



# **SAFETY VALVES**

## **BASIC KNOWLEDGE**

Protection against overpressure.






# CONTENTS

1.

2.

3.

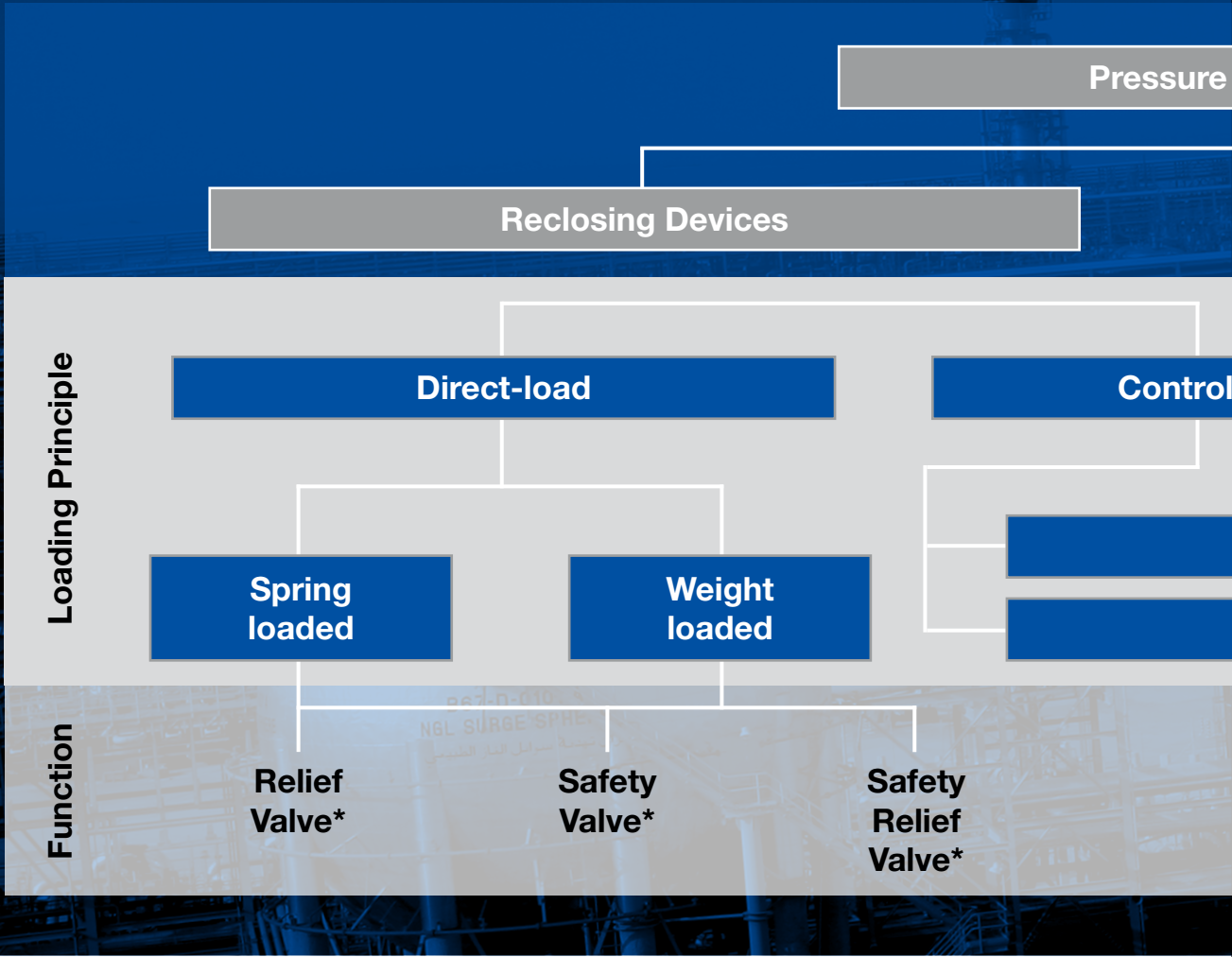


The primary purpose of a safety valve is the protection of life, property and environment. A safety valve is designed to open and relieve excess pressure from vessels or equipment and to reclose and prevent the further release of fluid after normal conditions have been restored.

REASONS FOR  
EXCESS PRESSURE IN A VESSEL | P. 04

SPRING LOADED  
SAFETY VALVES | P. 06

PILOT-OPERATED  
SAFETY VALVES | P. 08



## Relief Devices

### Non-reclosing Devices

Rupture Disc

Pin-actuated Device

### Controlled Safety Pressure Relief System

#### Pilot-Operated Safety Valve

Snap-acting

Modulating

\*acc. to ASME

A safety valve is a safety device and in many cases the last line of defence. It is important to ensure that the safety valve is capable to operate at all times and under all circumstances. A safety valve is not a process valve or pressure regulator and should not be misused as such. It should have to operate for one purpose only: overpressure protection.

## 1. REASONS FOR EXCESS PRESSURE IN A VESSEL

There is a number of reasons why the pressure in a vessel or system can exceed a predetermined limit. API Standard 521/ISO 23251 Sect. 4 provides a detailed guideline about causes of overpressure. The most common are:

- Blocked discharge
- Exposure to external fire, often referred to as "Fire Case"
- Thermal expansion
- Chemical reaction
- Heat exchanger tube rupture
- Cooling system failure

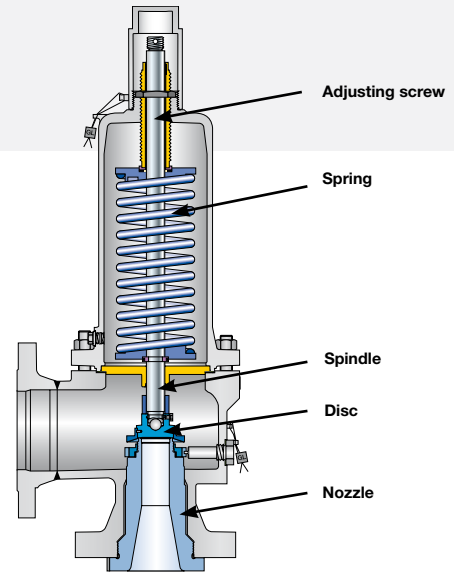
Each of the above listed events may occur individually and separately from the other. They may also take place simultaneously. Each cause of overpressure also will create a different mass or volume flow to be discharged, e.g. small mass flow for thermal expansion and large mass flow in case of a chemical reaction. It is the user's responsibility to determine a worst case scenario for the sizing and selection of a suitable pressure relief device.

## MAIN TYPES OF SAFETY VALVES AND THEIR FUNCTION

There are two main types of safety valves. Spring loaded safety valves and pilot operated safety valves.

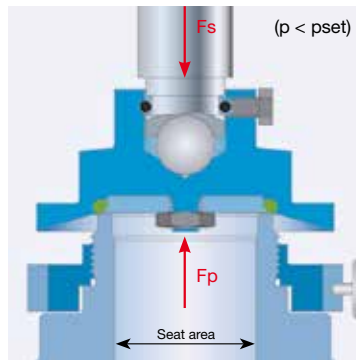
# 2. SPRING LOADED SAFETY VALVES

The spring force  $F_s$  is transmitted via the spindle to the plate closing against the nozzle, which together with the plate closes the process and ensures sealing. This condition is maintained as long as the spring force is greater than the force  $F_p$  generated by the pressure at the valve inlet.



### Valve closed ( $p < p_{set}$ )

$F_p < F_s$   
 $F_s$  = Spring force  
 $F_p = p \cdot A_s$   
 = Force by pressure  
 $A_s$  = Seat area affected by pressure ( $p$ )

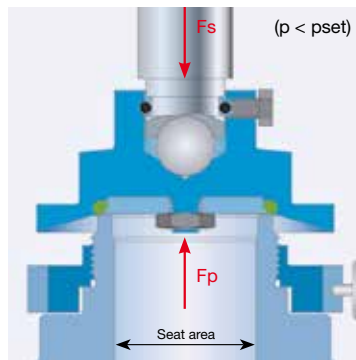


### Valve closed

In a direct spring loaded safety valve the closing force or spring force is applied by a helical spring which is compressed by an adjusting screw. The spring force is transferred via the spindle onto the disc. The disc seals against the nozzle as long as the spring force is larger than the force created by the pressure at the inlet of the valve. The figure shows the enlarged nozzle and disc area of a safety valve with the forces acting on the disc.

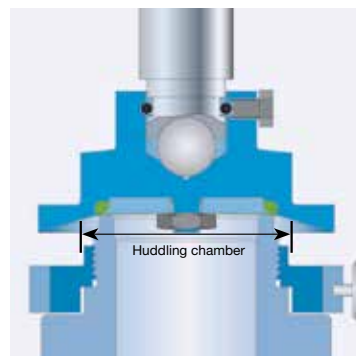
### Valve closed ( $p \approx p_{set}$ )

$F_p < F_s$   
 $F_s$  = Spring force  
 $F_p = p \cdot A_s$   
 = Force by pressure where  
 $A_s$  = seat area affected by pressure  $p$

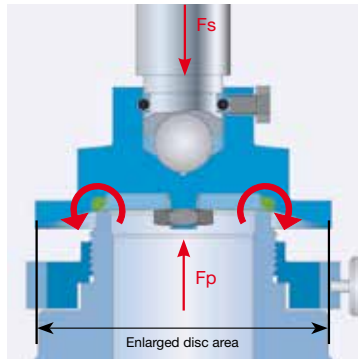


### Valve opening

In an upset situation a safety valve will open at a predetermined set pressure. The spring force  $F_s$  is acting in closing direction and  $F_p$ , the force created by the pressure at the inlet of the safety valve, is acting in opening direction. At set pressure the forces  $F_s$  and  $F_p$  are balanced. There is no resulting force to keep the disc down on the seat. The safety valve will visibly or audibly start to leak (initial audible discharge).



The pressure below the valve must increase above the set pressure before the safety valve reaches a noticeable lift. As a result of the restriction of flow between the disc and the adjusting ring, pressure builds up in the huddling chamber. The pressure now acts on an enlarged disc area. This increases the force  $F_p$  so that the additional spring force required to further compress the spring is overcome. The valve will open rapidly with a "pop", in most cases to its full lift.



Valve closed ( $p > p_{set}$ )  
 $F_s$  due to enlarge disc area

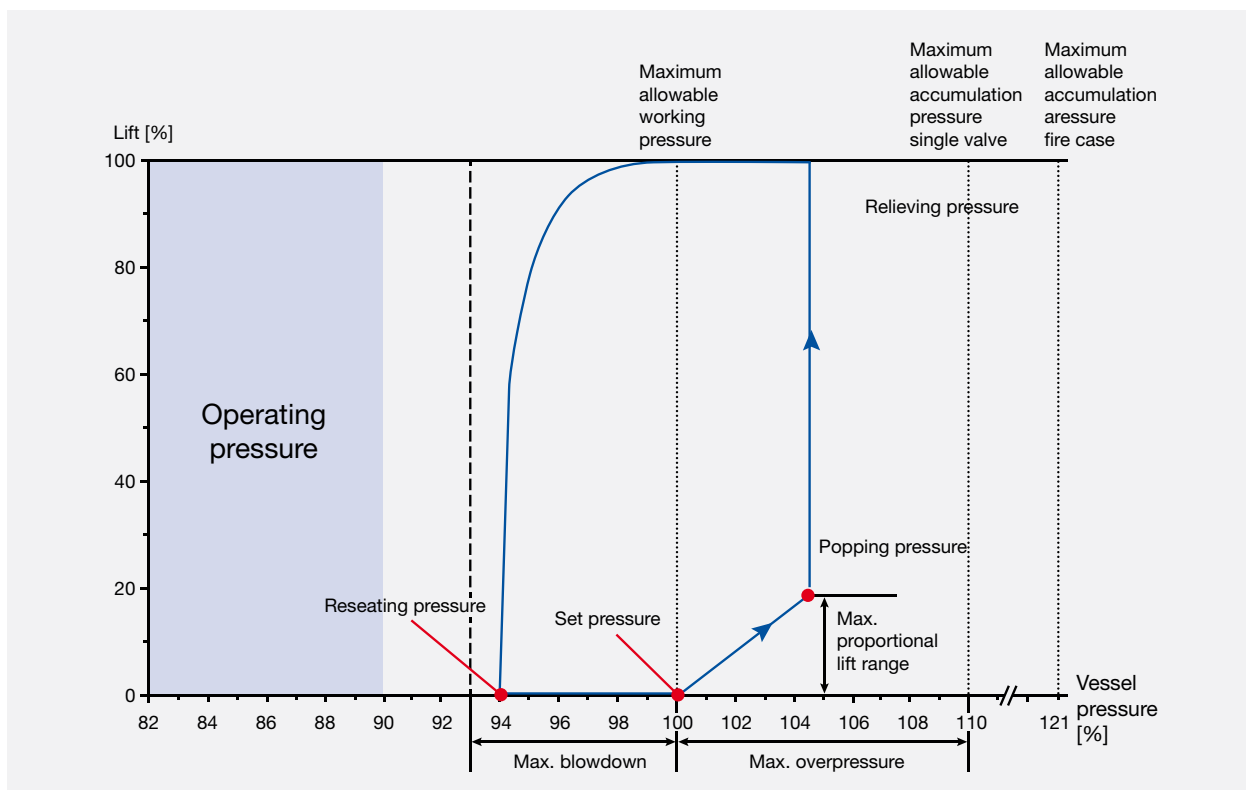
Overpressure is the pressure increase above the set pressure necessary for the safety valve to achieve full lift and capacity. The overpressure is usually expressed as a percentage of the set pressure. Codes and standards provide limits for the maximum overpressure. A typical value is 10%, ranging between 3% and 21% depending on the code and application

### Valve reclosing

In most applications a properly sized safety valve will decrease the pressure in the vessel when discharging. The pressure in the vessel will decrease at any subsequent point, but not later than the end of the upset situation. A decreasing pressure in the vessel will lower the force  $F_p$ . At set pressure however the flow is still acting on the enlarged disc area, which will keep the valve open. A further reduction in pressure is required until the spring force  $F_s$  is again greater than  $F_p$  and the safety valve begins to reclose. At the reseating pressure the disc will touch the nozzle again and the safety valve recloses. Blowdown is the difference between set pressure and reseating pressure of a safety valve expressed as a percentage of set pressure. Typical blowdown values as defined in codes and standards are -7% and -10%, ranging from -4% to -20% depending on the code and service (steam, gas or liquid).

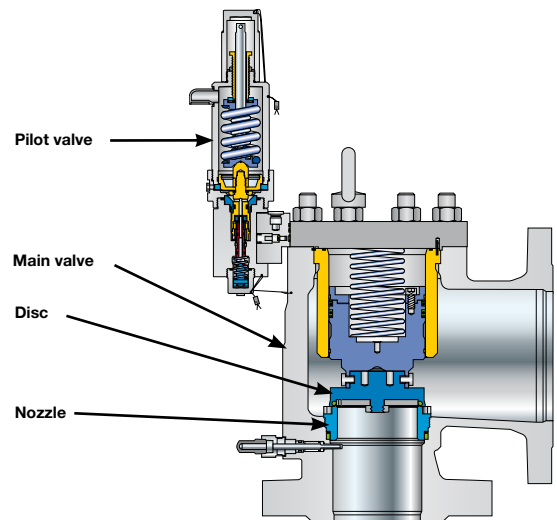
### FUNCTIONAL DIAGRAM

The following diagram shows a typical functional curve of a spring loaded safety valve. Operation of a Series 526 API safety valve with adjusting ring and initial audible discharge set pressure definition. It is important to understand that the operating pressure of the protected equipment should remain below the reseating pressure of the valve. Most manufacturers and codes and standards recommend a difference of 3 – 5% between reseating pressure and operating pressure to allow proper reseating of the valve and achieve good seat tightness again.



# 3. PILOT-OPERATED SAFETY VALVES

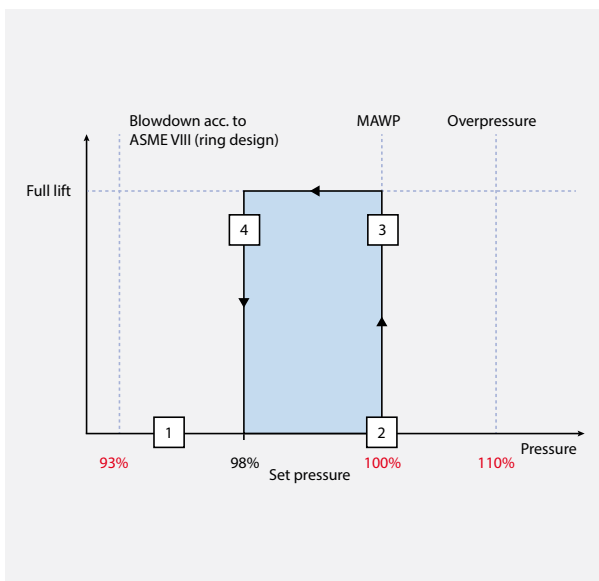
Pilot-operated safety valves limit the pressure in the system by compensating for the overpressure by opening the main valve. They are self-medium controlled and, as with all medium-loaded safety valves, the same pressures act on both sides of the sealing disc. However, a greater force acts in the closing direction due to surfaces of different sizes.



## OPERATING CYCLE OF A PILOT OPERATED SAFETY VALVE

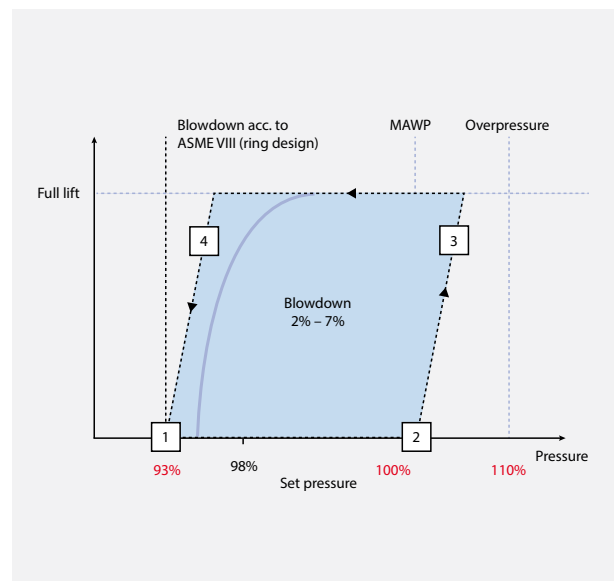
The LESER Pilot Operated Safety Valve (POSV) is controlled by process medium. To achieve this, the system pressure is applied to the pilot valve (= control component for the main valve) via the pressure pickup. The pilot valve then uses the dome above the main valve piston to control the opening and closing of the main valve.

There are two types of pilot-operated safety valves, showing their difference in the opening characteristics.



### LESER Series 810 – Pop Action

The LESER Series 810 – Pop Action opens and closes abruptly.



### LESER Series 820 – Modulate Action

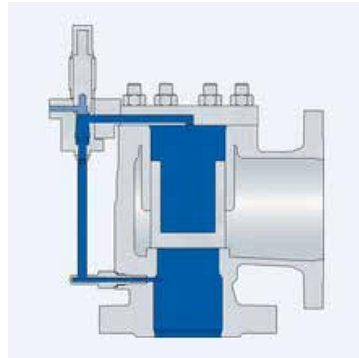
The LESER Series 820 – Modulate Action is characterized by proportional opening.



### 1. Below set pressure: Normal operation

During normal operation, the system pressure is picked up at the main valve inlet and routed to the dome (see illustration).

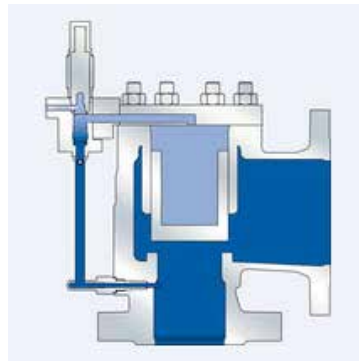
Since the dome area is larger than the area of the main valve seat, the closing force is greater than the opening force. This keeps the main valve tightly closed.



### 2. At set pressure: Actuating state

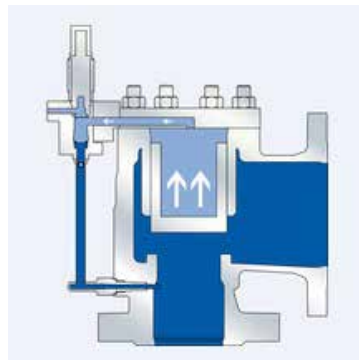
At set pressure, the pilot valve actuates. The medium is no longer routed to the dome (see illustration). This prevents a further rise in dome pressure.

Also, the dome is vented. As a result, the closing force ceases as a precondition for the system overpressure to push the main valve open.



### 3. Main valve opening

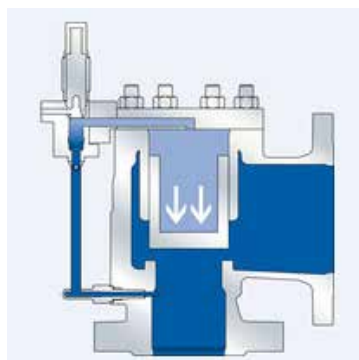
The main valve opens. Depending on the design of the pilot valve, this opening is either rapid and complete (Pop Action) or gradual and partial following system pressure (Modulate Action).



### 4. At closing pressure: Refilling the dome

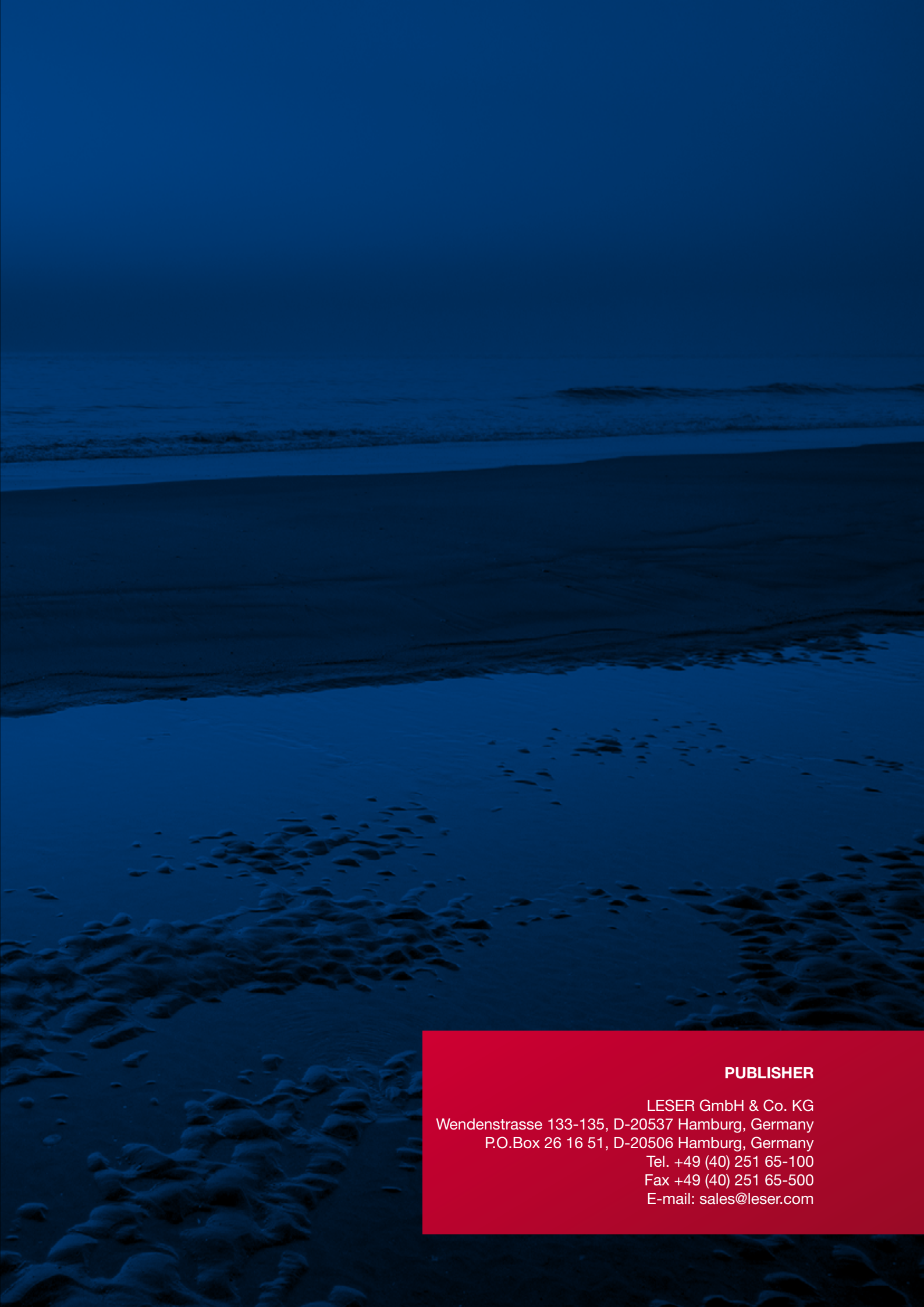
If system pressure drops to closing pressure, the pilot valve actuates and again routes the medium to the dome.

The pressure in the dome builds up and the main valve recloses either rapidly and completely (Pop Action) or gradually and partially following system pressure (Modulate Action).



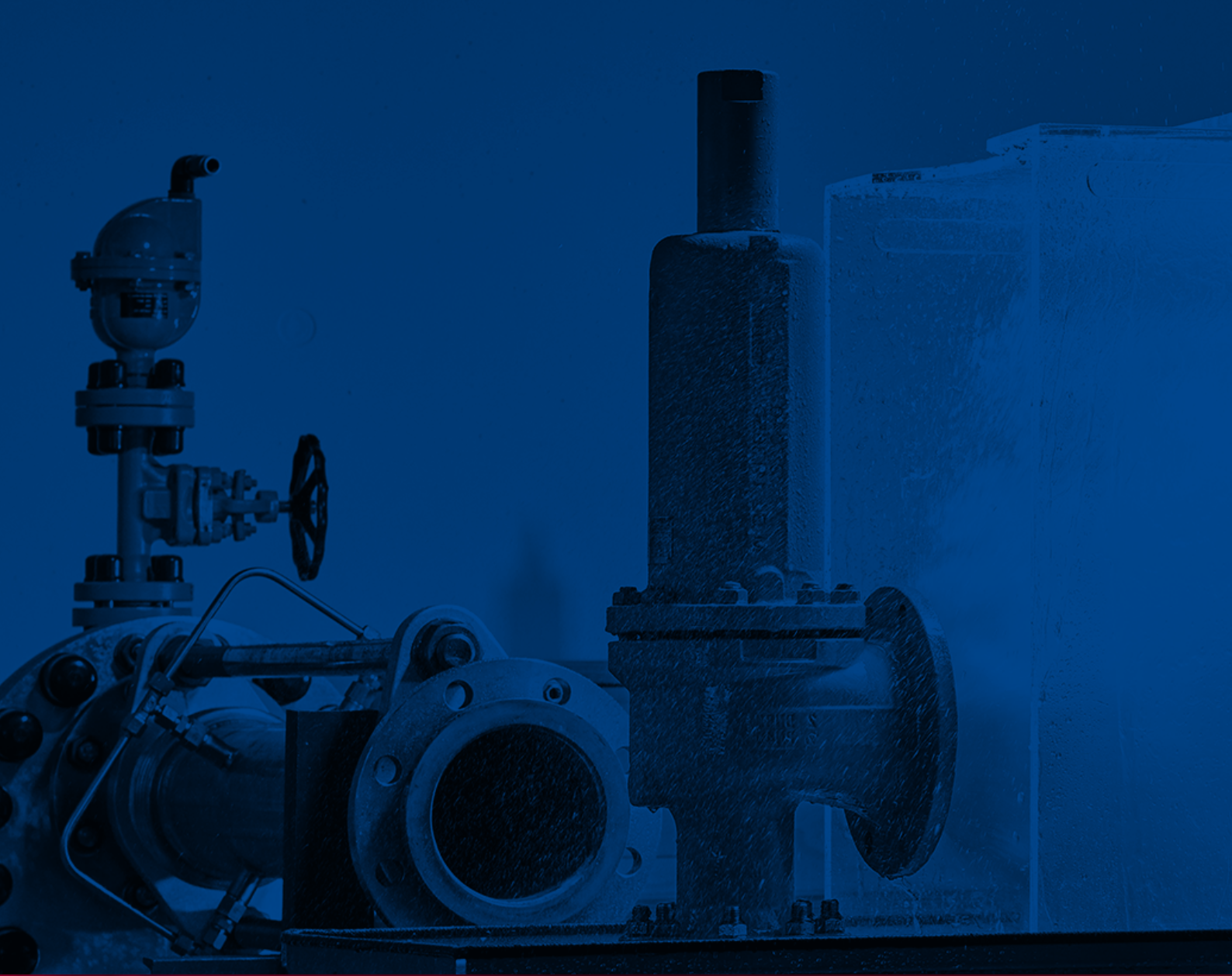


PROTECTION  
AGAINST OVERPRESSURE.



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