

Contents

2.1	Introduction	1
2.2	Loading Principle	1
2.3	Primary and Secondary Pressure Zone	1
2.3.1	Nominal Sizes Inlet and Outlet	2
2.3.2	2 Angle Type Body	2
2.4	Vessel Connections	1
2.4.1	Flanged Connections	1
2.4.2	2 Threaded Connections	1
2.4.3	8 Other Connections	1
2.5	Conventional and Balanced Safety Valves	1
2.5.1	Conventional Safety Valves	1
2.5.2	Balanced Safety Valves	3
2.5.3	Balanced-Bellows Safety Valves with Auxiliary Balanced Piston	5
API	520-1, Figure 4 LESER Type 526	
Figui	re 2.5.3-1: Balanced-bellows pressure relief valve with an auxiliary balanced piston	
2.5.4	Balanced-Bellows Safety Valve with Auxiliary Balanced Piston	5
2.6	Parts of a Spring Loaded Safety Valve	1
2.6.1	Parts of a Conventional Spring Loaded Safety Valve – Flanged	1
Figul	re 2.6.1-1: Parts of a Conventional Spring Loaded Safety Valve – Flanged	
2.6.2	Parts of a Balanced Bellows Spring Loaded Safety Valve – Flanged	2
Figui	re 2.6.2-1: Parts of a Balanced Bellows Spring Loaded Safety Valve - Flanged	
2.6.3	Parts of a Conventional Spring Loaded Safety Valve – Threaded	3
2.6.4	Parts of a Balanced Bellows Spring Loaded Safety Valve – Threaded	3
Figui	re 2.6.4-1: Parts of a balanced bellows spring loaded safety valve - threaded	
2.6.5	Parts Description acc. to ASME PTC 25	4
2.6.6	Pressure Retaining or Containing Parts acc. to the ASME Code	5
2.6.7	Pressure Retaining or Containing Parts acc. to PED 2014/68/EU	7
2.6.8	Critical Parts Influencing the Operating Characteristic of the Safety Valve	9
2.6.9	Parts Providing Alignment	10
2.7	Full Nozzle and Semi Nozzle Design	1
Figui	re 2.7-1: Full nozzle and semi nozzle design	
2.7.1	Criteria for Selecting a Full Nozzle or Semi Nozzle Design	1
2.8	Adjusting Ring and Ringless Designs	1
2.8.1	Ringless Designs	1
2.8.2	2 Designs with One Adjusting Ring	1
Figul	re 2.8.2-1: Blowdown ring and ringless design	
2.8.3	Designs with Two Adjusting Rings	2
2.8.4	Adjusting Ring at LESER	3
2.9	Steam/Gas Trim and Liquid Trim versus Single Trim	1
2.9.1	Trim Definition	1
2.9.2	Steam/Gas Trim and Liguid Trim	1
2.9.3	Single Trim	1
2.10	Common Optional Features	1
2.10.	1 Closed or Open Bonnet	1
2.10.	2 Lifting Devices	2
2.10.	3 Soft Seat	4



2.1 Introduction

The purpose of this chapter is to provide an overview about the general design of safety valves. The parts commonly used in a safety valve are explained with reference to their function. Design variations are shown as well as the most common optional features.

The most common design is the direct spring loaded safety valve. Therefore, the focus of ENGINEERING is on direct spring loaded safety valves.

Other safety devices, like bursting discs or pressure vacuum valves, are not covered in this handbook.



2.2 Loading Principle

The loading principle significantly influences the design and components of a safety valve and is often used for the classification of safety valves.

Loading in this context refers to the application of a closing force to the safety valve. Thus, in the following diagram safety valves are classified according to the principle by which the closing force is applied:



Figure 2.2-1: Loading principles of safety valves

- Direct spring loaded safety valve: a safety valve in which the disc is held closed by a spring
- Direct weight loaded safety valve: a safety valve in which the disc is held closed by a weight, or by a lever and a weight
- Pilot operated safety valve (POSV): a safety valve in which the disc is held closed by system pressure and the holding pressure is controlled by a pilot valve actuated by system pressure pressure. The pilot valve itself is a spring loaded safety valve.
- Controlled safety pressure relief system (CSPRS): a system consisting of a main valve in combination with control units. The closing force is applied by a control device which will typically control an actuator on a direct acting safety valve
- Rupture / Buckling pin safety valve: a safety valve in which the disc is held closed by a buckling pin. According to Euler's law of 1776 the pin will buckle at a particular load and release the disc.

There are further classifications of safety valves according to the operating characteristic, e.g. in the ASME Code XIII and the German AD 2000 – A2 standard. These classifications can be found in chapter 5 of this handbook.



2.3 Primary and Secondary Pressure Zone

A safety valve can be divided into two separate pressure zones. The primary pressure is the pressure at the inlet of a safety valve. The secondary pressure is the pressure existing in the zone situated after the valve nozzle in the course of the medium's passage through the valve, e.g. in the body and bonnet (for component definitions see section 6).

The pressure zones determine the pressure rating of valve components. In most cases the secondary pressure is significantly lower than the primary pressure. Therefore the pressure rating of components in the primary pressure zone (= valve inlet) is in most cases higher than the pressure rating of components in the secondary pressure zone (= components behind the valve nozzle).

- primary pressure zone (inlet): all parts of the safety valve affected by the primary pressure, these will typically be: nozzle, disc, inlet part of the body
- secondary pressure zone (outlet): all parts affected by the secondary pressure, these are among others: outlet part of the body, bonnet, cap.

This applies to conventional safety valves. A different design and distribution of primary and secondary pressure zones is found in balanced bellows safety valves (figure on right). In those valves the bonnet is not pressurized by the secondary pressure, because the bonnet must be vented to atmospheric pressure to prevent a pressure build up.



Figure 2.3-1 :Pressure zones in a conventional safety valve

Figure 2.3-2: Pressure zones in a balanced bellows safety valve



2.3.1 Nominal Sizes Inlet and Outlet

During discharge, compressible fluids like steam or gases will expand when passing the nozzle. In order to not restrict the flow of the expanded fluid, the nominal outlet size is typically larger than the inlet size of the valve, e.g. 1"x2", 2"x3",

The following table shows typical combinations of inlet and outlet sizes for flanged safety valves. NPS = Nominal Pipe Size; DN = Nominal Diameter

API / ASI	ME - NPS	EN - DN		
Inlet Outlet		Inlet	Outlet	
		25	40	
1	2	25	50	
		32	50	
1 1/2	2	40	50	
1 1/2	2 ¹ / ₂	40	65	
1 1/2	3	40	80	
2	3	50	80	
2 ¹ / ₂	4	65	100	
3	4	80	100	
		80	125	
4	6	100	150	
		125	200	
6	8			
6	10	150	250	
8	10			
		200	300	

Note:

Safety valves with relatively small capacity related to the inlet size or safety valves which are primarily used for liquid applications like the LESER Modulate Action Series may have the same inlet and outlet size.

Table 2.3.1-1: Typical inlet and outlet sizes for flanged safety valves

Inlet and outlet sizes for safety valves with threaded connections are typically expressed in inches.

Threaded				
Conne	ctions			
Inlet	Outlet			
1/2"	1/2"			
1/2"	1"			
3/4"	1"			
1"	1"			
1"	1 ½"			

Table 2.3.1-2: Typical inlet and outlet sizes for safety valves with threaded connections

2.3.2 Angle Type Body

Unlike many other industrial valves, most safety valves have an angle type body and only very few inline designs are available. The main reason is that this facilitates the connection of the valve to pressure nozzles, which are mounted vertically on the pressure vessel.

Always avoid vertical upward orientation of the safety valve outlet to allow the valve outlet to be drained and remain free of condensate or other liquids.



2.4 Vessel Connections

Safety valves are offered in a variety of connections to fit the user's application and requirements across different industries. The most common are flanged and threaded connections according the standards listed in section 4.1 and 4.2. Please refer to chapter 10 of ENGINEERING for more detailed information about connections.

2.4.1 Flanged Connections

Standard	Originates from
ASME B16.5 (former ANSI B16.5)	America
EN 1092-1	Europe
JIS B 2220 (JIS = Japanese Industry Standard)	Japan, equivalent to KS (Korean Standard)

Table 2.4.1-1: Standards for flanged connections

2.4.2 Threaded Connections

Standard	Other common designation	Originates from
ASME B 1.20.1 - NPT		America
ASME B1.20.3 – NPTF		America
ISO 7-1 – R	BS 21, BSP-T	Europe
ISO 7-1 – Rp	BS 21, BSP-P	Europe
ISO 228-1 - G	BS 2779	Europe

Table 2.4.2-1: Standards for threaded connections

2.4.3 Other Connections

In some industries connections other than flanged or threaded are common due to specific requirements like cleanability in the food and beverage industry. Examples are:

- Connections for sanitary applications, e.g. according to ASME BPE or DIN 11864: clamps, threaded, flanged
- Butt weld ends for high temperature / high pressure applications
- Grayloc[®], Techlok[®] clamp connections for high pressure pipeline applications



Figure 2.4.3-1: Typical connections for safety valves



2.5 Conventional and Balanced Safety Valves

2.5.1 Conventional Safety Valves

A conventional direct spring loaded safety valve is a spring loaded safety valve whose operational characteristics are directly affected by changes in the back pressure (API 520-1, 1.2.1.2). Back pressure is the pressure present in the secondary pressure zone (outlet) of the valve (see also chapter 6 of ENGINEERING).

Conventional Safety Valves - Flanged



Figure 2.5.1-1: Conventional flanged safety valves

The API 520-1 figure 2 shows a typical design for a conventional flanged safety valve.

The LESER API Series 526 complies with all requirements of API 520-1 and API 526. Compared with the typical design there are some major improvements in the LESER design:

- one piece spindle spindle with widely spaced top and bottom guide for better alignment of moving parts
- smaller guiding diameter and length for less friction in the guide and less galling
- needle bearing between adjusting screw and upper spring plate for more precise and easier setting
- top guided nozzle for better alignment
- self-draining body for less corrosion
- horizontal installation possible at pressures > 3 barg / 45 psig and horizontal transport and storage due to one piece spindle design



Conventional Safety Valves - Threaded





API 520 – 1 figure 5: Conventional pressure relief valve with threaded connections

LESER design: Compact Performance Series 459

Figure 2.5.1-2: Conventional safety valves - threaded

The API 520-1 figure 5 shows a typical design for a conventional threaded safety valve. Compared with the typical design there are some major improvements in the LESER design:

- the two point guiding of the spindle instead of a disc guided in a "cage" for less corrosion and less friction in the guide
- less galling
- self-draining body for less corrosion
- free and unrestricted flow with larger discharge coefficient
- horizontal installation possible at pressures > 3 barg / 45 psig



2.5.2 Balanced Safety Valves

A balanced direct spring loaded safety valve is a spring loaded safety valve that incorporates a bellows or other means for minimizing the effect of back pressure on the operational characteristics of the valve. Back pressure is the pressure present in the secondary pressure zone (outlet) of the valve (see also chapter 6 of ENGINEERING).





API 520 – 1 figure 3: Balanced-bellows pressure relief valve

LESER API Series 526: Improvements in the design

Figure 2.5.2-1: Balanced safety valves - flanged

The API 520 figure 3 shows a typical design for a balanced flanged safety valve. The LESER API Series 526 complies with all requirements of API 520-1 and API 526. Compared with the typical design there are some major improvements in the LESER design:

- all advantages as listed under "Conventional Safety Valves Flanged"
- additionally: the protection of the bellows by a bonnet spacer for a shielded bellows with longer lifetime



Balanced Safety Valves - threaded





LESER Compact Performance Series 459 with balanced bellows

Typical competitor's design with balanced piston

Figure 2.5.2-2: Balanced safety valves - threaded

The API 520-1 does not show a design for a balanced threaded safety valve.

The design of the LESER Compact Performance Series 459 with a separated bonnet and outlet body allows to insert a balanced bellows the same way as in a flanged safety valve resulting in:

- full back pressure compensation
- protection of moving parts from dirt and corrosion

Many competitor's designs provide back pressure compensation by a balanced piston design requiring a spindle sealing by O-rings or similar sealing elements. A bellows design is superior because:

- no risk of locking the spindle due to O-ring failure, e.g. by swelling
- wider temperature range
- better chemical resistance



2.5.3 Balanced-Bellows Safety Valves with Auxiliary Balanced Piston



Figure 2.5.3-1: Balanced-bellows pressure relief valve with an auxiliary balanced piston

2.5.4 Balanced-Bellows Safety Valve with Auxiliary Balanced Piston

The API 520-1 figure 4 shows a typical design for a balanced flanged safety valve with Auxiliary Balanced Piston.

The balanced piston shall provide back pressure compensation in case of a bellows failure. The effective area of the piston is equal to the seat area to provide the back pressure compensation. Other than the bellows does not seal off the bonnet area from the valve outlet.



2.6 Parts of a Spring Loaded Safety Valve

2.6.1 Parts of a Conventional Spring Loaded Safety Valve - Flanged



Figure 2.6.1-1: Parts of a Conventional Spring Loaded Safety Valve – Flanged







Figure 2.6.2-1: Parts of a Balanced Bellows Spring Loaded Safety Valve - Flanged







Figure 2.6.3-1: Parts of a conventional spring loaded safety valve - threaded

2.6.4 Parts of a Balanced Bellows Spring Loaded Safety Valve - Threaded



Figure 2.6.4-1: Parts of a balanced bellows spring loaded safety valve - threaded



2.6.5 Parts Description acc. to ASME PTC 25

ltem	Component	Description per ASME PTC 25 – Parts used by LESER
1	Body	a pressure-retaining or containing component of a pressure relief device
		that supports the parts of the valve assembly and has provision(s) for
F	Nessle	
Э	NOZZIE	a primary pressure- containing component in a safety valve
5	Soat	the pressure cooling surfaces of the fixed and maying pressure containing
5	Seal	components.
6	Adiusting ring	a ring assembled to the nozzle or guide of a direct spring valve.
	(blowdown ring)	used to control the opening characteristics and/or the reseat pressure.
7	Disc	a moveable component of a pressure relief device that contains
		the primary pressure when it rests against the nozzle.
9	Bonnet	a component of a direct spring valve or of a pilot in a pilot-operated valve
		that supports the spring. It may or may not be pressure containing.
8	Guide	a component in a direct spring or pilot-operated pressure relief device
		used to control the lateral movement of the disc or disc holder.
12	Spindle	a part whose axial orientation is parallel to the travel of the disc. It may be
	(stem)	used in one or more of the following functions: (a) assist in alignment,
		(b) guide disc travel, and (c) transfer of internal or external forces to the
45	.	seats.
15	Bellows	a flexible pressure-containing component of a balanced direct spring valve
		used to prevent changes in set pressure when the valve is subject to
		superimposed back pressure, or to prevent corrosion between the disc
16/17	Spring plate	or spring step: a load-transferring component in a safety value that supports
10/17	(spring plate	the spring step. a load-transferring component in a safety valve that supports
	-buttonwasher)	the spring.
18	Adjustment screw	a screw used to adjust the set pressure or the reseat
		pressure of a reclosing pressure relief device.
40	Сар	a component used to restrict access and/or protect the adjustment screw in
	-	a reclosing pressure-relief device. It may or may not be a pressure-
		containing part.
40	Lift Lever	A device to apply an external force to the stem of a pressure relief valve to
		manually operate the valve at some pressure below the set pressure
54	Spring	the element in a safety valve that provides the force to keep
		the disc on the nozzle.

Table 2.6.5-1: Parts description acc. to ASME PTC 25

The following parts are described in ASME PTC 25, but are not used in LESER safety valves.

Component	Description per ASME PTC 25	Not used in LESER safety valves, because			
Disc Holder	a moveable component in a pressure relief device that contains the disc	One piece spindle with different disc design, does not require a disc holder			
Yoke	a pressure-retaining component in a pressure relief device that supports the spring in a pressure relief valve or pin in a nonreclosing device but does not enclose them from the surrounding ambient environment	Open bonnets are used for the same purpose.			

Table 2.6.5-2: Parts description acc. to ASME PTC 25 – not contained in LESER safety valves

ASME PTC 25 contains descriptions of other components. These include components of pilot operated safety valves, rupture discs and non-reclosing safety devices that are not listed here.



2.6.6 Pressure Retaining or Containing Parts acc. to the ASME Code

The ASME code provides a precise description of pressure retaining or containing components of a safety valve. The classification pressure retaining or containing has consequences regarding the material selection and testing as described below.

Definition of the Terms "Pressure Retaining" and "Pressure Containing"

ASME PTC 25-2001, Section 2 Definitions and Description of Terms:

- Pressure-containing member: a component which is exposed to and contains pressure
- Pressure-retaining member: a component which holds one or more pressure-containing members together but is not exposed to the pressure

Component	Classification per ASME PTC 25, 2.4
Body	pressure-retaining or containing
Bonnet	may (closed design) or may not (open design) be pressure containing
Сар	may (closed design) or may not (open design) be pressure containing
Nozzle	pressure-containing
Disc	pressure-containing

Table 2.6.6-1: Parts classification acc. to ASME PTC 25, 2.4

Material Selection

The materials for specific pressure retaining components of a safety valve must comply with the following requirements:

ASME Code XIII, 3.3.1(a) gives the following definition:

"(a) Materials used in bodies, bonnet or yokes, and body-to-bonnet or body-to-yoke bolting shall be as permittedin Section II, Part D by the referencing Code,

In addition, the following requirements apply:

(1) For Section VIII, Division 1 (UV Designator) pressure relief valves, the bodies, bonnets, yokes, and body-to-bonnet or body-to-yoke bolting shall meet all applicable requirements of Section VIII, Division 1, Subsection C."

The reason why the ASME XIII code restricts the choice of materials that may be used for the above mentioned components is that these components are the most critical components in a safety valve. The failure of one of these components will result in an uncontrolled hazardous release of the inlet pressure. Failure of other safety valve components like nozzle, disc, spindle or spring may result in the release of pressure, but the release will be a controlled discharge through the valve outlet.

Hydrostatic Pressure Test

ASME Code XIII, 3.6.1 gives the following definition:

"(a) The pressure-containing parts of the shell of each valve are subject to pressure testing. The valve shell is defined by parts such as the body, bonnet, and cap that isolate primary or secondary pressure from atmosphere.

(b) A valve shell part is exempt from pressure testing if both of the following conditions apply:

(1) The stress that would be applied under hydrostatic test conditions does not exceed 50% of the allowable stress.

(2) The part is not cast or welded.

(c) When the valve is designed for discharging directly to atmosphere, the valve components downstream of the valve disk are exempt from pressure testing.

(d) Valve components are exempt from pressure testing if they are fully contained within pressurecontaining parts that have been either pressure tested or exempted from pressure testing by (b).

e) A valve shell part requiring pressure testing shall be tested either

- (1) hydrostatically at a minimum 1.5 times the design pressure of the part, or
- (2) pneumatically at a minimum 1.25 times the design pressure of the part"



As a consequence of this definition, normally the following components require a hydrostatic pressure test, unless they fulfill requirements for exemption:

- body, inlet body

- bonnet-closed
- nozzle-casted
- cap or gastight lifting device

The disc would fall into the same category, but testing of the disc is not practical and stresses within the disc become lower when pressurized.

The stainless steel bellows and the guide do not have to be tested, because they are downstream of the disc and fully contained within the body.

Material Certificates

The ASME Code does not define exact requirements for material certificates and does not distinguish between different types of material certificates that are defined in EN 10204.



2.6.7 Pressure Retaining or Containing Parts acc. to PED 2014/68/EU

Definition of the Terms "Pressure Retaining" and "Pressure Containing"

The PED does not distinguish between "pressure retaining" and "pressure containing". Instead, the term "main pressure-bearing parts" is used.

However, neither the PED 2014/68/EUnor the ISO 4126 determine those components of a safety valve that are main pressure-bearing.

The general definition of a main pressure-bearing component is given in a guideline from the Commission's Working Group "Pressure" as follows:

Guideline 7/6 related to: Annex I Section 4.3:

"The main pressure-bearing parts are the parts, which constitute the envelope under pressure, and the parts which are essential for the integrity of the equipment.

Examples of main pressure-bearing parts are shells, ends, main body flanges, tube sheet of exchangers, tube bundles.

The materials for these main pressure-bearing parts of equipment of categories II to IV shall have a certificate of specific product control (see Guideline 7/5).

See also guideline 7/8 for bolting parts (fasteners)."

Material Selection

The requirements for the main pressure-bearing parts are defined in:

PED 2014/68/EU, Annex 1, 4. Materials, section 4.2. (b):

"The manufacturer must provide in his technical documentation elements relating to compliance with the materials specifications of the Directive in one of the following forms:

- by using materials which comply with harmonized standards,

- by using materials covered by a European approval of pressure equipment materials in accordance with Article 11,

- by a particular material appraisal"

Hydrostatic Pressure Test

See ISO 4126-1, Section 6.3.1 Application:

"The portion of the valve from the inlet to the seat shall be tested to a pressure 1.5 times the manufacturer's stated maximum pressure for which the safety valve is designed.

The shell on the discharge side of the seat shall be tested to 1.5 times the manufacturer's stated maximum back pressure for which the valve is designed."

As a consequence of this definition, normally the following components require a hydrostatic pressure test, unless they fulfill requirements for exemption as stated in section 6.2 of ISO 4126-1:

- body, inlet body
- bonnet
- nozzle
- cap or gastight lifting device



Material Certificates

See PED 2014/68/EU, Annex 1, 4. Materials, section See 4.3:

"... For the **main pressure-bearing parts** of equipment in categories II, III and IV, this must take the form of a certificate of specific product control. Where a material manufacturer has an appropriate quality-assurance system, certified by a competent body established within the Community and having undergone a specific assessment for materials, certificates issued by the manufacturer are presumed to certify conformity with the relevant requirements of this section."

Note: It is common practice in Europe to request material certificates only for the pressure bearing safety valve body and not for other pressure bearing components. This results from the previously applied AD 2000 – A4 standard, which requires a material certificate only for the safety valve body.



2.6.8 Critical Parts Influencing the Operating Characteristic of the Safety Valve

Nozzle and disc

The geometry of nozzle and disc is critical to the valve operation. Small changes to the dimensions of these parts can change overpressure, blowdown and general valve operation significantly. Maintenance instructions of the manufacturer typically include critical dimensions of these parts. Critical dimensions must be maintained when performing repair and maintenance work. Maintenance work should only carried out by authorized and trained personnel!

Nozzle and disc also form the seat of the valve. The surface finish of the contact surfaces is critical for the tightness of the safety valve. For a metal to metal seat the contact surfaces are lapped for a specified tightness acc. to API 527.

Spring

The closing force on the disc is applied by the compression of the spring. When the valve opens, a further compression of the spring must be achieved by the opening forces underneath the disc. The correct spring rate of the spring is critical to overpressure and blowdown of the valve. Each spring has a defined set pressure range. The spring charts of the manufacturer must be followed when readjusting or changing the set pressure of the safety valve.

The following table lists the potential consequences of using a spring for a set pressure outside of its range.

Condition	Consequences
Set pressure above spring range	 increased blowdown risk of excessive spring compression with coils approaching each other, resulting in restricted lift pressure accumulation in the vessel above acceptable levels due to restricted lift
Set pressure below spring range	 increased overpressure potential pressure accumulation in the vessel above acceptable levels

Table 2.6.8-1: Influence of incorrect set pressure on overpressure and blowdown



2.6.9 Parts Providing Alignment

Correct alignment of nozzle and disc are critical for proper valve operation and tightness. Disc and spindle of the valve will move up and down during valve operation.

Proper guiding of the spindle is essential for trouble free valve performance. The spindle is guided by the guide and the adjusting screw.

Tolerances and materials must be selected such that no corrosion or galling will prevent the valve from operating.

When installed, the user must ensure that no dust, particles in the fluid or sticky media may enter the guiding surfaces and negatively influence the valve performance. In some cases the use of a bellows is advisable to protect the guiding parts.



Figure 2.6.9-1 Parts providing alignment



2.7 Full Nozzle and Semi Nozzle Design

The nozzle is a primary pressure- containing component in a safety valve that forms a part or all of the inlet flow passage.

- Full nozzle: the nozzle forms all of the inlet flow passage and is typically threaded into the valve body
- Semi nozzle: the nozzle forms only a part of the inlet flow passage and is typically not removeable from the valve body

Most nozzles and discs are made from stainless steel to avoid corrosion and to ensure trouble free valve performance. Selection of other corrosion resistant materials may be advisable depending on the application.







Semi nozzle design - LESER Type 441

2.7.1 Criteria for Selecting a Full Nozzle or Semi Nozzle Design

Criteria	Full Nozzle	Semi Nozzle
Regional Preference	USA and regions where the API standard is the dominating standard	Europe USA for ASME I applications
Design Standard	Design per API 526 / API 520 required	No design standard required
Application (corrosion)	Together with a disc in stainless steel, all permanently wetted parts have excellent corrosion resistance. In corrosive process applications selection of a carbon steel body material is possible.	The valve body will be permanently in contact with the medium. A carbon steel body material can be selected for non corrosive applications, e.g. utility, air, steam, water. A stainless steel body material should be selected for corrosive process applications.
Pressure	All pressure ranges	Max set pressure approx. 100 bar / 1450 psig
Capacity	In most cases according to API orifice designations.	In most cases full bore designs with maximum capacity relative to the valve size.
Repair	A full nozzle is typically removable and can either be replaced or repaired outside of the valve body	A semi nozzle can typically not be removed. Repair is possible inside of the valve body with lapping tools. To repair major damages of the seat, the complet body must be taken on a lathe.
Cost	Full nozzle designs require more machining and material and are less cost effective than semi nozzle designs.	A semi nozzle design requires less machining and less material than a full nozzle design thus being more cost effective.

Table 2.7.1-1: Criteria for selecting a full nozzle or semi nozzle design.



2.8 Adjusting Ring and Ringless Designs

Codes and standards specify limits for the overpressure and blowdown of safety valves. In some designs adjusting rings are used to adjust the overpressure and blowdown of the safety valve in order to meet the requirements of codes and standards. In many of them a 10% accumulation pressure is used as a basis for the design strength calculation of a pressure vessel. Therefore the overpressure for safety valves is limited to 10% of the set pressure for the majority of the applications.

Overpressure:

For steam and gas applications the max. overpressure varies between 3% and 10% depending on applicable code and application. For liquids most codes specify a maximum overpressure of 10%.

Blowdown:

Typical values for the blowdown are 4% to 15% for steam and gas and 20% to unlimited for liquids. See tables 2.8.4-1 and 2.8.4-2

2.8.1 Ringless Designs

Precise machining within narrow tolerances of all flow relevant components allow to meet code requirements without any blowdown adjustments on the valve. Safety valves without adjustment options are called fixed blowdown valves. Safety valves of this type are very common in Europe.

2.8.2 Designs with One Adjusting Ring

In the USA the majority of flanged valves are equipped with one or two adjusting rings, positioned around the nozzle and/or the disc. The position of these rings is usually factory set to meet overpressure and blowdown requirements of the applicable codes. The position of the rings can be adjusted to fine tune overpressure and blowdown of the valve.

Designs with one ring are typically used for ASME VIII pressure vessel applications in the process industry. These designs are in most cases safety valves built according to the API 526 Standard, which shows a design containing a lower adjusting ring (API 520-1 figure 2).

It is however not required to have an adjusting ring to meet ASME XIII requirements (see also section 2.8.4).

For the most common design with one lower adjusting ring, changing the ring position has the following effects:

Lowering ring: overpressure increases, blowdown decreases overpressure decreases, blowdown increases

According to LESER's experience a significant change in the operating characteristic can only be achieved when the adjusting ring position is close to the disc and the ring almost touches the disc.

Manufacturer's instructions however do not provide information on how to adjust to specific values based on charts or tables. The effect of changed ring positions must be tested on suitable test benches that allow to measure overpressure and blowdown.

Ring adjustment should only be performed by authorized personnel and according to manufacturer's instructions. Otherwise the operation of the safety valve in accordance with code limitations may not be guaranteed anymore.



LESER Series 526

Figure 2.8.2-1: Blowdown ring and ringless design

LESER High Performance Series



2.8.3 Designs with Two Adjusting Rings

Designs with two rings are typically used for ASME I steam boiler applications in order to fulfill the stringent requirements for overpressure and blowdown.



Figure 2.8.3-1: Typical ASME I safety valve design with two adjusting rings



2.8.4 Adjusting Ring at LESER

The LESER API Series 526 is the only safety valve in LESER's product range that is equipped with an adjusting ring, following the requirements of the API 520 and API 526 standard.

The adjusting ring in Series 526 should be turned to the lowest possible position on the nozzle to ensure all code requirements are met. No further ring adjustment depending on set pressure or medium is required.

The benefit for the user is the easier maintenance, because no complicated ring adjustment is required.

The same applies to all other LESER designs which are ringless designs. These designs still meet all requirements of the ASME XIII, PED 2014/68/EU and other worldwide codes and standards without any change of components. This means that even if there is no requirement for the blowdown acc. to ASME XIII for ringless designs, the ringless valve types like 441 or 459 still have certified values for the blowdown. Thus, exactly the same valve types meet the most stringent requirements of ISO 4126-1 and AD 2000 A2.

The tables below show the overpressure and blowdown requirements of ASME XIII, ISO 4126-1 and AD 2000 A2 and the actual values for selected LESER safety valve types. These actual values are met independently from the code applicable to an individual order. In other words, e.g a LESER type 441 with UV stamp acc. to ASME XIII will be fully open at 5% on a steam/gas application with a blowdown of 10%.

For the LESER API Series 526 it is possible to completely leave out the adjusting ring including the lock screw. Series 526 still meets the below certified values for overpressure and blowdown. This ringless design is certified according to ASME XIII within a separate certification and is part of the CE certification as an optional version.

Overpressure Requirements (max. values)							
	Code Requirements			Certified Values for LESER Types			
Medium	edium ASME XIII ISO 4126-1 AD 2000 A2 ¹⁾				459	526	
Steam/Gas	+10%	+10%	+5% full lift +10% other	+5%	+5%	+10%	
Liquid	+10%	+10%	+5% full lift +10% other	+10%	+10%	+10%	

Table 2.8.4-1: Overpressure requirements and actual values of selected LESER types

Notes: 1) +5% for "full lift" safety valves acc. to the AD 2000 A2 definition, +10% for all other safety valves

Blowdown Requirements (max. values)							
	Code Requirements			Certified Values for LESER Types			
Medium	ASME XIII	ISO 4126-1	AD 2000 A2	441	459	526	
Steam/Gas - ringless design Steam/Gas - with adj. ring	No requirement -7%	15%	-10%	-10%	-10%	-7%	
Liquid	No requirement	-20%	-20%	-20%	-20%	-20%	

Table 2.8.4-2: Blowdown requirements and actual values of selected LESER types



2.9 Steam/Gas Trim and Liquid Trim versus Single Trim

2.9.1 Trim Definition

The trim is formed by the nozzle and the disc of the safety valve. The trim is often referred to as the "permanently wetted" parts of the safety valve.

2.9.2 Steam/Gas Trim and Liquid Trim

Different types of fluids have different properties which may influence the valve operation (overpressure and blowdown). The most significant difference can be found between a gas and a liquid. A liquid typically has a larger density than a gas and can be considered to be incompressible.

In order to account for different fluid properties many manufacturers select to use a "standard trim" for steam/gas applications and a separate "liquid trim" for liquid applications. A different trim in this sense may include some or all of the following components:

- nozzle, disc, spring, bonnet

In addition, a different setting of the adjusting ring depending on the service may be required.

2.9.3 Single Trim

So called "single trim" designs have been optimized to use the exact same components for steam/gas and liquid applications. The development of a single trim design requires extensive testing on flow test labs to find a geometry of the components that works for both types of fluids. Single trim designs meet the overpressure and blowdown requirements of codes and standards for steam/gas and liquids without any change of components.

The advantages of a single trim design are:

- less spare parts, because nozzle and disc are the same for all services
- easier repair and maintenance
- less potential mistakes during valve repair, because there is no risk to confound parts for different services/trims
- ensured operation under two phase flow conditions

All LESER designs are single trim designs.



2.10 Common Optional Features

2.10.1 Closed or Open Bonnet

The standard bonnet design for ASME VIII applications is the closed bonnet with a plain cap. A closed bonnet protects the spring and the guiding surfaces from intrusion of foreign matters like dust. A closed bonnet also will avoid any tampering with the valve spring from the outside.

If combined with a plain (gastight) cap or packed lever the closed bonnet further prevents any medium from escaping from the inside of the safety valve. This is important for the protection of humans and equipment from aggressive or toxic media.

An open bonnet is preferred mainly in high temperature steam applications to protect the spring from too high temperatures and to avoid the collection of condensate in the bonnet area.



Closed bonnet

Open bonnet Figure 2.10.1-1: Closed and open bonnet



2.10.2 Lifting Devices

Standard design for the valve top is a plain cap, covering and sealing the adjustment of the safety valve.

Lifting levers allow users to check if the safety valve is still operational by lifting the disc off the seat. The valve remains in place while testing is performed.

Lifting levers must allow users to lift the disc off the seat when a certain percentage of the set pressure is present at the valve inlet. LESER safety valves fulfill the most stringent requirements of ASME XIII with a minimum of 75% of the set pressure (see table 10.2-1).

Caps and levers are sealed to prevent any unauthorized modification of the set pressure.

Certain codes require the installation of lifting levers for specific applications. The following chart provides an overview about the code requirements.

Code	Section	Requirement to use lifting devices	Omission of lifting device
ASME XIII	3.2.7(a)	(a) Section VIII (UV Designator) pressure relief valves intended for use on air or steam service, or on water service where the valve inlet temperature exceeds 60°C (140°F) excluding overpressure or relief events, shall have a substantial lifting device that, when activated, will release the seating force on the disk when the pressure relief valve is subjected to a pressure of at least 75% of the set pressure of the valve.	 Code Case 2203: the user has a documented procedure for the periodic removal of pressure relief valve for inspection and repair as necessary the omission is specified by the user the user shall obtain permission to omit the lifting device from the authority having jurisdiction over the installation of pressure vessels.
ISO 4126-9	9	Not required. Information in ISO 4126-9, section 9: Safety valves for steam and compressed air duties may be provided with lifting (easing) gear, with the gear so arranged that the valves can be lifted positively off their seats when under operating pressure.	Not applicable
AD-2000 A2	4.3	It shall be possible for safety valves	If it is necessary for operational
TRD 421	4.3	to be made to open without	reasons (inflammable / toxic gases or
TRD 721	4.4	external aids in the range \ge 85% of the set pressure.	refrigerating plants) or if the serviceability of the safety valve can be checked in some other way.

Table 2.10.2-1: Lever requirements in codes and standards





Plain Cap H2 - gastight -



Plain lever H3-- not gastight -



Packed lever H4 - gastight -



Bolted Cap H1 - gastight -

Figure 2.10.2-1: Cap and lever designs



- clean service -

Valve Top LESER Select when Designation Plain cap H2 Standard valve top Lifting lever is requested or required by codes and Plain lever H3 standards and application and medium is non-hazardous, e.g. steam, air Packed lever Lifting lever is requested or required by codes and H4 standards and application or medium is hazardous Bolted cap H1 For large valve sizes, allows easy removal of cap with small sized wrenches Pneumatic lever H8 For Clean Service Series 48X, when valve lifting for CIP or SIP is requested

Table 2.10.2-2: Cap and lever selection



2.10.3 Soft Seat

The standard design for safety valves is to be equipped with a metal to metal seat, which covers the largest variety of applications with regard to pressure/temperature combinations.

Selection of a soft seat design can provide the following advantages:

- Superior tightness especially at operating pressures above 90% of set pressure
- Maintained tightness
 - o for media containing small particles, which would damage the metal to metal seat
 - o for light, hard to hold fluids (e.g. helium)
 - o where vibrations occur
 - under nozzle icing conditions (e.g. ethylene)

Specific temperature limits and medium resistance must be considered by the user when selecting soft seat materials.

Details can be found in the individual product catalogs.



Metal to Metal Seat Figure 2.10.3-1: Soft seat discs



Soft Seat - O-ring



Soft Seat - Sealing Plate