MATERIAL AND ENGINEERING STANDARD

FOR

PRESSURE AND VACUUM RELIEF DEVICES

CONTENTS :

PAGE No.

APPENDICES:

0. INTRODUCTION

Pressure and vacuum safety relief devices are normally used to terminate an abnormal internal or external rise in pressure above a predetermined design value in boilers, pressure vessels and related piping and process equipment. Pressure relief valves or rupture discs may be used independently or in combination to provide the required protection against excessive over pressure. As used in this Standard the term pressure relief valve includes safety relief valves used in compressible-fluid service and relief valves used in liquid service.

1. SCOPE

1.1 This Standard covers the minimum requirements for design, material, fabrication, inspection and shop test of pressure and vacuum safety relief devices.

1.2 Pressure and vacuum safety relief devices include safety valves, safety relief valves, vacuum breakers and rupture discs. Other types of relief systems are not within the scope of this Standard.

1.3 For installation recommendations on pressure relieving devices, reference is made to Part 2 of API Recommended Practice RP-520.

2. REFERENCES

Throughout this Standard the following standards and codes are referred to, the editions of these standards and codes that are in effect at the time of publication of this Standard shall, to the extent specified herein, form a part of this Standard. The applicability of changes in standard and codes that occur after the date of this Standard shall be mutually agreed upon by the Company and the Vendor.

API (AMERICAN PETROLEUM INSTITUTE)

RP 520	"Recommended Practice for the Design and Installation of Pressure Relieving Systems in Refineries"
Part I	"Design"
Part II	"Installation"
Standard 526	"Flanged Steel Safety Relief Valves"
Standard 527	"Commercial Seat Tightness of Safety Relief Valves with Metal to Metal Seats"
Standard 2000	"Venting Atmospheric and Low-Pressure Storage Tanks (Non-Refrigerated and Refrigerated)"

ASME (AMERICAN SOCIETY OF MECHANICAL ENGINEERS)

ASME Boiler and Pressure Vessel Code

Section I	"Power Boilers"
Section VIII	"Pressure Vessels"

ANSI (AMERICAN NATIONAL STANDARD INSTITUTE)

B 16.5	"Pipe Flanges and Flange Fittings"

BSI (BRITISH STANDARD INSTITUTION)

BS	"Materials Standard"

ASTM (AMERICAN SOCIETY FOR TESTING AND MATERIALS)

IPS (IRANIAN PETROLEUM STANDARDS)

E-PR-450	"Pressure Relieving and Depressuring Systems"

3. UNITS

This Standard is based on International System of Units (SI), except where otherwise specified.

4. PRESSURE AND VACUUM RELIEVING DEVICES

Pressure and vacuum relieving devices are of different types, a brief description of some common types are given below:

4.1 Relief Valve

A relief valve is an automatic pressure-relieving device actuated by the static pressure upstream of the valve. The valve opens in proportion to the increase in pressure over the opening set pressure. It is used primarily for liquid services.

4.2 Safety Valve

A safety valve is an automatic pressure relieving device actuated by the static pressure upstream of the valve and characterized by rapid full opening or pop action. It is used for gas or vapor services.

4.3 Safety-Relief Valve

A safety relief valve is an automatic pressure relieving device suitable for use as either a safety or relief valve, depending on application. It is used in gas and vapor services or for liquid.

4.3.1 Direct loaded safety-relief valve

A safety-relief 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.

4.3.2 Pilot operated safety-relief valve (indirect loaded safety-relief valve)

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

4.3.3 Balanced bellows safety-relief 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.

4.3.4 Conventional safety-relief valve

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

4.4 Rupture Disk

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

4.5 Vacuum Relief Valves

Vacuum relief valves are usually installed on storage tanks and shall normally be of the weight loaded or pilot operated type. For full description and determination of size of vacuum relief valves reference is made to API Standard 2000 "Venting Atmospheric and Low Pressure Storage Tanks (Non-Refrigerated and Refrigerated)".

5. DESIGN

5.1 Design Base

5.1.1 The pressure relieving devices shall be designed in accordance with the following codes and standards.

5.1.1.1 API-RP 520 "Design and Installation of Pressure Relieving Systems in Refineries".

Part I : Design
Part II: Installation

5.1.1.2 API Standard 526 "Flanged Steel Safety Relief Valves".

5.1.1.3 API Standard 527 "Commercial Seat Tightness of Safety Relief Valves with Metal to Metal Seats".

5.1.1.4 ASME Boiler and Pressure Vessel Code:

Section I: Power Boilers
Section VIII: Pressure Vessels

5.1.1.5 IPS-E-PR-450 "Pressure Relieving and Depressuring Systems".

5.1.2 The design of pressure and vacuum relief devices for storage tanks should be in accordance with API Standard 2000 "Venting Atmospheric and Low pressure Storage Tanks (Non-Refrigerated and Refrigerated).

5.2 Selection of Type

5.2.1 Conventional safety/relief valve shall be provided:

a) When the built-up back pressure and variable superimposed back pressure does not exceed 10% of the set pressure;

b) when constant superimposed back pressure exists.

5.2.2 Balanced-bellows safety/relief valve shall be provided:

a) When the built up back pressure and variable superimposed back pressure does not exceed 50% of the set pressure if the back pressure is incorporated in the safety/relief valve sizing.

b) When the fluid-flow is a corrosive service (service in which the corrosion allowance is 6 mm or more or in which stainless steel or alloy material is used to prevent corrosion from occurring).

5.2.3 Pilot operated pressure safety/relief valve shall be used primarily in the following services

a) When the built-up back pressure and variable superimposed back pressure does not exceed 50% of the set pressure.

b) For equipment that operate between 90 and 95% of the set pressure.

c) When the pressure drop to the inlet of the safety/relief valve is greater than 3% of the set pressure (in this case, the remote pressure pickup type should be used).

d) Where the valve size is so large that a direct loaded safety/relief valve would be unsuitable.

5.2.4 All safety/relief valves except thermal relief valves with the inlet nozzle size of DN 25 (1 in.) and larger should be flanged, spring loaded, high lift, high capacity type with a top guided disc. Safety/relief valves in services other than steam, hot water, and air should not be provided with a lifting device. Safety/relief valves with the inlet nozzle size under DN 25 may be of the screwed type connection.

5.2.5 All safety/relief valves shall be provided with pressure tight bonnets except bellows type valves.

5.3 Dimensions

5.3.1 Center-to-face dimensions shall be in accordance with API Standard 526. Flange facings and dimensions shall be in accordance with ANSI B16.5.

5.3.2 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 pressure and temperature lower than the ANSI ratings. Outlet pressure limits shall be determined by the valve design.

5.4 Determination of Orifice Area

5.4.1 The required orifice area shall be determined in accordance with API Recommended Practice 520 Part I Appendix C.

5.4.2 The standard effective orifice areas and the corresponding letter designations are listed in Table 1 below:

TABLE 1 - STANDARD EFFECTIVE ORIFICE AREAS AND LETTER DESIGNATIONS

ORIFICE LETTER DESIGNATION	EFFECTIVE AREA (SQUARE mm)
D	71
E	126.5
F	198
G	324.5
H	506.5
J	830.5
K	1186
L	1840.5
M	2322.5
N	2800
P	4116
Q	7129
R	10322.5
T	16774

5.5 Spring

5.5.1 Springs are usually designed and fabricated to the manufacturers own standards. A general specification for springs of safety/relief valves are given in Appendix B of this standard as a guide. The Appendix covers design, material, testing, dimensional checks and tolerances.

5.6 Design of Rupture Disks

5.6.1 Rupture disks are recommended in the following cases:

5.6.1.1 In services where the operation of a relief valve may be affected by corrosion or corrosion products, or by the deposition of material that may prevent the valve from lifting in service. Rupture disks can be used instead of or in conjunction with a relief valve.

5.6.1.2 With highly toxic or other materials where leakage through a relief valve cannot be tolerated. The rupture disk should be upstream of any relief valve.

5.6.1.3 For low positive set pressure, where relief valves tend to leak, a rupture disk can be used in place of the relief valve.

5.6.1.4 For the relief of a pressure rise which is too fast for conventional relief valves.

5.6.2 Calculation of relief area shall be in accordance with Appendix C of API Recommended Practice 520 Part I.

5.6.3 Protecting a vessel from over pressure that results from an internal explosion is a function of the vapor volume of the vessel, the area of the rupture disk, and the allowable pressure rise. Because no generally accepted method exists by which a calculation can be made, selecting the best means of protecting a vessel against an internal explosion depends solely on the designer's judgment. The following are two possible design approaches:

5.6.3.1 By applying a suitable safety factor to the normal operating pressure, the vessel can be designed to withstand an internal explosion. However this may become impractical when the safety factor is considered.

5.6.3.2 By applying a rupture disk based on the contained tank volume, the vessel can be protected. The basis for the sizing of the rupture disk must then be arbitrary. For cases involving an explosion pressure rise factor of 8, this choice varies from 3.3 to 6.6 square meters of relief area per 100 cubic meters of vapor volume. For normal refinery applications, a general rule of 6.6 square meters per 100 cubic meters will provide adequate area to protect against the explosion of an air-hydrocarbon mixture. Until more work is done in this area, an authoritative guideline cannot be recommended.

6. MATERIAL

6.1 General

6.1.1 The material of construction shall be compatible with the process fluid and the adjoining components and the environment in which the relief devices is to be used. Proposed material for pressure and vacuum relieving devices shall be approved by the Company. For pressure and vacuum relieving valves the following materials are proposed.

6.2 Body and its Relative Parts

6.2.1 Bodies and bonnets

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

a) Cast or forged material, listed in Table 8, 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.

TABLE 8 - MATERIALS FOR PRESSURE CONTAINING COMPONENTS

MATERIAL	COMPARABLE ASTM
Castings Grey iron	 A126 : CLASS B
Copper alloy	—
Carbon steel 1¼ % chromium, ½ % molybdenum 2¼ % chromium, 1% molybdenum	A216: WCB A217: WC6 A217: WC9
Austenitic chromium nickel Austenitic chromium nickel 2½ % molybdenum	A351: grade CF8 A351: grade CF8M
Carbon steel 3½ % nickel	A352: LCB A352: LC3
Forgings Carbon steel Austenitic chromium nickel Austenitic chromium nickel molybdenum	 A105: A182: grade F304 A182: grade F316

6.2.2 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.

6.2.3 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%.

6.2.4 Carbon steel for sub-zero service

Steels for sub - zero service shall comply with the impact and other requirements as specified by the Company.

6.2.5 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 gage nor the design temperature exceed 220°C or be below 0°C.

Note:

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

b) Carbon, low and high alloy steels

The minimum and maximum temperature limitations shall be in accordance with the relevant material/application standard.

c) Copper alloy

Copper alloy pressure containing parts shall not be used in locations or service where a fire risk exists, due to the relatively low melting point of the alloy.

6.3 Spring

6.3.1 For spring material reference is made to Appendix B of this Standard.

6.4 Internal Parts

6.4.1 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.

6.4.2 Bolting

Bolting for pressure containing joints shall be in accordance with ASTM A-193 & A-194 or the Purchaser's specification sheet.

6.4.3 Gaskets

Gasket material shall be suitable for the application.

7. INSPECTION AND SHOP TESTS

7.1 Inspection

7.1.1 Each pressure and vacuum safety device shall be checked against manufacturer's documents to see that it conforms to the design requirements.

7.1.2 Complete data of all parts shall be checked by the inspector prior to any test. Safety valve parts may be required to be dismantled for this purpose at the discretion of the inspector.

7.1.3 Records of inspection and testing and any possible repairs and corrections carried out shall be sent to the Company.

7.2 Pressure Test

7.2.1 Pressure testing shall be carried out by the manufacturer prior to any painting which may be required.

7.2.2 All pressure measuring devices fitted to test equipment shall be tested and calibrated to ensure the required accuracy during testing.

7.2.3 The bodies of all safety valves, relief valves and safety relief valves shall be subjected to pressure test to ensure the integrity of the part.

7.2.4 All closed bonnets and caps shall be pressure tested at a pressure not less than that specified for the body.

7.2.5 The testing and adjustment of cold set pressure using air or other gas as the test medium shall not be carried out unless the safety valve components have previously been pressure tested.

7.2.6 Unless specified otherwise, all safety valves shall be set and adjusted in accordance with the manufacturer's standard practice. The test medium shall be gas for valves which are to be used with gas but it shall be permissible to use liquid or gas as the test medium for valves to be used in liquid service.

7.2.7 One sample from each group of rupture disks of the same size and material should be tested in a holder of the same form and dimensions as that with which the disk is to be used. The disk shall burst within ±5% of its specified bursting pressure.

7.2.8 A test shall be applied to the discharge side of those safety valves fitted with bellows to test the pressure tightness of the bellows and its joints. The bonnet vent which shall be open, shall have a soapy water film placed across it and there shall be no visible leakage. The test shall be carried out using air or nitrogen at a pressure not less than the maximum specified back pressure. The duration of the test shall be as for the seat leakage test.

7.2.9 Type test certificate for each type of pilot operated safety/relief valves shall be provided by the manufacturer.

7.3 Seat Leakage Test

7.3.1 Safety, relief and safety relief valves shall be subject to a seat leakage test in accordance with API standard 527, as applicable, or as agreed upon by the manufacturer and the Company.

7.3.2 The seat leakage tests shall be carried out subsequent to the cold set pressure adjustment test.

8. MARKING AND PREPARATION FOR SHIPMENT

8.1 Body Marking

8.1.1 Each safety valve shall bear legible and permanent marking on the body, as follows.

a) The inlet nominal size;

b) the material designation of the body;

c) the manufacturer's name and/or trade mark;

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

e) ring joint number (where applicable) to be marked on the flange.

8.2 Nameplate

8.2.1 The following information shall be marked on a corrosion resistant nameplate:

a) The limiting operating temperature for which the valve has been designed, where applicable;
b) the set pressure;
c) the back pressure;
d) the nominal size (inlet by outlet);

e) the certified discharge capacity;
f) the flow area in square millimeters;
g) the manufacturer's type reference;
h) any other information required by the Company.

8.2.2 The nameplate shall be permanently attached to the body or bonnet of the valve.

8.2.3 Rupture disk nameplate shall bear the following information:

a) The size, net inside diameter of opening leading to the flange or holding arrangement for the disk in mm;
b) material of construction;
c) temperature for continuous operation and at burst pressure;
d) relief capacity;
e) rupture pressure;
f) test pressure;
g) manufacturer's name or identifying trade mark;
h) any other information required by the company.

8.3 Preparation for Shipment

8.3.1 After test and inspection, all exterior surfaces, except flange facings, shall be painted. Corrosion resistant materials need not be painted.

8.3.2 Unless otherwise specified, safety, relief valves shall be painted with the following color identification:

a) Conventional valves: Canary yellow;
b) bellows type valves: Body canary yellow; Bonnet-red.

8.3.3 Machined or threaded exterior surfaces shall be protected from corrosion during shipment and subsequent storage by coating with rust preventive.

8.3.4 Inlet and outlet flanges shall be protected to prevent damage from or entrance of foreign material during shipment.

8.3.5 Threaded openings shall be plugged with suitable protective devices. Temporary plugs should be readily distinguishable from permanent metal plugs.

8.3.6 Valves shall be so packaged as to minimize the possibility of damage during transit or storage. Instructions shall be provided for removing devices used for temporary protection.

APPENDICES

APPENDIX A

PRESSURE RELIEF VALVE SPECIFICATION SHEET

Sheet No. ....
Requisition No. ....
Job No. ....
Date ....
Revised ....
By ....

	General					
1	Item No.	____	____	____	____	____
2	Tag No.	____	____	____	____	____
3	Service, Line, or Equipment No.	____	____	____	____	____
4	Number required	____	____	____	____	____
5	Full nozzle, seminozzle, or other	____	____	____	____	____
6	Design type A. Safety, relief, or safety relief	____	____	____	____	____
	B. Conventional, bellows, or pilot operated	____	____	____	____	____
7	Bonnet type	____	____	____	____	____
	Connections					
8	Size(inlet/outlet)	____/____	____/____	____/____	____/____	____/____
9	Flange class, ANSI or screwed	____/____	____/____	____/____	____/____	____/____
10	Type facing	____/____	____/____	____/____	____/____	____/____
	Material					
11	Body/bonnet	____/____	____/____	____/____	____/____	____/____
12A	Seat/disk	____/____	____/____	____/____	____/____	____/____
12B	Resilient seat seal	____	____	____	____	____
13	Guide/rings	____/____	____/____	____/____	____/____	____/____
14	Spring	____	____	____	____	____
15	Bellows	____	____	____	____	____
	Accessories					
16	Cap, screwed or bolted	____	____	____	____	____
17	Lever, plain or packed	____	____	____	____	____
18	Gag	____	____	____	____	____
19	____________	____	____	____	____	____
20	____________	____	____	____	____	____

(to be continued)

APPENDIX A (continued)

	Basis of Selections					
21	Code	________	________	________	________	________
22	Fire	________	________	________	________	________
23	Other	________	________	________	________	________
	Service Conditions					
24	Fluid and state	________	________	________	________	________
25	Required capacity per valve and units	________	________	________	________	________
26	Molecular weight or specific gravity at flowing temperature	________	________	________	________	________
27	Viscosity at flowing temperature and units	________	________	________	________	________
28	Operating pressure, bar/set pressure, bar	____/____/____/___/___/___/___/___/___/___/____/____				
29	Operating temperature, C/flowing temperature, °C	____/____/____/___/___/___/___/___/___/___/____/____				
30	Constant back pressure, bar	________	________	________	________	________
31	Variable back pressure, bar	________	________	________	________	________
32	Differential set pressure	________	________	________	________	________
33	Allowable over pressure, percent	________	________	________	________	________
34	Compressibility factor	________	________	________	________	________
35	______________	________	________	________	________	________
	Orifice Area					
36	Calculated, square inches	________	________	________	________	________
37	Selected, square inches	________	________	________	________	________
38	Orifice designation	________	________	________	________	________
39	Manufacturer’s model No.	________	________	________	________	________
40	Manufacturer	________	________	________	________	________

Notes:

APPENDIX B
GENERAL SPECIFICATION FOR SPRINGS OF SAFETY/RELIEF VALVES

B.1 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 B.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 behavior of spring materials taking into consideration the temperature of the spring, the environment and the amount of relaxation which is permissible in service.

TABLE B.1 - SPRING MATERIALS

MATERIAL		RECOMMENDED LIMITING SECTION (DIAMETER)	RECOMMENDED TEMPERATURE LIMIT AT THE SPRING °C	
TYPE	SPECIFICATION		Min.	Max.
Carbon steels	BS 2803 094A65 HS	Up to 12.5 mm	-20	+150
	BS 5216 HS2 and HS3	Up to 13 mm	-20	+130
	BS 970: Part 5 070A72	10 mm to 20 mm	-20	+150
	070A78	10 mm to 20 mm	-20	+150
Alloy steels	BS 970 : Part 4 302 S25	Above 10 up to 30 mm	- 200	+ 250
	316 S16	Above 10 up to 30 mm	- 200	+ 250
	BS 970 : Part 5 250A58*	10 mm to 40 mm	- 20	+ 150
	250A61*	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
	British Standard 2S 143	—		
	British Standard 2S 144	—		
	British Standard 2S 145	Up to 50 mm	- 90	+ 350
	DTD 5086 : 1969♣	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
	British Standard 2HR 501	Up to 8 mm	- 200	+ 540
	British Standard 2HR 502	Up to 8 mm	- 200	+ 540
	SAE AMS 5698C: 1953 (reaffirmed 1977)	Up to 12.5 mm		+ 540

(to be continued)

APPENDIX B (continued)

B.2 The material selected shall comply with the limitations on temperature range given in Table B.1 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.

B.3 Dimensions

B.3.1 Proportion

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

B.3.2 Spring index

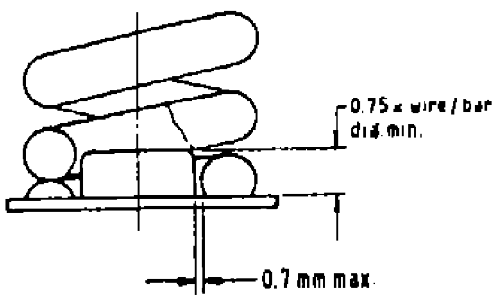
The spring index, i.e. the mean diameter of the coil, D, divided by the diameter of the section, d, shall be within the range 3 to 12.

B.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 clearance 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.

B.4 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 Fig. 1).



SPRING PLATE
Fig. B.1

(to be continued)

APPENDIX B (continued)

B.5 Stress

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

$$q = \frac{8WDKA}{\pi\, d^3}$$

Where:

- q is the corrected shear stress (N/mm²):
- W is the force at set pressure (N);
- D is the mean diameter of the coil (mm);
- d is the diameter of the section (mm);
- K is the stress correction factor for curvature (see Table B.2):

$$= \frac{\frac{D}{d} + 0.2}{\frac{D}{d} \quad 1.0}$$

$$A = \frac{\delta_1 + \delta_2}{\delta_1}$$

Where:

- δ_1 is the axial deflection due to force W (mm);
- δ_2 is the lift (in mm) of the valve, at certified discharge capacity.

B.6 Number of Working Coils

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

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

Where:

- G is the shear modulus (N/mm²);
- n is the number of working coils.

Other symbols used in the equation are defined in 5.6.5.

(to be continued)

APPENDIX B (continued)

TABLE B.2 - STRESS CORRECTION FACTOR FOR CURVATURE (K)

$\frac{D}{d}$	K	$\frac{D}{d}$	K	$\frac{D}{d}$	K
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				

B.7 Handing of Coils

Where springs are nested, the adjacent springs shall be opposite handed. Single springs may be coiled either right hand or left hand.

B.8 Testing and Dimensional Checks

B.9 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.

(to be continued)

APPENDIX B (continued)

B.10 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;

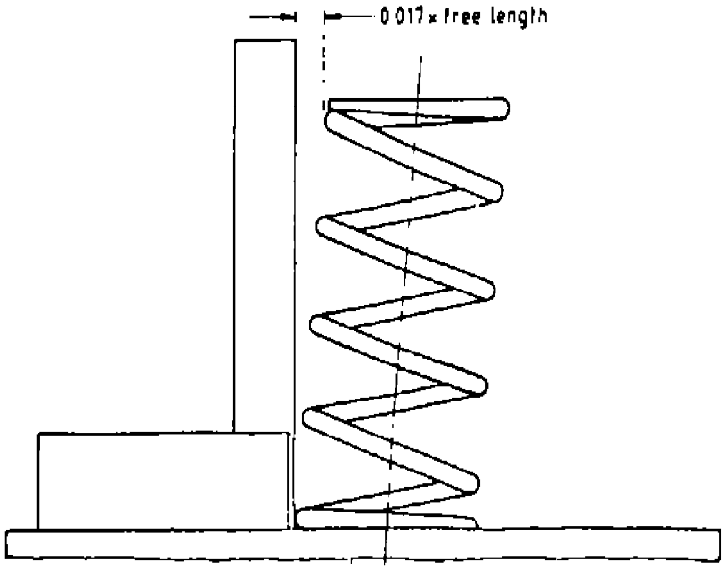
2) load/length at the maximum compression at which the spring will be used, or the spring rate over a given range above 15% of the calculated total deflection.

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 Fig. B.2).

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 Fig. B.2).

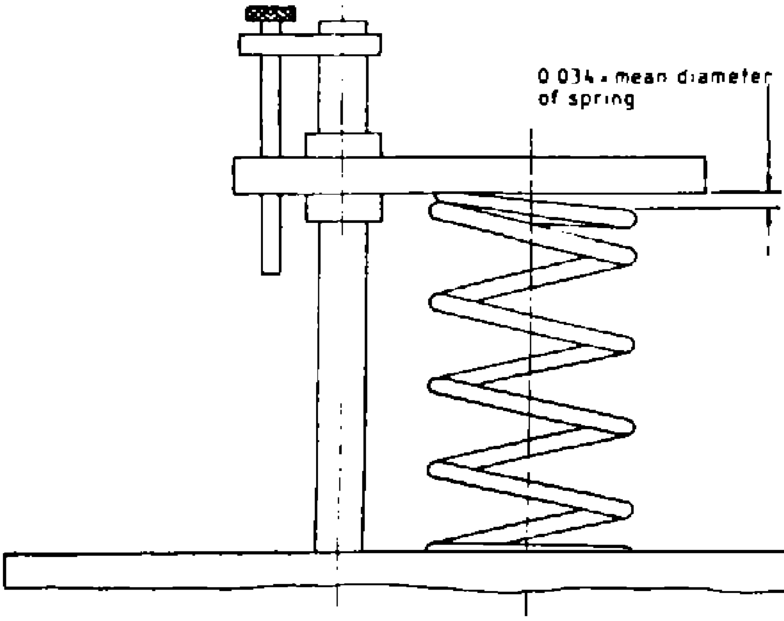
The tolerances shall comply with B. 12.



END - SQUARENESS
Fig. B.2

(to be continued)

APPENDIX B (continued)



END - PARALLELISM
Fig. B.3

B.11 Hardness

Where maximum hardness is specified, hardness tests shall be carried out for each spring.

B.12 Tolerances

B.12.1 Load/length

The tolerances on load/length requirements shall be as given in Table B.3.

TABLE B.3 - 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

(to be continued)

APPENDIX B (continued)

B.12.2 Spring rate

The tolerances on spring rate shall be as given in Table B.4.

TABLE B.4 - 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	+ 8.5 - 6.0
4 or more	± 3.0	+ 7.5 - 5.0

B.12.3 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 B.5.

TABLE B.5 - INSIDE DIAMETER TOLERANCES

INSIDE DIAMETERS mm	TOLERANCE mm
25 Diameter and smaller	+ 0.8 - 0.0
Over 25 to 50	+ 1.5 - 0.0
Over 50 to 100	+ 2.5 - 0.0
Over 100	+ 3.0 - 0.0

B.12.4 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 straight-edge 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 B.6.

(to be continued)

APPENDIX B (continued)

TABLE B.6 - FREE LENGTH TOLERANCES

NOMINAL FREE LENGTH mm	TOLERANCE mm
Up to 75	± 0.8
Over 75 to 165	± 1.5
Over 165 to 250	± 2.5
Over 250 to 360	± 3.0
Over 360 to 560	± 4.0

B.12.5 End - squareness

The maximum deviation from end-squareness (see B.10 (c)) shall not exceed 0.017 × free length (see Fig. B.2).

B.12.6 End - parallelism

The maximum deviation from end-parallelism (see B.10 (d)) shall not exceed 0.034 × the mean diameter of the spring (see Fig. B.3).

B.13 Condition of Material

Bars or wires used in the unmachined condition shall be limited to the following:

a) **Surface defects:** 1% of bar diameter or 0.25 mm, whichever is the greater.

b) **Decarburization:** 2% of bar diameter or 0.30 mm, whichever is the greater. No more than 1/3 of the total affected depth shall be complete decarburization.

c) Machined bars shall be free from all surface defects, there shall be no complete decarburization and partial decarburization shall not exceed 0.13 mm in depth.

B.14 Marking

Identification marks which involve stamping or etching shall be confined to the inactive coils and be located between the tip and 180° of the circumference from the tip.

B.15 Spring test certificate

When required, the safety valve manufacturer shall request a test certificate stating that the spring(s) has been made from the specified material and has been tested in accordance with this Standard.

This certificate shall be submitted to the Company along with other documents.