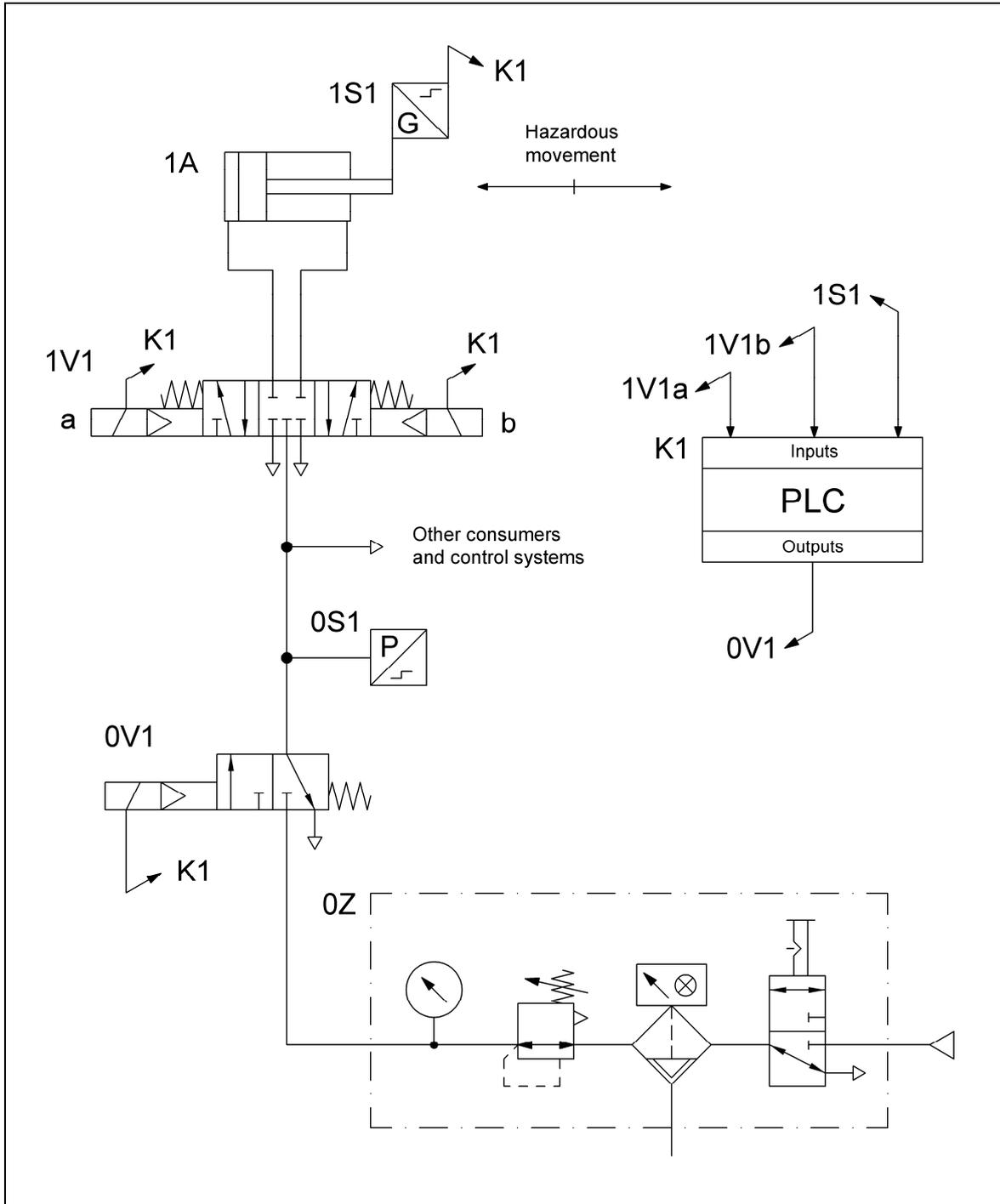
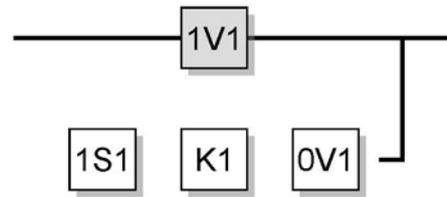




8.2.11 Tested pneumatic valve (subsystem) – Category 2 – PL d (for PL c safety functions) (Example 11)

Figure 8.21:
Pneumatic valve with electronic testing for the control of hazardous movements





Safety functions

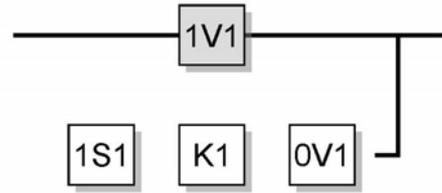
- Safety-related stop function: stopping of a hazardous movement and prevention of unexpected start-up from the rest position
- Only the pneumatic part of the control is shown here, in the form of a sub-system. Further safety-related control components (e.g. protective devices and electrical logic elements) 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.
- Failure of the directional control valve 1V1 between function tests may result in loss of the safety function. The failure is dependent upon the reliability of the directional control valve.
- Testing of the safety function is implemented via the PLC K1 by means of a displacement sensor system 1S1. Testing takes place at suitable intervals and in response to a demand upon the safety function. Detection of the failure of 1V1 leads to the exhaust valve 0V1 being switched off.
- Hazardous movement interruption by the exhaust valve 0V1 generally results in a longer overrun. The distance from the hazardous area must be selected in consideration of the longer overrun.
- The test function must not be impaired by failure of the directional control valve. Failure of the test function must not lead to failure of the directional control valve.
- 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 directional control valve with closed centre position, sufficient overlap and spring centering.
- The safety-oriented switching position is attained by removal of the control signal.
- Testing may for example take the form of checking of the time/distance characteristic (displacement sensor system 1S1) of the hazardous movements in

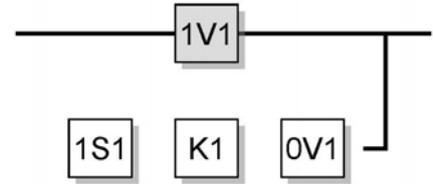


conjunction with the switching position of the directional control valve, with evaluation in a PLC (K1).

- In order to prevent a systematic failure, the higher-level de-energization function (acting upon exhaust valve 0V1 in this instance) is checked at suitable intervals, e.g. daily.
- It is implemented for use in applications with infrequent operator intervention in the hazardous area. This enables the requirement of the designated architecture for Category 2 to be satisfied, i.e. “testing much more frequent than the demand upon the safety function” (cf. Annex G).
- The standard component K1 is employed in accordance with the instructions in Section 6.3.10.
- The software (SRASW) is programmed in accordance with the requirements for PL b (downgraded owing to diversity) and the instructions in Section 6.3.

Calculation of the probability of failure

- $MTTF_d$ of the functional channel: a B_{10d} value of 20,000,000 switching operations [S] 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 switching operations per year and the $MTTF_d$ is 72.3 years. This is also the $MTTF_d$ value for the functional channel.
- $MTTF_d$ of the test channel: an $MTTF_d$ value of 150 years [E] is assumed for the displacement sensor system 1S1. An $MTTF_d$ value of 50 years [E] is assumed for the PLC K1. A B_{10d} value of 20,000,000 cycles [S] applies for the exhaust valve 0V1. At actuation once daily on 240 working days, the $MTTF_d$ value for 0V1 is 833,333 years. The $MTTF_d$ of the test channel is thus 37.5 years.
- DC_{avg} : the DC of 60% for 1V1 is based upon the comparison of the distance/time characteristic of the hazardous movement in conjunction with the switching status of the directional control valve. This is also the DC_{avg} (“low”).
- Adequate measures against common cause failure (85 points): separation (15), diversity (20), overvoltage protection etc. (15) and environmental conditions (25 + 10)
- The combination of the pneumatic control elements corresponds to Category 2 with a high $MTTF_d$ (72.3 years) and low DC_{avg} (60%). This results in an average probability of dangerous failure of 7.62×10^{-7} per hour. This corresponds to PL d. Following the addition of further safety-related control parts (subsystems) for completion of the safety function, PL c is generally attained for the complete safety function.



- The wearing element 1V1 should be replaced approximately every seven years (T_{10d}).

Figure 8.22:
Determining of the PL by means of SISTEMA

SISTEMA - Safety Integrity Software Tool for the Evaluation of Machine Applications

File Edit View Help

New Open... Save Close Project Library Report Help Wizard-Help

Projects

- PR 11 Tested pneumatic valve (subsystem)
 - SF Safety-related stop function and prevention
 - SB Pneumatic control system
 - CH Channel 1
 - BL Valve 1V1
 - EL Valve 1V1
 - CH Channel 2
 - TE Test channel
 - BL Displacement sensor
 - EL Displacement sensor
 - BL PLC K1
 - EL PLC K1

Safety-related stop function and prevention

PLr	c
PL	d
PFH [1/h]	7,62E-7

Pneumatic control system

PL	d
PFH [1/h]	7,62E-7
Cat	2
MTTFd [a]	72,34 (High)
DCavg [%]	60 (Low)
CCF	85 (fulfilled)

Clipboard: X

Subsystem BGIA

Documentation PL Category MTTFd DCavg CCF Blocks

Channel 1

Name	DC [%]	MTTFd [a]
BL Valve 1V1	60 (Low)	72,34 (High)

Channel 2

Name	DC [%]	MTTFd [a]
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