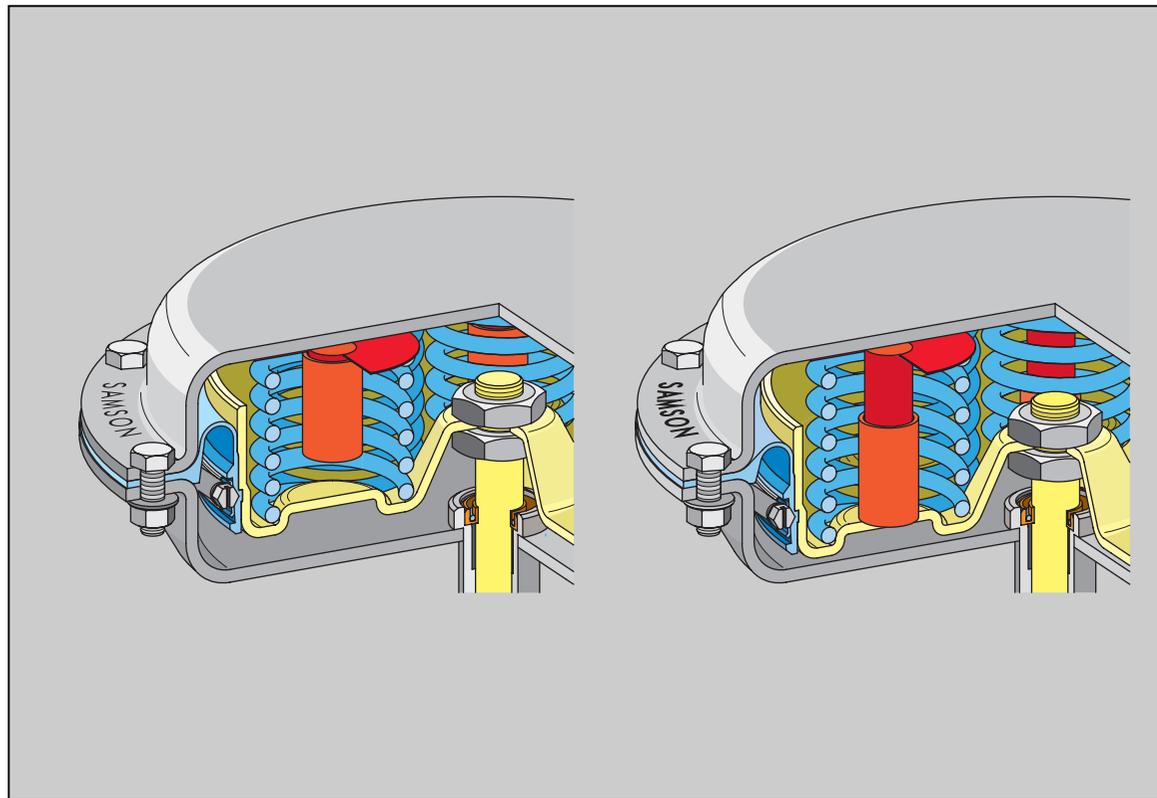




## Control valves in case of fire



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# Control valves in case of fire

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An essential part of equipment safety is the fail-safe position to be maintained when a fire breaks out. In case of pneumatic linear actuators, the fail-safe position must be assumed and maintained when air supply fails or the diaphragm ruptures.

## Introduction

Usually, springs are used to perform this task. They force the valve to move to the fail-safe position when dangerous situations emerge or damages occur. The springs act against the pressure of the process medium to move the valve to the fail-safe position upon failure of air supply, and keep it in this position.

When a fire breaks out, the fail-safe position of the pneumatic actuator will be negatively affected. The high temperatures cause the springs to lose their force. With time passing by and temperatures rising, the springs can no longer keep the valve in its fail-safe position. In case of fail-safe action „Fail-close“, increasing leakage cannot be avoided.

Fig. 2 shows how a preloaded spring loses its force under the influence of temperature. Shortly after the fire has broken out, the spring force decreases considerably. As a result, the ability to keep the valve in fail-safe position during the fire will be lost within a short period. The loss of rigidity and the considerable decrease of force are caused by recrystallization processes within the material structure of the spring.

The use of conventional fire protection systems, such as coatings, do not provide decisive advantages since springs are moving components and subject to dynamic stress. Coatings cannot sufficiently retard the loss of force either.

## Safety cartridge

The problems discussed above were solved by developing a thermostatic system. This passive system was supposed to recognize non-typical temperature rises and respond to them actively. A quite simple element, a cartridge, was developed to perform this task. This cartridge consists of two cylinders sliding freely within each other. It is filled with intumescent material which can be composed in such a way that it determines the release temperature within certain boundaries and, of course, the increase in force it exerts (Fig. 3).

The cartridge is made up of a two-piece cylindrical case. The enclosed cylindrical chamber contains the intumescent material.

This material is composed in a special way to ensure activation of the cartridge before the diaphragm of the pneumatic actuator is destroyed. The increase in volume causes the cylinders to move in opposing directions. During this process, considerable forces are developed (Fig. 4). The operating direction of the cylinders corresponds to that of the springs, thus opposing their gradual loss in strength. Installed in actuators with safety equipment [5], these patented cartridges ensure decreasing spring force compensation.

The safety cartridge is heated according to the unit-temperature curve in which the development of temperature over time is plotted in accordance with DIN 4102, Part 8 [6] (Fig. 5).

The design of this irreversibly operating cartridge is simple and allows retrofitting of already installed pneumatic actuators. To do this, the safety cartridge must be installed in the center of the actuator springs. The mounting position of the pneumatic actuator is not important, the cartridge can always perform its task of closing the valve in the event of a fire.



Fig. 1: Control valve with pneumatic actuator

The selected overall length of the cartridge does not affect the travel or operating range of the springs at standard ambient temperatures. Only in the event of a fire does the cartridge become effective, reacting to the unusually high temperatures.

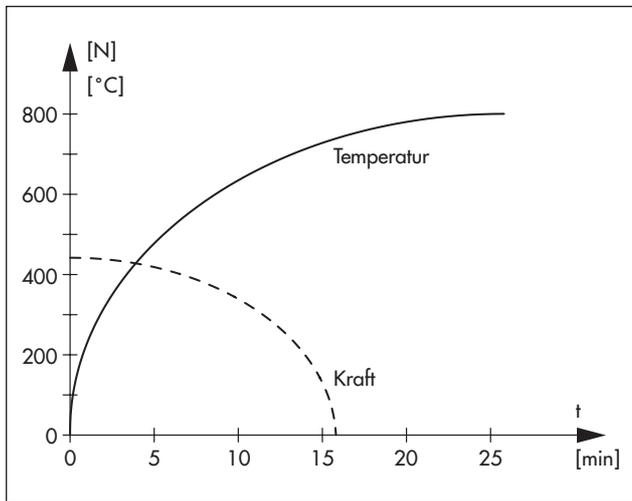


Fig. 2: Force-temperature-time-diagramm, loss of spring force

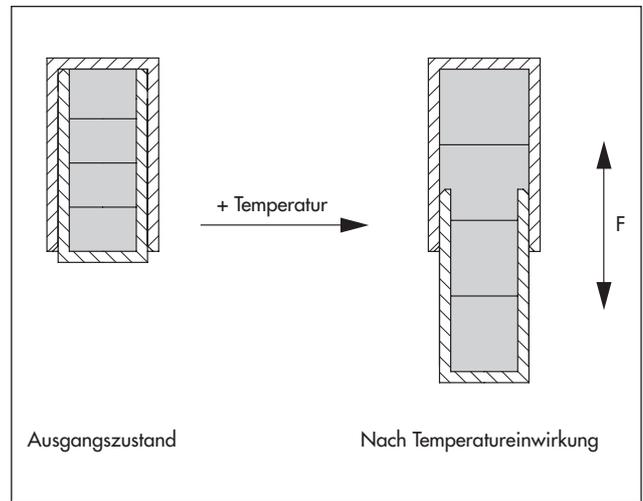


Fig. 3: Schematic of safety cartridge

## Simulation of a fire

A control valve equipped with such a safety cartridge was subjected to a simulated fire.

Technical data of the control valve used in the simulation:

- Valve:
  - SAMSON, Type 3241,
  - nom. size DN 25, nom. pressure PN 40
  - Characteristic: equal percentage
  - Valve plug: lapped-in-metal
  - Plug material: Cr steel, WN 1.4006
  - Seat material: Cr steel, WN 1.4006
  - Body material: GS-C 25, WN 1.0619
- Actuator:
  - SAMSON, Type 3271 Pneumatic Actuator
  - Effective diaphragm area: 350 cm<sup>2</sup>
  - Actuator stem extends
  - Signal pressure range: 0.6 to 3 bar
  - Material: St 1203
  - Diaphragm: NBR with polyester fabric

The test aimed at maintaining the tightness of the valve over 30 minutes minimum with constant system pressure acting on the valve. The time span is based on the specifications given in BSI 6755/2 [7].

The test valve described above was heated in a test room according to the unit-temperature curve. The pneumatic actuator was equipped with 6 cartridges installed in the actuator spring assemblies. The valve contained water. During the heating phase, steam was produced. A pressure regulator installed outside the test room maintained a constant system pressure of 30 bar. Prior to starting the test, a pump had been used to produce this pressure. Downstream of the seat/plug restriction area, the valve was open to atmosphere. The temperature in the test room and the pneumatic actuator was measured via thermocouples. The temperature increase over time in the test room and in the pneumatic actuator was correspondent to the unit-temperature curve (see Fig. 5). The system pressure of 30 bar in the valve upstream of the seat remained constant during the entire test procedure.

As was expected, the rubber diaphragm was completely destroyed at the end of the test. With the exception of the springs, none of the metallic components showed any visible damages or deformations. The task, to provide tight shut-off against the pressure of 30 bar prevailing throughout the test and during the high temperatures of the fire, could be fulfilled over the entire period of temperature supply.

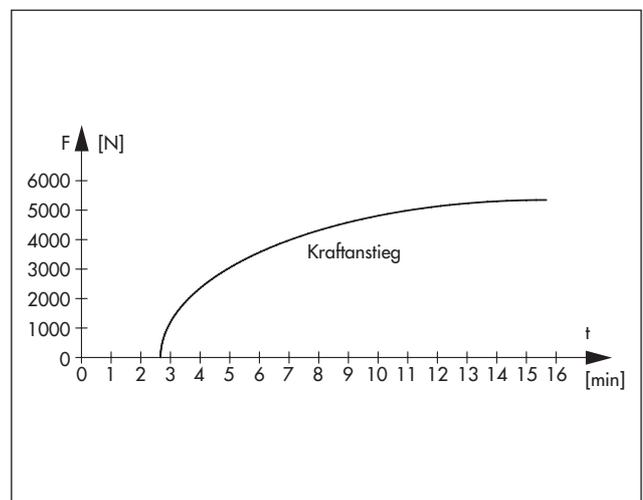


Fig. 4: Force of safety cartridge increasing over time; after heating in accordance with the unit-temperature curve

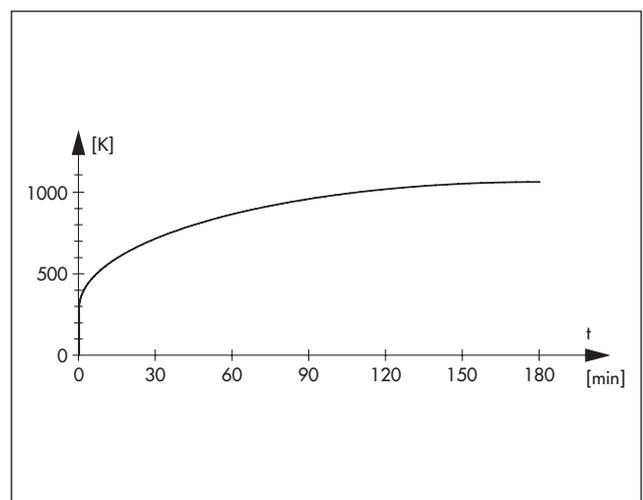


Fig. 5: Unit-temperature curve

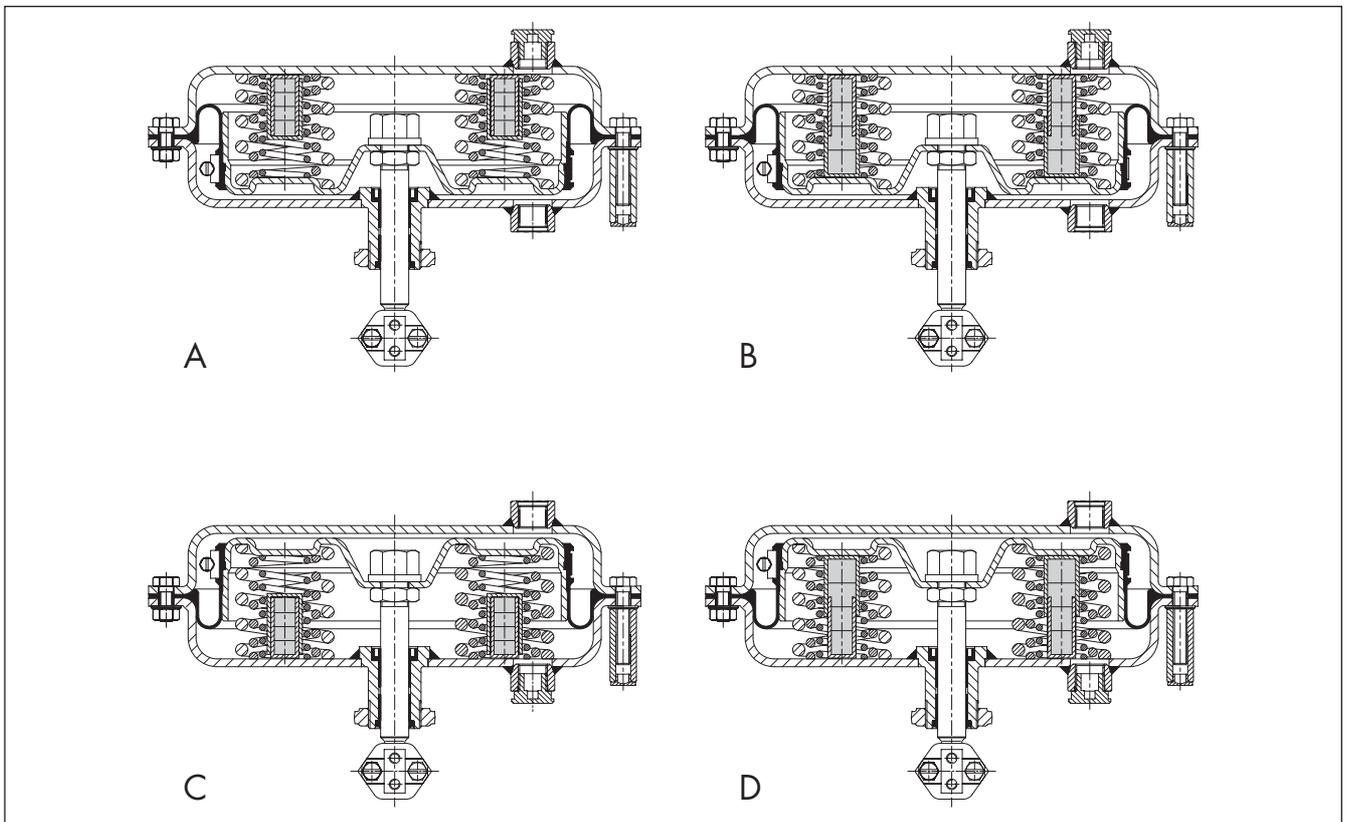


Fig. 6: Arrangement of cartridges in the pneumatic actuator (sectional drawing)

- a) Actuator springs “fail-close”; safety cartridges in deactivated state
- b) Safety cartridges after temperature rise
- c) Actuator springs “fail-open”; safety cartridges in deactivated state
- d) Safety cartridges after temperature rise

### Reversible operating direction

A part from the safety cartridges, there are additional solutions that can be integrated in the pneumatic actuator for safety. It is possible to use a preloaded spring assembly released at an adjustable temperature to oppose the standard fail-safe position. This patented method [8] includes preloaded spring discs which act in opposition to the standard actuator springs. The spring discs are bound by a solder strip. The type of solder determines at which temperature the spring discs are released to act as an additional safety device. Upon release of the spring discs, the standard fail-safe action is reversed. The solder joint is extremely stable under practical operating conditions, such as permanently increased ambient Temperatures.

A pneumatic actuator equipped with such a safety device is presented in the sectional drawing below (Fig. 7).

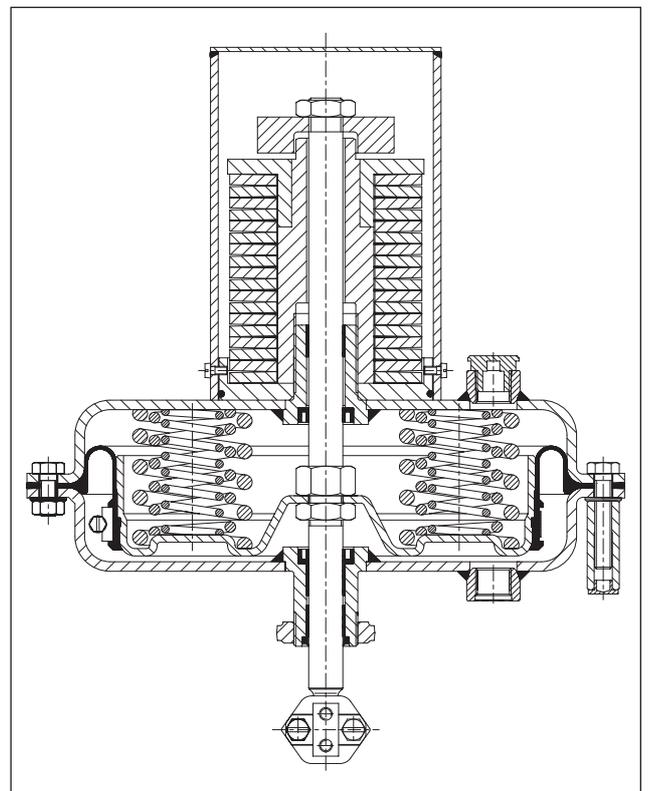


Fig. 7: Sectional drawing of a pneumatic actuator whose standard fail-safe action is reversed in the event of a fire.

The release temperature range of the spring discs bound by a solder strip depends on the kind of solder used.

## Summary

The safety equipment shows a simple structure, enabling the pneumatic control valve to assume fail-safe position or reverse this fail-safe position upon outbreak of fire. Pneumatic control valves could now be used in fields of application never considered possible before.

Compared to pneumatic control valves with standard fail-safe action, actuators equipped with these innovative safety devices are able to maintain the fail-safe position over an extended period of time when exposed to fire.

The safety cartridge filled with intumescent material plays an essential role in this safety technique. Thanks to these cartridges, the valve trim remains effective even at the extremely high temperatures of a fire, thus preventing leakage of hazardous media! The cartridges compensate for the loss in force of the springs, which under less extreme conditions guarantee fail-safe action.

Another asset of the safety equipment is its cost-effectiveness compared to other safety equipment in use. Since the safety cartridges can replace more complex and hence expensive safety devices, they will prove to be another remedy against the pressure on costs.

Alternatively, conventional fail-safe action can be reversed when a fire breaks out. Releasing preloaded and bound spring discs reverses the direction of standard fail-safe action of pneumatic actuators. An important aspect in this innovative method is the fact that the temperature range in which the springs are released can be adjusted as needed.

In view of all the advantages of the modern safety equipment developed by SAMSON, the use of pneumatic control valves could now be taken into consideration even where sensitive applications are concerned.

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