilermakers' Association

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Foreword

The preparation of this British Standard has been undertaken under the direction of the Pressure Vessel Standards Committee and, as far as is applicable to safety valves for fluids, takes account of 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.*

To provide guidance to manufacturers and users, appendices to the standard are included which cover aspects relevant to the ordering and installation of safety valves together with other relevant matters of general interest.

The need to distinguish between a valve installed because of statutory requirements, invariably known as a safety valve, and a valve for the relief of liquids, commonly known as a relief valve, has led to the extensive use of the term safety relief valve in the process industries. Unfortunately, it proved impossible to define safety valve, safety relief valve and relief valve in a manner which was unambiguous and acceptable to representatives of all interested parties in both the power and process industries in the UK. Thus, in the interests of standardization, it has been decided to refer to all valves for the automatic relief of pressure as safety valves, irrespective of the type of fluid on which they are designed to operate and their functional characteristics.

The requirements of this standard call for the manufacturer of a safety valve to certify its capacity in terms of the flow rate of a reference fluid to the satisfaction of the independent authority. This certified capacity, founded on tests carried out on the actual or similar valves in order to establish the coefficient of discharge, provides the basis for certified discharge capacity tables from which the equivalent capacity of the valve for fluids other than the reference fluid may be calculated.

To assist manufacturers and independent 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.

A British Standard does not purport to include all the necessary provisions of a contract. Users of British Standards are responsible for their correct application.

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

Summary of pages

This document comprises a front cover, an inside front cover, pages i to iv, pages 1 to 48, an inside back cover and a back cover.

This standard has been updated (see copyright date) and may have had amendments incorporated. This will be indicated in the amendment table on the inside front cover.

Section 1. General

1 Scope

This Part of this British Standard specifies requirements for the design, type selection and flow certification relating to safety valves for process fluids. It does not cover safety valves for the following.

- a) Steam and hot water, covered by BS 6759-1.
- b) Compressed air and inert gases, covered by BS 6759-2 (in course of preparation).
- c) The protection of low pressure storage tanks and tanks storing liquefied gases at or near atmospheric pressure within the scope of BS 799-5, BS 2594, BS 2654 and BS 5387.
- d) The protection of vessels and containers used for the transport of fluids under pressure.

NOTE The titles of the publications referred to in this standard are listed on page 48.

2 Definitions

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

NOTE See Figure 1 for safety valve layout and components.

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. (See Appendix A.)

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 overpressure 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 subject to the requirements of this standard (see also Appendix A)

2.1.5

balanced bellows safety valve

a valve incorporating a bellows which has an effective area equal to that of the valve seat to eliminate the effect of back pressure on the set pressure of the valve and which effectively prevents the discharging fluid entering the bonnet space

2.1.6

balanced bellows safety valve with auxiliary piston

a balanced bellows valve incorporating an auxiliary piston which has an effective area equal to the valve seat which becomes effective in the event of a bellows failure

2.1.7

balanced piston safety valve

a valve incorporating a piston which has an area equal to that of the valve seat to eliminate the effect of back pressure on the set pressure of the valve

2.1.8

bellows seal safety valve

a valve incorporating a bellows which prevents discharging fluid from entering the bonnet space

2.1.9

conventional safety valve

a valve of the direct loaded type, the set pressure of which will be affected by changes in the superimposed back pressure

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 bar¹⁾ (See Appendix B.)

2.3**built-up back pressure**

the pressure existing at the outlet of a safety valve caused by flow from the valve through the discharge system

2.4**bursting disc**

a thin disc of material of controlled thickness which will burst when a predetermined pressure is reached below the disc, so preventing a predetermined safe pressure being exceeded in the vessel to be protected

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 measured flow rate X derating factor, or theoretical flow rate X coefficient of discharge X derating factor, or theoretical flow rate X derated coefficient of discharge.

2.6**closed disposal system**

a system in which the discharge from a safety valve is prevented from leaking to atmosphere

2.7**coefficient of discharge**

ratio of the measured capacity to the theoretical capacity

2.8**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

2.9**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 test.

2.10**derated coefficient of discharge**

the coefficient of discharge multiplied by the derating factor

2.11**discharge area of a safety valve**

the minimum cross-sectional area between inlet and seat, including the curtain area, which controls the flow of fluid through the safety valve when it is discharging its certified discharge capacity (See Appendix C.)

2.12**equivalent calculated capacity**

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

2.13**flow area (orifice area)**

the minimum cross-sectional flow area (but not the curtain area) between inlet and seat which is used to calculate the theoretical flowing discharge capacity, with no deduction for any obstruction (See Appendix C.)

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**lift**

the travel of the disk away from the closed position

2.16**measured capacity**

actual flow rate of discharge on test

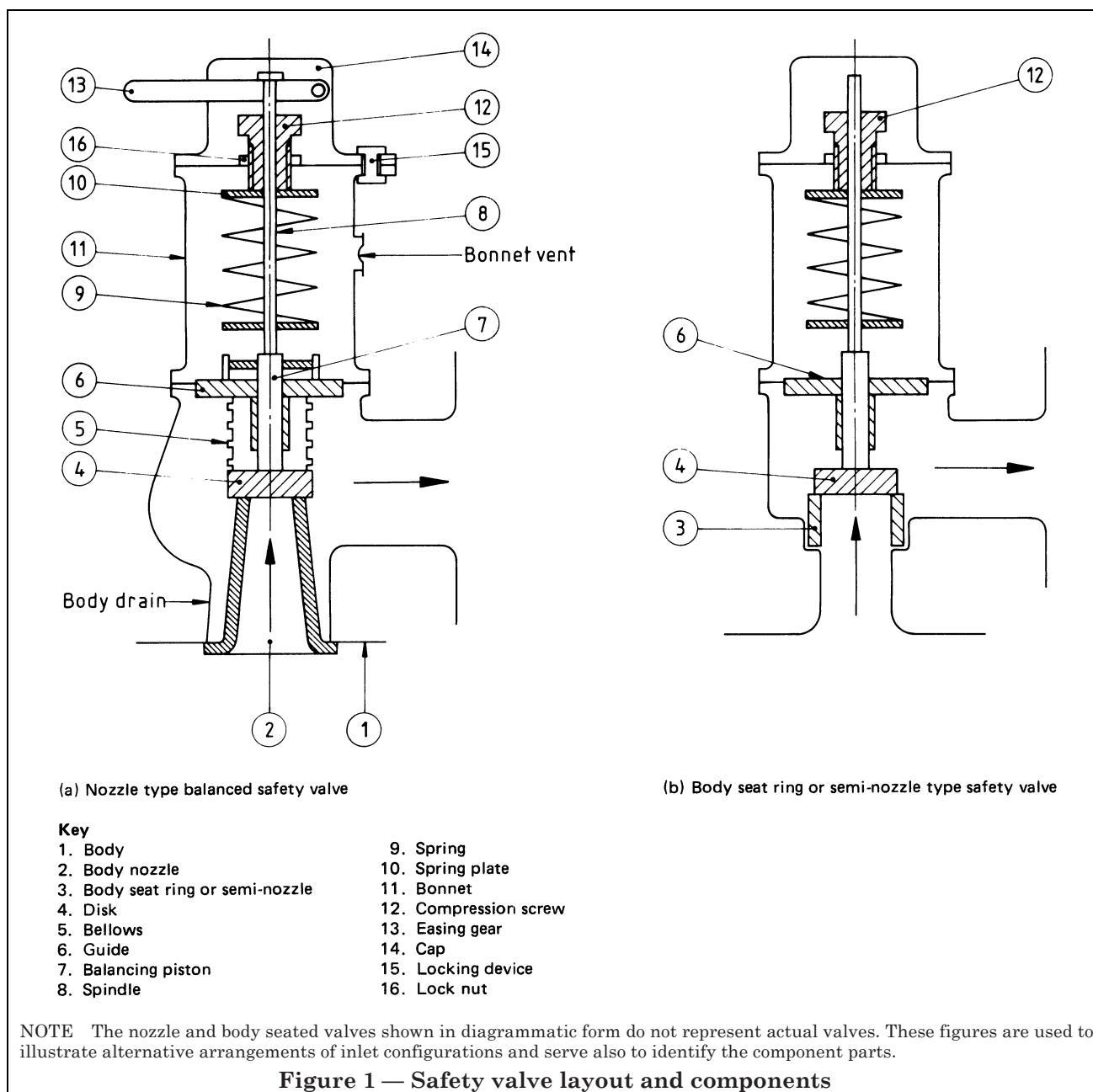
2.17**nominal size (DN)**

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**open disposal system**

a system in which the discharge of fluid from a safety valve is to atmosphere

¹⁾ 1 bar = 10⁵ N/m² = 100 kPa.



2.19 overpressure of a safety valve

a pressure increase over the set pressure of a safety valve, usually expressed as a percentage of set pressure (See Appendix B.)

2.20 relieving pressure of a safety valve (flow rating pressure)

set pressure plus overpressure

2.21 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 (See Appendix B.)

2.22**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 (See Appendix B.)

2.23**superimposed back pressure**

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

2.24**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 2. Material requirements and limitations

3 Pressure containing components

3.1 General. The materials of construction shall comply with this standard and shall be compatible with the process fluid, the adjoining components and the environment in which the valve is to be used.

3.2 Bodies and bonnets. Bodies and bonnets, or yokes, of safety valves shall be manufactured from either:

- a) cast or forged material, listed in Table 1, or equivalent grades of plate or bar, or
- b) materials other than those listed, providing they comply with a standard or specification that ensures control of chemical and physical properties and quality, appropriate to the end use.

3.3 Disk, nozzle and body seat ring. Material for these components shall be capable of withstanding the corrosive and erosive effects of the particular service conditions. If a resilient insert is employed the material and design shall be such that it will not become distorted under operating conditions or adhere to the body seat/disk so as to change the discharge or operating characteristics of the valve. Cast iron shall not be used.

3.4 Materials intended to be welded. The chemical composition, by ladle analysis, of carbon, carbon-manganese and carbon-molybdenum steels intended to be welded shall have a maximum carbon content of 0.25 %.

3.5 Carbon steel for sub-zero service. Steels for sub-zero service shall comply with the impact and other requirements of Appendix D of BS 5500:1982.

3.6 Pressure and/or temperature limitations. The following limitations shall apply.

- a) *Cast iron.* When cast iron is used for bodies, bonnets or caps, the set pressure shall not exceed 13 bar gauge nor the design temperature exceed 220 °C or be below 0 °C.

NOTE Cast iron shall not be used for service with hydrocarbon vapours or for other flammable or toxic materials or in an area where a fire risk exists.

- b) *Carbon, low and high alloy steels and copper alloy.* The minimum and maximum temperature limitations shall be in accordance with the relevant material/application standard.

4 Spring materials

Spring materials shall be selected from those listed in Table 2 with particular reference to their corrosion resisting properties and the temperature at the spring (see also clause 7).

5 Other internal parts

5.1 Guiding surfaces. The material of the guiding surfaces shall be compatible with the service conditions and shall be selected to reduce the possibility of galling or seizure.

5.2 Bolting. Bolting for pressure containing joints shall be in accordance with BS 4882.

5.3 Gaskets. Gasket material shall be suitable for the application.

Section 3. Design and construction

6 General

NOTE Guidance on safety valve installation is given in Appendix D.

6.1 Valve passage areas. The minimum bore area of the inlet connection of the safety valve shall be not less than the minimum flow area of the body seat ring or nozzle.

The bore area of the outlet connection and the passages in the valve body leading to it shall be not less than the bore area of the inlet.

Table 1 — Materials for pressure containing components

Material	British Standard reference	Comparable ASTM reference ^b
<i>Castings</i>		
Grey iron	BS 1452 grade 220 min.	A126:1973 (reaffirmed 1979) class B
Copper alloy	BS 1400 grade LG2 min.	—
Carbon steel	^a BS 1504-161, grade 480 A	A216:1983 WCB
1 1/4 % chromium, 1/2 % molybdenum	BS 1504	A217:1983 WC6
2 1/4 % chromium, 1 % molybdenum	^a BS 1504-622 E	A217:1983 WC6
Austenitic chromium nickel	^a BS 1504-304C15A	A351:1983 Grade CF8
Austenitic chromium nickel 2 1/2 % molybdenum	^a BS 1504-316C16A	A351:1983 Grade CF8M
Carbon steel	BS 1504-161, grade 430 LT40	A352:1983 LCB
3 1/2 % nickel	BS 1504-503 LT60	A352:1983 LC3
<i>Forgings</i>		
Carbon steel	^a BS 1503-221430 ^a BS 1503-221490	A105:1983
Austenitic chromium nickel	^a BS 1503-304S31	A182:1982a Grade F304
Austenitic chromium nickel molybdenum	^a BS 1503-316S31	A182:1982a Grade F316
^a Nominal design stress values for the British Standard materials are given in BS 5500. ^b American Society of Materials and Testing. Publications available from the Library, BSI, Linford Wood, Milton Keynes MK14 6LE. These materials may not be exact equivalents of the British Standard material but are included as generally acceptable alternatives.		

In the case of a double safety valve, i.e. a safety valve with two body seat rings in one body, the bore area of the inlet connection and the bore area of the outlet(s) connection(s) and passages leading thereto shall be not less than the sum of the flow areas of the body seat rings.

6.2 Prevention of obstruction. The design of a safety valve shall be such that breakage of any part or failure of any device does not obstruct free and full discharge through the safety valve.

6.3 Moving parts. The valve disk and spindle shall be guided efficiently and so constructed as to prevent their lifting out of the guides. The working parts shall have sufficient clearance to ensure freedom of movement under all conditions of service particularly temperature effects during discharge. Spindles shall not be fitted with glands. Guides below the disk shall not be permitted.

6.4 Body seat ring or nozzle. Safety valve body seat ring or nozzle seating faces shall be either:

- flat and at right angles to the axis of the body seat ring or nozzle; or
- tapered, provided that the included angle of the taper is not less than 90°.

The seat ring or nozzle shall be secured effectively in the body.

6.5 Prevention of alteration to the set pressure. Interference with the load on the spring after the safety valve has been adjusted shall be prevented by the fitting of a ferrule or compression ring under the adjusting screw collar or by suitably locking the adjusting screw, and a separate bolted or screwed cover shall be sealed to the bonnet by means of a lead seal or other suitable device.

6.6 Easing gear. Easing gear, when fitted, shall be so arranged that when the valve is pressurized to a minimum of 90 % of set pressure, the valve disk can be lifted.

If valves are handling fluids where an escape to atmosphere might create a hazard, the easing gear, if fitted, shall be of sealed design.

NOTE Where the fluid is likely to cause gumming or the formation of deposits, the valve should be fitted with easing gear to provide a means of checking that the valve will lift.

6.7 Gagging device. When a gagging device is provided, due account shall be taken of the suitability of the valve spindle, seat face and disk to accept additional compression loading arising from the use of the gagging device. On totally enclosed safety valves, the gagging device hole in the pressure containing part shall be sealed with a suitable plug.

NOTE It is recommended that the gagging device be supplied by the safety valve manufacturer.

6.8 Certified capacity. Safety valves for use on gases shall be so designed as to achieve their certified discharge capacity at an overpressure of 10 % (i.e. 110 % of set pressure), whilst those for liquid service shall be at 10 % or 25 % of overpressure (i.e. 110 % or 125 % of set pressure) (see 16.1).

6.9 Tolerance on set pressure. Under operating conditions, the tolerances on set pressure shall be:

- a) set pressure below 5 bar: ± 0.14 bar;
- b) set pressure 5 bar and above: ± 3 %.

6.10 Blowdown. The blowdown shall be as follows.

- a) Under operating conditions, the blowdown shall be adjustable between 5 % and 10 % of the set pressure except for valves having:
 - 1) seat bore less than 15 mm, when the maximum limit of blowdown shall be 15 % of set pressure;
 - 2) a set pressure less than 3.0 bar, when the blow-down shall be a maximum of 0.3 bar.
- b) Limits for valves with non-adjustable blowdown shall be a maximum of 15 % of set pressure.
- c) Limits of blowdown for incompressible fluids shall be a maximum of 20 % of set pressure except for values of set pressure less than 3 bar, when the blowdown shall be a maximum of 0.6 bar.

6.11 Drainage. Where circumstances permit, each safety valve shall be provided with a drain connection at the lowest point of the body on the discharge side of the valve. This drain connection shall be supplied with a suitable plug.

NOTE When circumstances do not permit the provision of a drainage connection this may be omitted by agreement between the manufacturer and the purchaser.

6.12 Pressure containing parts. The design of the pressure containing parts of a safety valve shall be the responsibility of the manufacturer.

6.13 Inlet and outlet connections

6.13.1 General. Limitations on the particular type of flanged, screwed or welded connections shall be as specified in the appropriate application standard.

6.13.2 Flanges. Flanges shall be forged or cast integral with the body. The dimensions of flanges, integral or otherwise, flange facings, ring joints (if used), bolt holes, bolting and the manufacturing tolerances of both inlet and outlet flanges shall be in accordance with BS 1560-2, BS 4504, BS 3293, API 605:1980²⁾ or MSS SP44:1982³⁾ (see also D.6).

NOTE 1 The dimensions of flanges should be specified by the purchaser (see Appendix E).

NOTE 2 Flanges may be attached by welding to the body, subject to agreement between the manufacturer and the purchaser.

6.13.3 Screwed connections. Valve bodies shall be screwed with a parallel or taper thread in accordance with BS 21, or with a taper thread in accordance with API Std 6A:1983.

NOTE Screwed connections should be avoided where crevice corrosion may occur.

6.13.4 Welded connections. Welded connections shall be as follows.

- a) Socket welding connections shall comply with BS 3799.

NOTE Socket welding connections should be avoided where crevice corrosion may occur.

- b) The valve stub shall be of a length which shall permit welding and heat treatment as required by the appropriate welding standard.

NOTE Butt welded end details shall be provided by the purchaser (see Appendix E).

6.14 Valve dimensions and selection

NOTE Preferred face-to-centre dimensions are listed in Appendix F, relative to connection sizes and BS 1560-2. In the interest of standardization, users are recommended to use these dimensions which correspond to those given in API 526 (second edition 1969).

Inlet pressure limits shall be governed by the inlet termination or the manufacturer's spring design limits, whichever is the smaller. Inlet flanges shall be capable of withstanding reaction forces due to the valve discharge in addition to the, internal pressure and are therefore generally suitable for pressures and temperatures lower than the ANSI ratings (see Appendix F). Outlet pressure limits shall be determined by the valve design.

²⁾ American Petroleum Institute. Publications available from the Library, BSI, Linford Wood, Milton Keynes MK14 6LE.

³⁾ Manufacturers' Standardization Society of America. Publications available from the Library, BSI, Linford Wood, Milton Keynes MK14 6LE.

Table 2 — Spring materials

Material		Recommended limiting section (diameter)	Recommended temperature limit at the spring	
Type	Specification		Min.	Max.
Carbon steels			°C	°C
	BS 2803 094A65 HS	Up to 12.5 mm	– 20	+ 150
	BS 5216 HS2 and HS3	Up to 13 mm	– 20	+ 130
	BS 970-5 070A72 070A78	10 mm to 20 mm 10 mm to 20 mm	– 20 – 20	+ 150 + 150
Alloy steels	BS 970-4 302 S25	above 10 up to 30 mm	– 200	+ 250
	316 S16	above 10 up to 30 mm	– 200	+ 250
	BS 970-5 250A58 ^a	10 mm to 40 mm	– 20	+ 150
	250A61 ^a	10 mm to 40 mm	– 20	+ 150
	527A60	10 mm to 40 mm	– 20	+ 150
	735A50	10 mm to 80 mm	– 20	+ 175
	805A60	10 mm to 80 mm	– 20	+ 150
	BS 2056 302S26	Up to 10 mm	– 200	+ 250
	316S42	Up to 10 mm	– 200	+ 250
	BS 2803 685A55 HS	Up to 12.5 mm	– 20	+ 175
	735A50 HS	Up to 12.5 mm	– 20	+ 175
	BS 4659 BH12	Up to 50 mm	– 20	+ 370
	BH13	Up to 50 mm	– 20	+ 370
	BH21	Up to 50 mm	– 20	+ 370
	BS 2S 143	—		
	BS 2S 144	—		
	BS 2S 145	Up to 50 mm	– 90	+ 350
	DTD 5086:1969 ^b	Up to 10 mm	– 90	+ 300
	ASTM A638:1982 Grade 660	Up to 80 mm	– 200	+ 400
Non-ferrous	BS 3075 NA13	Up to 10 mm	– 40	+ 200
	NA14	Up to 10 mm	– 200	+ 370
	N18	Up to 8 mm	– 200	+ 230
	BS 2HR 501	Up to 8 mm	– 200	+ 540
	BS 2HR 502	Up to 8 mm	– 200	+ 540
	SAE AMS 5698C:1953 (reaffirmed 1977) ^c	Up to 12.5 mm	– 200	+ 540

NOTE These materials may require cold working during wire manufacture or heat treatment after coiling to produce an adequate spring for the temperatures in the table.

^a Above 30 mm diameter special heat treatment may be necessary which could induce brittleness.

^b Department of Technical Development. Publications available from HMSO. Can be obtained as 17/7 PH in larger sizes.

^c American Society of Automotive Engineers. Publications available from the Library, BSI, Linford Wood, Milton Keynes MK14 6LE.

6.15 Bonnet venting. Bonnet venting arrangements shall be as follows.

- a) *Conventional safety valves:* external vent not required.
- b) *Balanced bellows safety valve and balanced piston safety valve:* the bonnet space in both types of valve shall be vented to prevent its becoming a closed chamber.

6.16 Pilot operated safety valves. The operation of the main valve shall be controlled by a pilot valve which is itself a direct loaded safety valve, complying with this standard and initiated and controlled by the system pressure.

The number of pilot valves controlling each main valve shall be such as to ensure that the main valve opens automatically and reliably at not over the set pressure and discharges its certified capacity if some essential part of a pilot valve should fail.

Where two or more pilot valves are provided, they shall be arranged such that failure of one or more pilot valve(s) does not prejudice the correct functioning of the remaining serviceable pilot valve(s) in controlling the main valve.

NOTE The pilot valve(s) may be mounted directly on the main valve or separate from it.

6.17 Valves with restricted lift. Valve lift shall be 30 % or more of full lift or 1.5 mm whichever is the greater.

The derated coefficient of discharge, K_{dr} [see equation (5) in 19.1] shall be reduced in proportion to the ratio of restricted lift over full lift.

7 Springs

7.1 General. Under normal operating conditions, springs used in safety valves shall be of helical coil design made of material complying with one of the specifications given in Table 2.

NOTE 1 Where operating conditions require an alternative material, this should be agreed between the manufacturer and the purchaser.

The allowable stresses shall be based on previous satisfactory experience and the current understanding of the behaviour of spring materials taking into consideration the temperature of the spring, the environment and the amount of relaxation which is permissible in service.

NOTE 2 Where appropriate, the hardness should be specified by the purchaser (see Appendix E).

7.2 Materials. The material selected shall comply with the limitations on temperature range given in Table 2 and shall have corrosion resistant properties for the duty specified. The material shall be of circular section.

NOTE The use of protective coatings is not covered by this standard and, if they are necessary, their use should be agreed between the manufacturer and the purchaser.

7.3 Dimensions

7.3.1 Proportion. The proportion of the unloaded length to the external diameter of the spring shall not exceed four to one.

7.3.2 Spring index. The spring index, i.e. the mean diameter of the coil, D , divided by the diameter of the section, d , shall be within the range 3 to 12.

7.3.3 Spacing of coils. The spacing of the coils shall be such that when the valve head is at the lift corresponding to its certified discharge capacity the space between coils shall not be less than 1 mm. The total of these clearances for the spring as a whole shall not be less than 20 % of the deflection of the spring from the free length to the solid length.

7.4 End coils. Both ends of each spring shall be closed against the adjacent full coils, and ground.

The ends of the springs shall present a flat bearing of between 270° and 300° of the circumference at right angles to the axis (see Figure 2), so that when placed on end on a horizontal plane the springs shall be within the tolerances for class A springs recommended in Appendix A of BS 1726-1:1964.

Smooth consistent tapers to smooth edges shall be provided with a coil tip thickness approximately equal to one-quarter of the wire (bar) diameter.

The end coils of a spring shall not encroach upon the specified inside or outside diameters of the spring (see Figure 2).

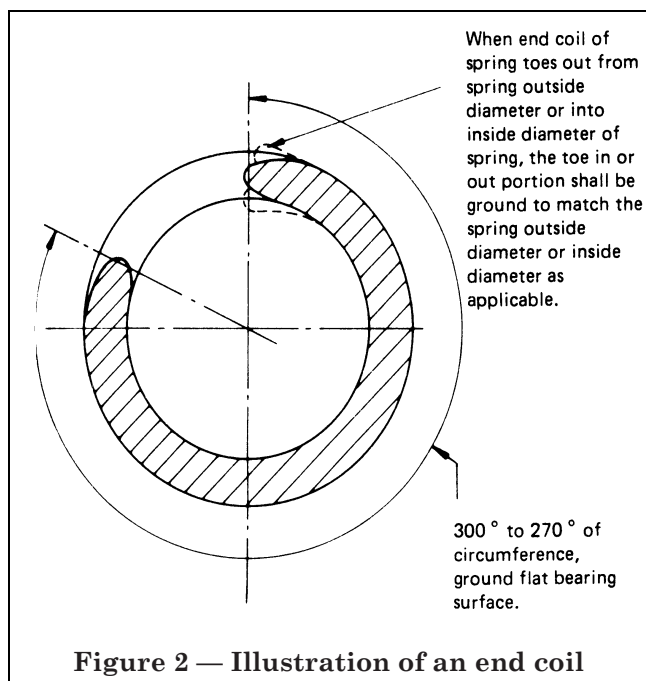


Figure 2 — Illustration of an end coil

7.5 Spring plates/buttons. The spring plates/buttons shall have a locating spigot length (excluding any radius or chamber) of at least 0.75 of the spring wire/bar diameter. The maximum clearance between the outside diameter of the locating spigot and the inside diameter of the spring shall not exceed 0.7 mm and shall rotate freely (see Figure 3).

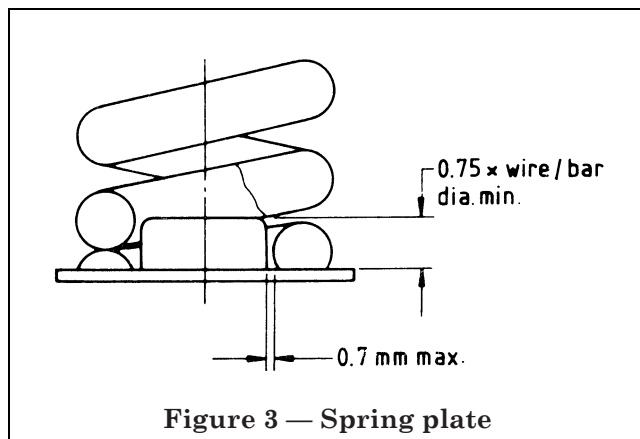


Figure 3 — Spring plate

7.6 Stress. The corrected shear stress, q , shall be determined from the following equation:

$$q = \frac{8WDKA}{\pi d^3} \quad (1)$$

where

- q is the corrected 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 stress correction factor for curvature (see Table 3):

$$K = \frac{D/d + 0.2}{D/d - 1.0};$$

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

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.

7.7 Number of working coils. The number of working or free coils in a spring, n , shall be determined from the following equation:

$$n = \frac{d^4 G \delta_1}{8 D^3 W} \quad (3)$$

where

G is the shear modulus (in N/mm²);

n is the number of working coils.

Other symbols used in the equation are defined in 7.6.

7.8 Handing of coils. Where springs are nested, the adjacent springs shall be opposite handed.

NOTE Single springs may be coiled either right hand or left hand.

7.9 Testing and dimensional checks

7.9.1 Permanent set. The permanent set of the spring (defined as the difference between the free length and the length measured 10 min after the spring has been compressed solid three additional times at room temperature) shall not exceed 0.5 % of the free length.

7.9.2 Dimensional checks. Following the above test, each spring shall then be subjected to the following minimum checks.

a) Measurements corresponding to:

- 1) load/length at 15 % of the calculated total deflection of the spring;
- 2) load/length at the maximum compression at which the spring will be used, or the spring rate over a given range above 15 % of the calculated total deflection.

b) Dimensional check of coil diameter and free length.

c) Dimensional check for end-squareness: by standing the spring on a surface plate against a square and measuring the maximum deviation between the top end coil and the square. This shall be repeated with the spring reversed end for end (see Figure 4).

d) Dimensional check for end parallelism: by standing the spring on a surface plate and measuring the difference between the levels of the highest and lowest points of the surface of the upper ground end. These measurements shall be repeated with the spring reversed end for end (see Figure 5).

The tolerances shall comply with 7.10.

Table 3 — Stress correction factor for curvature (*K*)

<i>D/d</i>	<i>K</i>	<i>D/d</i>	<i>K</i>	<i>D/d</i>	<i>K</i>
3.0	1.600	6.1	1.235	9.1	1.148
3.1	1.571	6.2	1.231	9.2	1.146
3.2	1.545	6.3	1.226	9.3	1.145
3.3	1.522	6.4	1.222	9.4	1.143
3.4	1.500	6.5	1.218	9.5	1.141
3.5	1.480	6.6	1.214	9.6	1.140
3.6	1.462	6.7	1.211	9.7	1.138
3.7	1.444	6.8	1.207	9.8	1.136
3.8	1.429	6.9	1.203	9.9	1.135
3.9	1.414	7.0	1.200	10.0	1.133
4.0	1.400	7.1	1.197	10.1	1.132
4.1	1.387	7.2	1.194	10.2	1.130
4.2	1.375	7.3	1.190	10.3	1.129
4.3	1.364	7.4	1.188	10.4	1.128
4.4	1.353	7.5	1.185	10.5	1.126
4.5	1.343	7.6	1.182	10.6	1.125
4.6	1.333	7.7	1.179	10.7	1.124
4.7	1.324	7.8	1.176	10.8	1.122
4.8	1.316	7.9	1.174	10.9	1.121
4.9	1.308	8.0	1.171	11.0	1.120
5.0	1.300	8.1	1.169	11.1	1.119
5.1	1.293	8.2	1.167	11.2	1.118
5.2	1.286	8.3	1.164	11.3	1.117
5.3	1.279	8.4	1.162	11.4	1.115
5.4	1.273	8.5	1.160	11.5	1.114
5.5	1.267	8.6	1.158	11.6	1.113
5.6	1.261	8.7	1.156	11.7	1.112
5.7	1.255	8.8	1.154	11.8	1.111
5.8	1.250	8.9	1.152	11.9	1.110
5.9	1.245	9.0	1.150	12.0	1.109
6.0	1.240				

7.9.3 Hardness. Where maximum hardness is specified, (see 7.8) hardness tests shall be carried out for each spring.

NOTE The method of testing should be subject to approval by the purchaser.

7.10 Tolerances

7.10.1 Load/length. The tolerances on load/length requirements shall be as given in Table 4.

Table 4 — Load/length tolerances

Number of working coils	Load tolerances	
	Wire/bar diameter up to and including 10 mm	Wire/bar diameter above 10 mm
	%	%
Less than 4	± 7.5	+ 7.5 – 5.0
4 to 10 inclusive	± 5.0	+ 6.0 – 4.0
More than 10	± 3.0	+ 6.0 – 4.0

7.10.2 Spring rate. The tolerances on spring rate shall be as given in Table 5.

Table 5 — Spring rate tolerances

Number of working coils	Spring rate tolerances	
	Wire/bar diameter up to and including 10 mm	Wire/bar diameter above 10 mm
	%	%
Less than 4	± 3.0	+ 8.0 – 6.0
4 or more	± 3.0	+ 7.5 – 5.0

7.10.3 Coil diameters. Assembly and machined part considerations determine whether the inside or outside diameter of the spring is critical and the spring specification shall indicate the limits on the spring diameters within which the spring shall be supplied.

Inside diameter tolerances are given in Table 6.

7.10.4 Free length. Prior to determination of free length, springs shall, at room temperature, be compressed to the nominal free length less 85 % of the average total deflection. After a 10 min wait, in an unloaded condition, the free length shall then be determined by placing a straightedge across the top of the spring and measuring the perpendicular distance from the plate on which the spring stands to the bottom of the straight-edge at the approximate centre of the spring. The measured free length shall be within the tolerance given in Table 7.

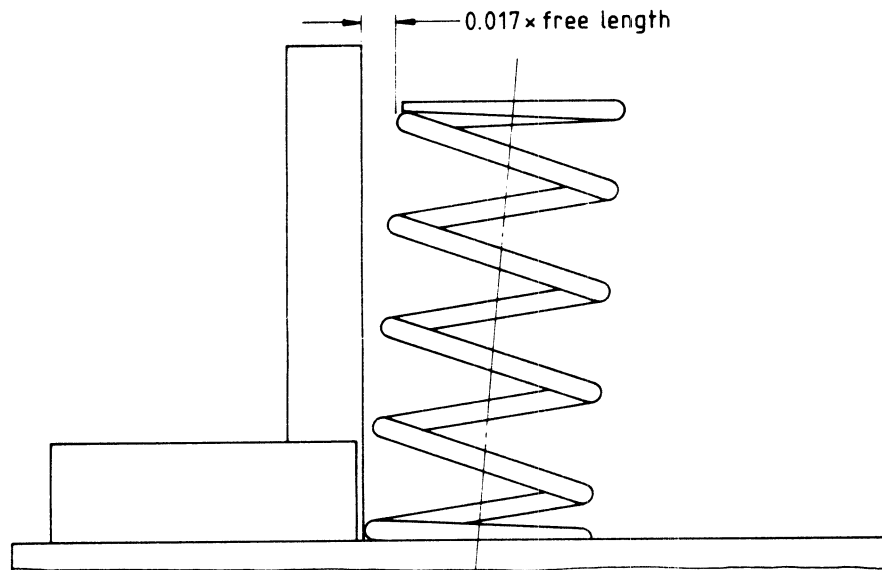


Figure 4 — End-squareness

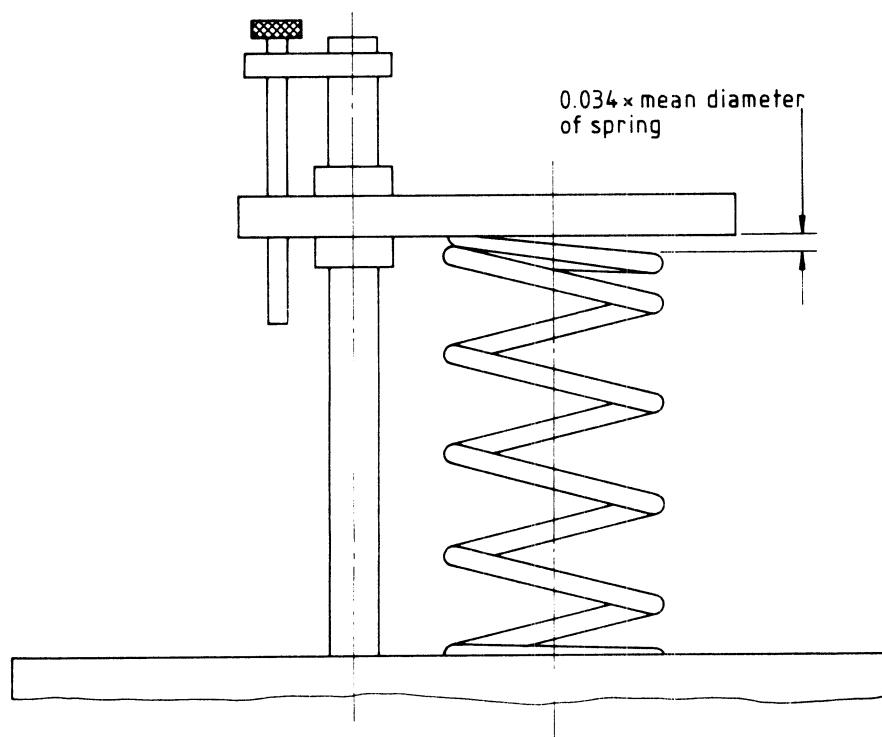


Figure 5 — End-parallelism