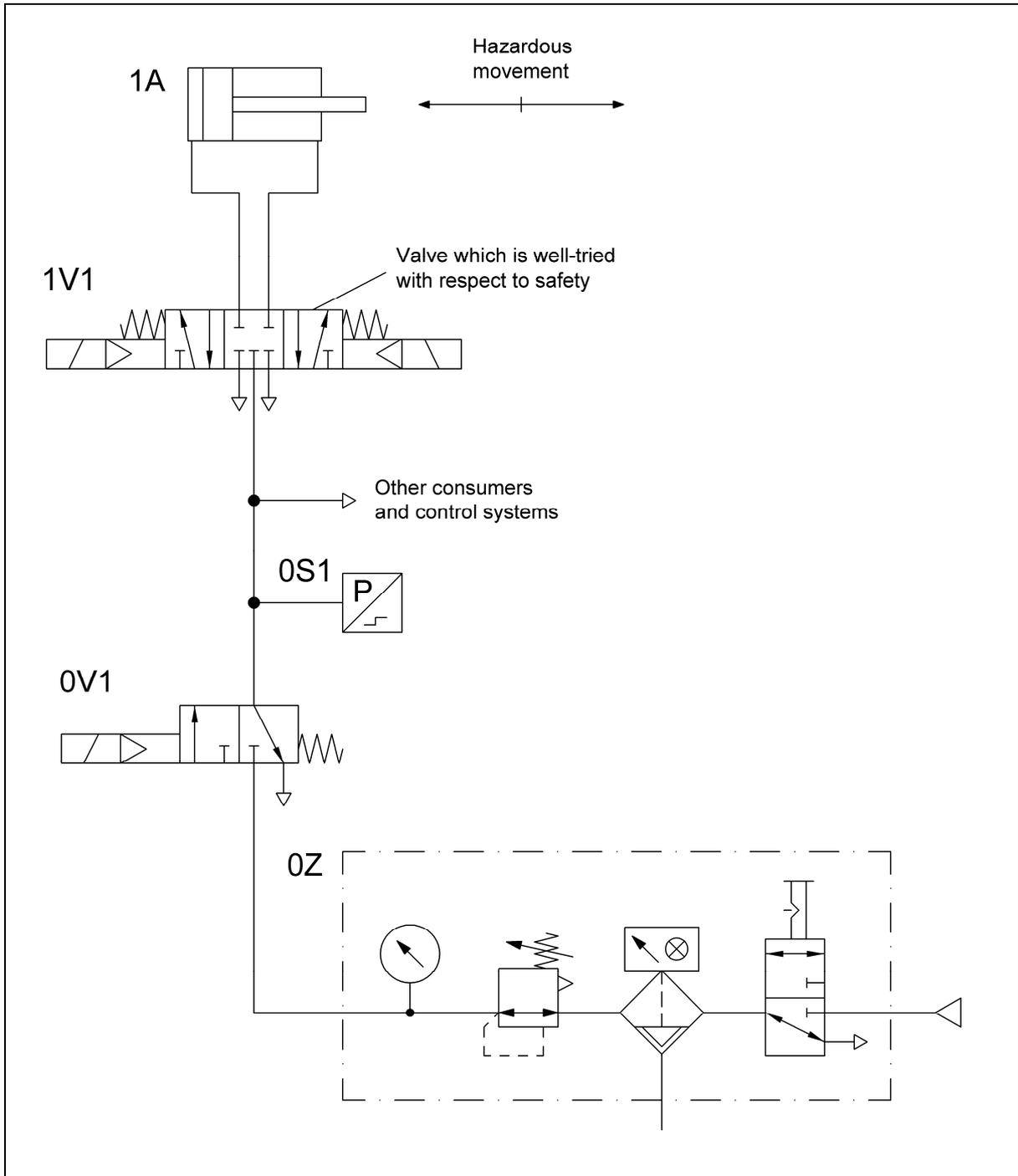
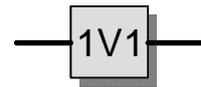




**8.2.2 Pneumatic valve (subsystem) – Category 1 – PL c (for PL b safety functions) (Example 2)**

Figure 8.5:  
Pneumatic valve for the control of hazardous movements





### Safety functions

- Safety-related stop function: stopping of the hazardous movement and prevention of unexpected start-up from the rest position
- Only the pneumatic part of the control is shown here, in the form of a sub-system. Further safety-related control components (e.g. protective devices and electrical logic elements) must be added in the form of subsystems for completion of the safety function.

### Functional description

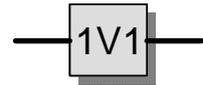
- Hazardous movements are controlled by a directional control valve 1V1 with well-tries safety functionality.
- Failure of the directional control valve may result in loss of the safety function. The failure is dependent upon the reliability of the directional control valve.
- No measures for fault detection are implemented.
- Should trapped compressed air pose a further hazard, additional measures are required.

### Design features

- Basic and well-tries safety principles are observed and the requirements of Category B are met.
- 1V1 is a directional control valve with closed centre position, sufficient overlap, spring centering and fatigue-resistant springs.
- The safety-oriented switching position is attained by removal of the control signal.
- Where necessary, the manufacturer/user must confirm that the directional control valve is a component with well-tries safety functionality (of sufficiently high reliability).
- The safety function can also be attained by a logical arrangement of suitable valves.

### Calculation of the probability of failure

- $MTTF_d$ : a  $B_{10d}$  value of 40,000,000 switching operations [E] is assumed for the directional control valve 1V1. At 240 working days, 16 working hours per day and a cycle time of 5 seconds,  $n_{op}$  is 2,764,800 cycles per year and the  $MTTF_d$  is 145 years. This is also the  $MTTF_d$  value per channel, which is capped to 100 years (“high”).
- $DC_{avg}$  and measures against common cause failures are not relevant in Category 1.



- The pneumatic control corresponds to Category 1 with a high  $MTTF_d$  (100 years). This results in an average probability of dangerous failure of  $1.14 \times 10^{-6}$  per hour. This corresponds to PL c. The addition of further safety-related control parts as subsystems for completion of the safety function generally results in a lower PL.
- In consideration of the estimation erring on the safe side as described above, a  $T_{10d}$  value of 14 years operating time is produced for specified replacement of the wearing directional control valve 1V1.

Figure 8.6:  
Determining of the PL by means of SISTEMA

The screenshot shows the SISTEMA software interface. The main workspace displays two channels:

Channel 1	Name	DC [%]	MTTFd [a]
	BL Valve 1V1	not relevant	144,68 (-)

Channel 2	Name	DC [%]	MTTFd [a]

At the bottom left, the 'Safety-related stop function and prevention' parameters are listed:

PLr	b
PL	c
PFH [1/h]	1,14E-6

The 'Pneumatic control system' parameters are listed below:

PL	c
PFH [1/h]	1,14E-6
Cat.	1
MTTFd [a]	100 (High)
DCavg [%]	not relevant
CCF	not relevant