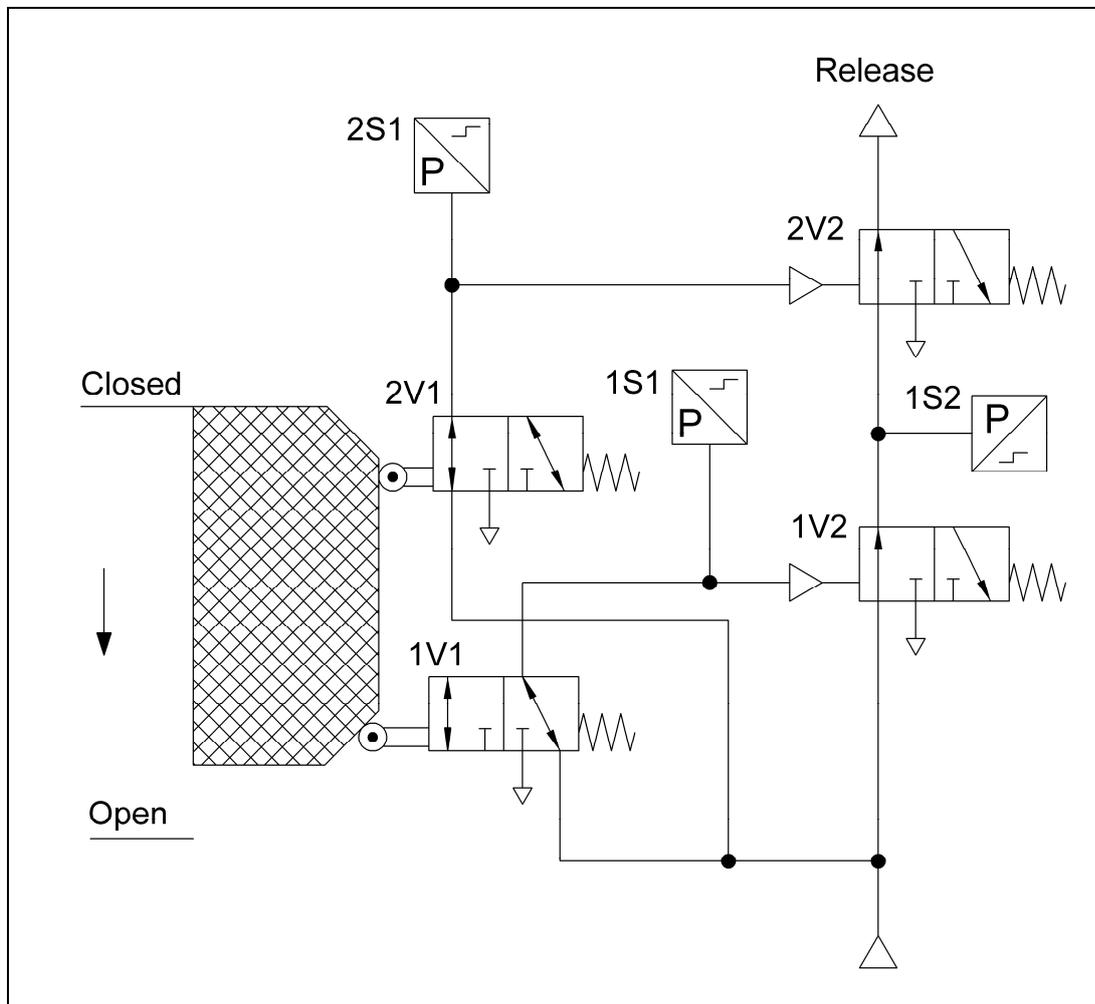




### 8.2.26 Pneumatic valve control – Category 3 – PL e (Example 26)

Figure 8.45:  
Redundant pneumatic control system for the interlocking of moveable guards

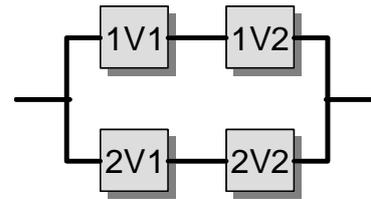


#### Safety function

- Safety-related stop function, initiated by a protective device: when the moveable guard is opened, the power is disconnected and the pneumatic control system depressurized.

#### Functional description

- The moveable guard is interlocked by two “pneumatic position switches” (1V1 and 2V1). 1V1 and 2V1 issue control commands to the directional control valves 1V2 and 2V2 respectively.
- Pneumatic power is supplied only when the protective device is closed.
- Failure of a “pneumatic position switch” or directional control valve does not result in loss of the safety function.



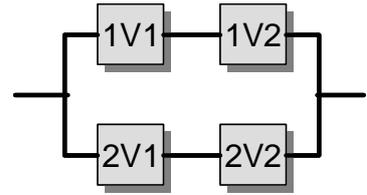
- Faults on valves 2V1 and 1V2 are detected by the pressure switches 1S1, 2S1 and 1S2. The relevant signals can be processed in a PLC. Should a fault be detected, the power can for example be disconnected. No fault detection is provided for the valve 2V2. This valve should be checked regularly for proper operation. An accumulation of undetected faults may lead to loss of the safety function.
- Should trapped compressed air pose a further hazard, additional measures are required.

### Design features

- Basic and well-tried safety principles are observed and the requirements of Category B are met.
- 1V1 is a pneumatic position switch with positive actuation by the moveable guard in accordance with EN 1088.
- A stable arrangement of the protective device is assured for actuation of the position switch.
- The safety-oriented switch position of the directional control valves 1V2 and 2V2 is attained by removal of the control signals.

### Calculation of the probability of failure

- $MTTF_d$ : fault exclusion is assumed for the valve 1V1, since positive operation is assured by the moveable guard and the valve takes the form of a position switch with personnel safety function (based upon IEC 60947-5-1).  $B10_d$  values of 20,000,000 cycles [S] are assumed for the valves 2V1, 1V2 and 2V2. At 240 working days, 16 working hours and a cycle time of 30 seconds,  $n_{op}$  is 460,800 cycles per year and the  $MTTF_d$  is 434 years. Capping of the two channels to 100 years results in a symmetrized  $MTTF_d$  value per channel of 100 years (“high”).
- $DC_{avg}$ : a  $DC$  of 99% is produced for the directional control valves 2V1 and 1V2 owing to fault detection by means of the pressure switches. A  $DC$  of 0% is assumed for the directional control valve 2V2 (estimation erring on the safe side). Averaging thus results in a  $DC_{avg}$  of 66% (“low”).
- Adequate measures against common cause failure (65 points): separation (15), overvoltage protection etc. (15) and environmental conditions (25 + 10)
- The combination of the pneumatic control elements corresponds to Category 3 with a high  $MTTF_d$  (100 years) and low  $DC_{avg}$  (66%). This results in an average



probability of dangerous failure of  $8.95 \times 10^{-8}$  per hour. This corresponds to PL e.

### More detailed reference

- IEC 60947-5-1: Low-voltage switchgear and controlgear – Part 5-1: Control circuit devices and switching elements – Electromechanical control circuit devices (11.03)

Figure 8.46:  
Determining of the PL by means of SISTEMA

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**SISTEMA Subsystem** | BGIA

Documentation PL Category MTTFd DCavg CCF Blocks

**Channel 1**

Name	DC [%]	MTTFd [a]
• BL Valve 1V1	not relevant	FE (-)
• BL Valve 1V2	99 (High)	434.03 (-)

Switch content of channels

**Channel 2**

Name	DC [%]	MTTFd [a]
• BL Valve 2V1	99 (High)	434.03 (-)
• BL Valve 2V2	0 (None)	434.03 (-)

**SF Safety-related stop function and prevention**

PLr	e
PL	e
PFH [1/h]	8.95E-8

**SB Pneumatic and mechanical control system**

PL	e
PFH [1/h]	8.95E-8
Cat.	3
MTTFd [a]	100 (High)
DCavg [%]	66 (Low)
CCF	65 (fulfilled)

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