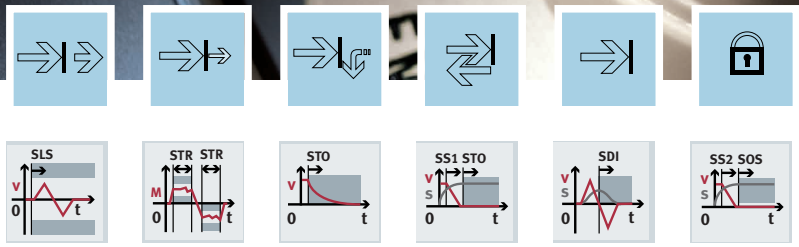
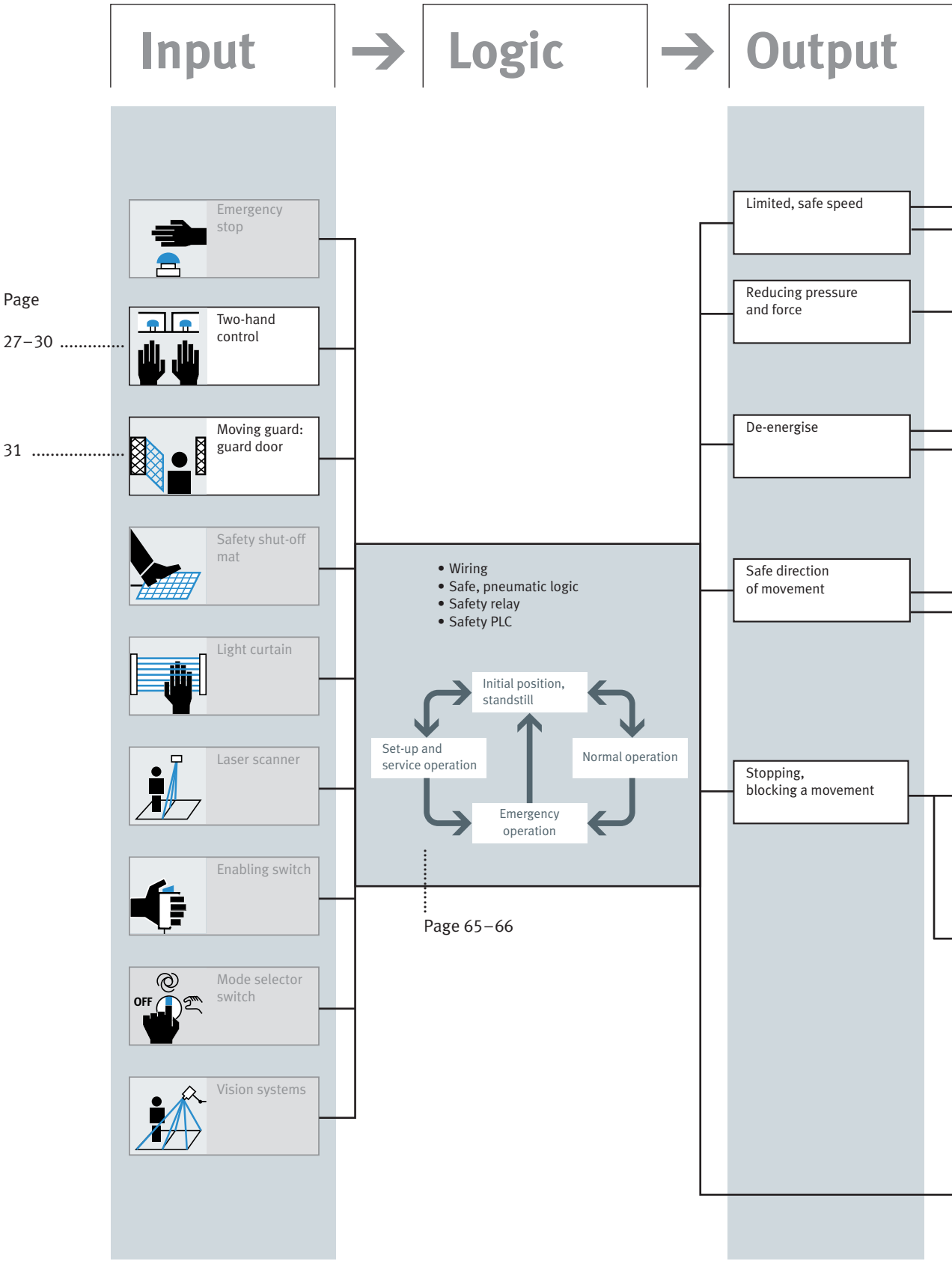
Safety engineering guidelines
Pneumatic and electric solutions

FESTO



Overview of technical safety measures



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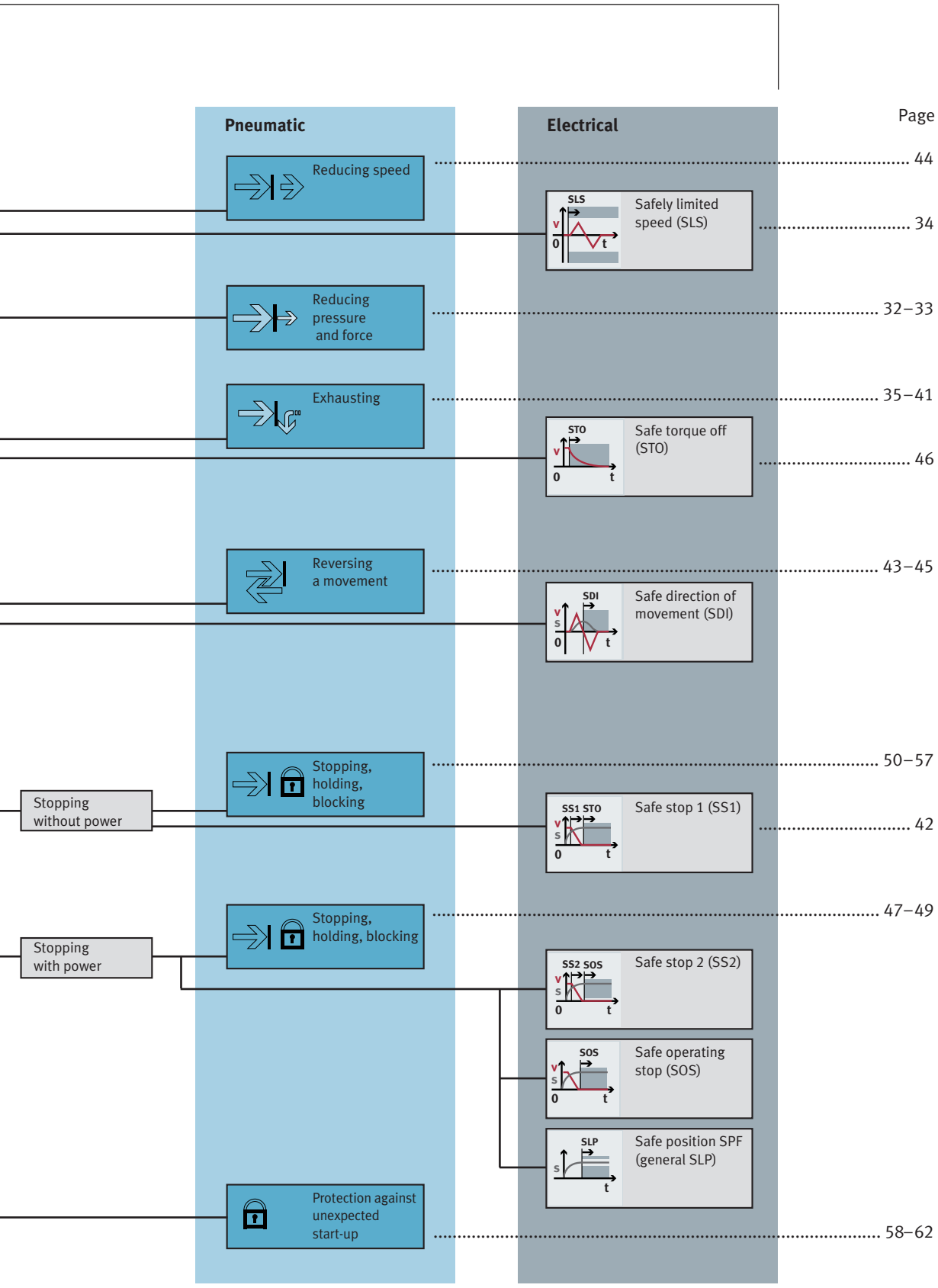


You will see these symbols frequently on the following pages.
They clearly and quickly point to the respective safety function.

Your partner for safety

At Festo, quality has many aspects – one of these is handling machines safely. This is the reason for our safety-oriented automation technology. These components ensure that optimum safety is achieved in the workplace.

This brochure is intended as a guide.
It covers the core questions relating to safety-oriented pneumatics and electrical engineering:

- Why use safety-oriented pneumatics?
- How can I identify the risk posed by a system or machine to the operator or user?
- Which standards and directives apply?
- Which safety measures are derived from these?
- What are the most common safety measures?

Simple and helpful: The second part of the brochure contains sample circuit diagrams for the most commonly used safety functions in conjunction with pneumatic and electric drives as well as the corresponding Festo product combinations.

These can be used to implement many safety functions.

If you have more extensive requirements, our specialists worldwide will be happy to help.

Contents

Reduce risk – think preventively

Machines have to be designed in a way that protects people, animals, property and the environment from harm. The goal is to prevent physical damage of any type. Using safety-oriented pneumatics from Festo provides you with the security of implementing safety measures in compliance with the EC machinery directive.

This reliably prevents collisions or uncontrolled restarts after EMERGENCY-STOP, for example. At the same time, using safety-oriented pneumatics also minimises the risk of liability claims.

The EC Machinery Directive specifies a risk analysis and assessment for machines. These have helped to develop and define protection goals.

The protection goals are achieved using various safety functions.

Safety-oriented solutions from Festo, in the form of
- Components
- Circuits
- Engineering

make it easy to achieve your safety objectives. Safe operation of machines should be possible in all modes and stages of their service life.

Safety-oriented solutions from Festo provide you with proposals for
- Commissioning
- Automatic/manual operation
- Setting up
- Risk situations and emergency functions, such as safe stop, safe exhausting.
- Restart -› Protection against unexpected start-up
- Service/maintenance

In addition to this, if errors occur, they must not lead to failure of the safety functions, depending on their hazard potential.

Simple but safe

As a general rule, the simpler the safety technology used in the application, the more efficient it is. The complexity of safety engineering is in the variety of state combinations and transitional states.

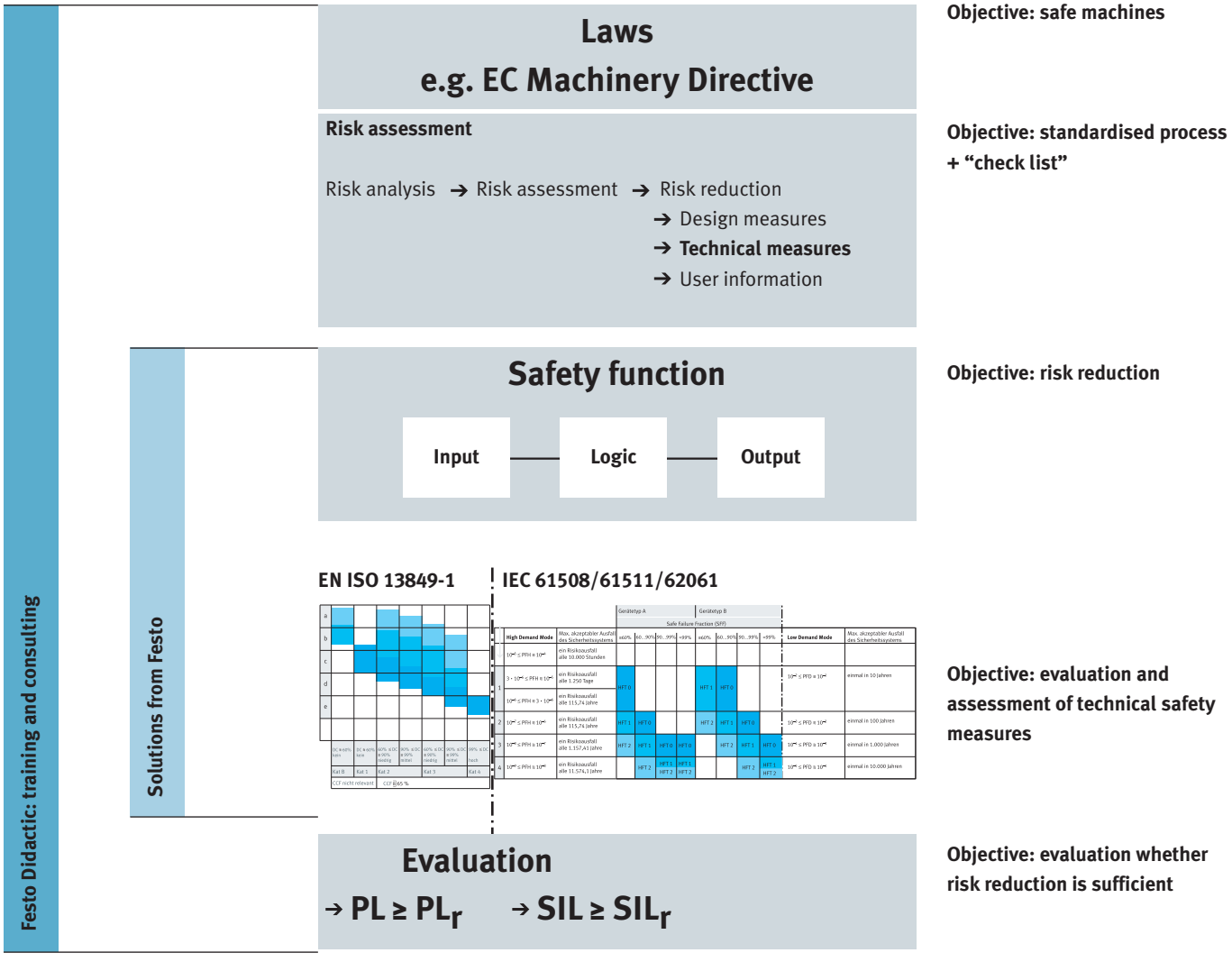
As a result, it would seem virtually impossible to implement standardised safety engineering concepts.

Due to their flexible applications, Festo drive systems can be incorporated in the risk analysis and assessment for each machine, depending on the application.

To ensure that the electrical safety functionality of your control system is a suitable continuation of in your safety concept for pneumatic components, Festo offers solutions based on risk analyses and risk assessments for the most commonly used applications.

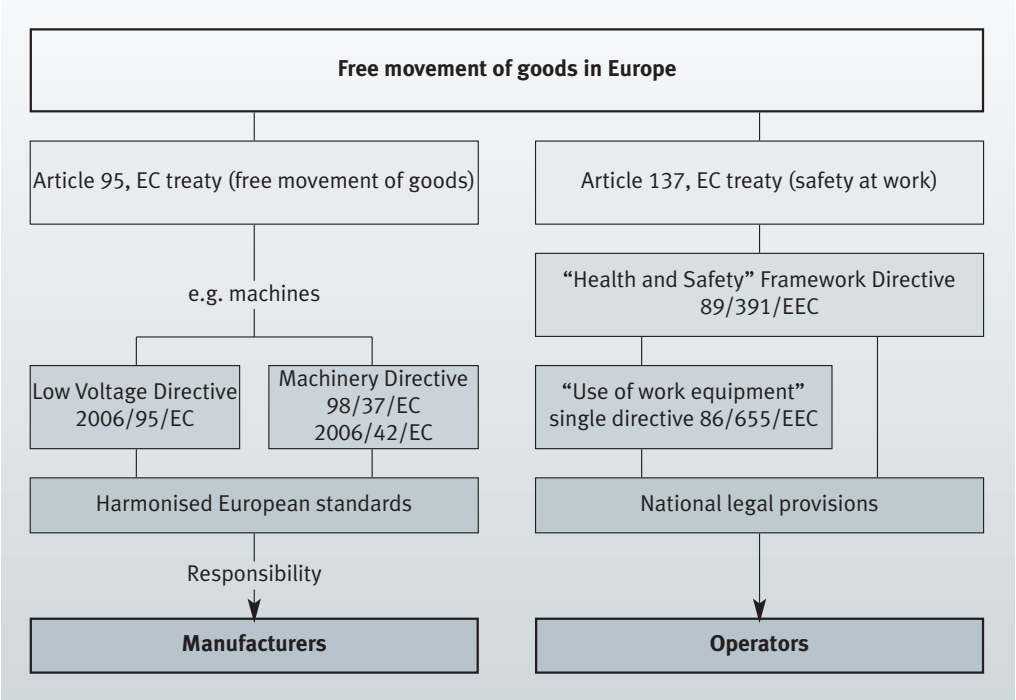
Technical safety conditions

There are global framework conditions to ensure that machinery can be built and operated safely. Almost all laws require a risk assessment which reveals risks and results in risk minimising measures.



Basic safety requirements in the manufacturing industry

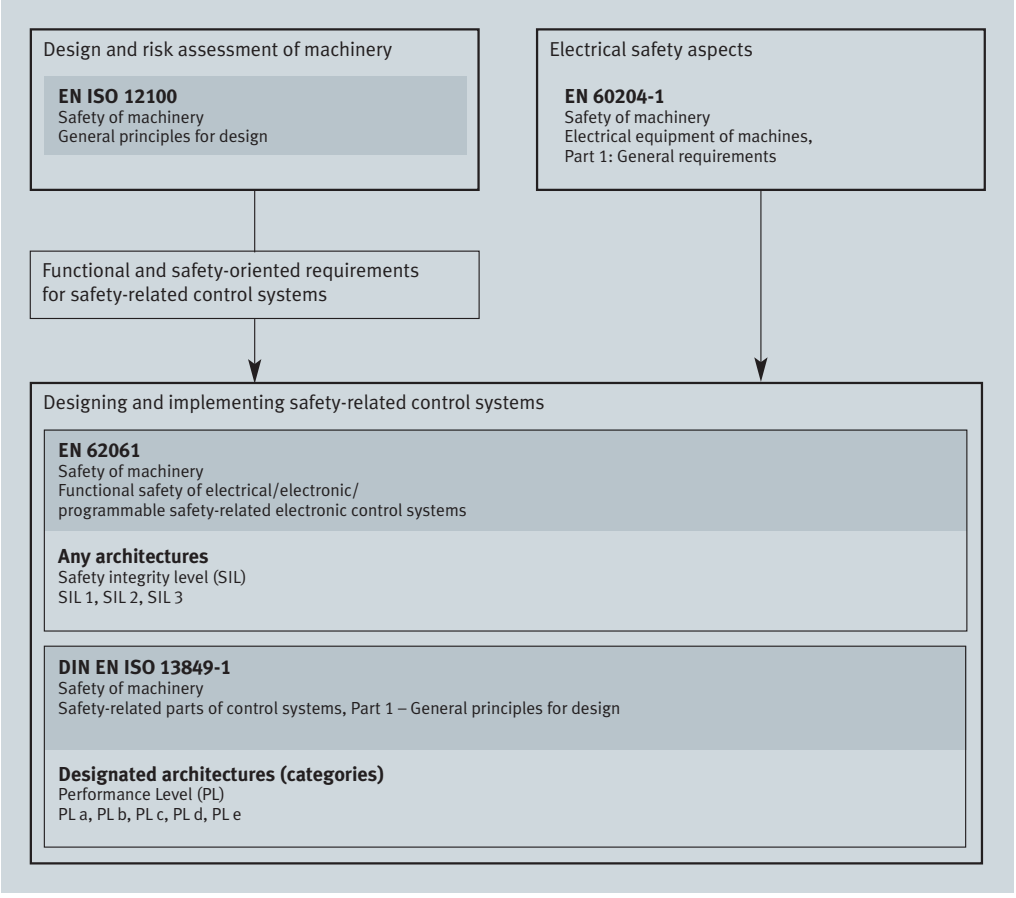
As part of the development of the single European market, the directives for machine construction in the manufacturing industry were harmonised.



Directives are comparable with laws. Among others, the EC machinery directive is applicable for machine construction.
The primary aim of the EC machinery directive is to specify basic health and safety requirements in relation to the design and construction of machines. The CE mark indicates compliance with the machinery directive.
Harmonised standards provide assistance in complying with the EC machinery directive. Harmonised standards are listed in the Official Journal of the European Communities. Applying these results in what is known as the "presumption of conformity", which reinforces the legal security of operators and manufacturers.

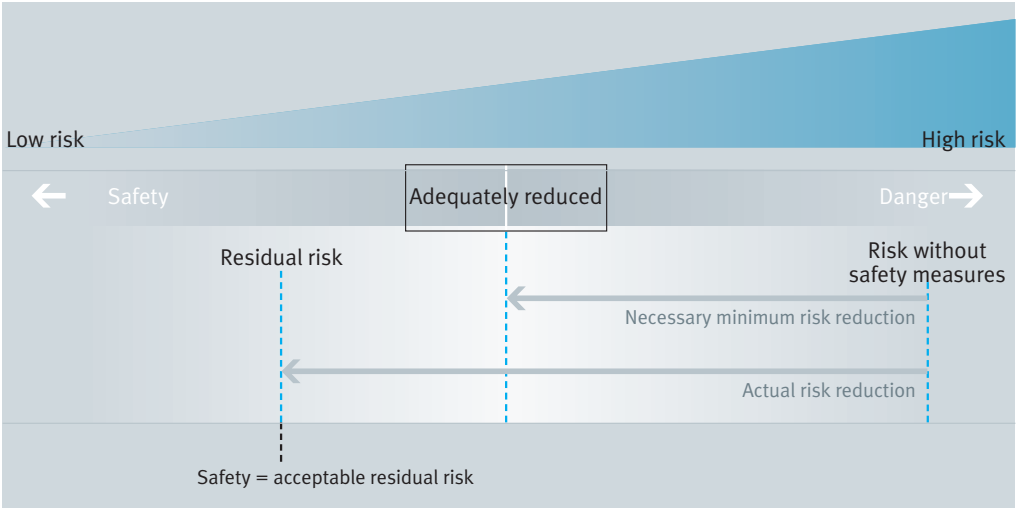
Basic standards for designing control functions

Harmonised standards that relate to machine safety serve to reduce safety risks to an acceptable minimum, as per the EC Machinery Directive.



Definition and concept of risk

Risks are the result of hazards and relate to the gravity of possible damage and the probability of the damage occurring.



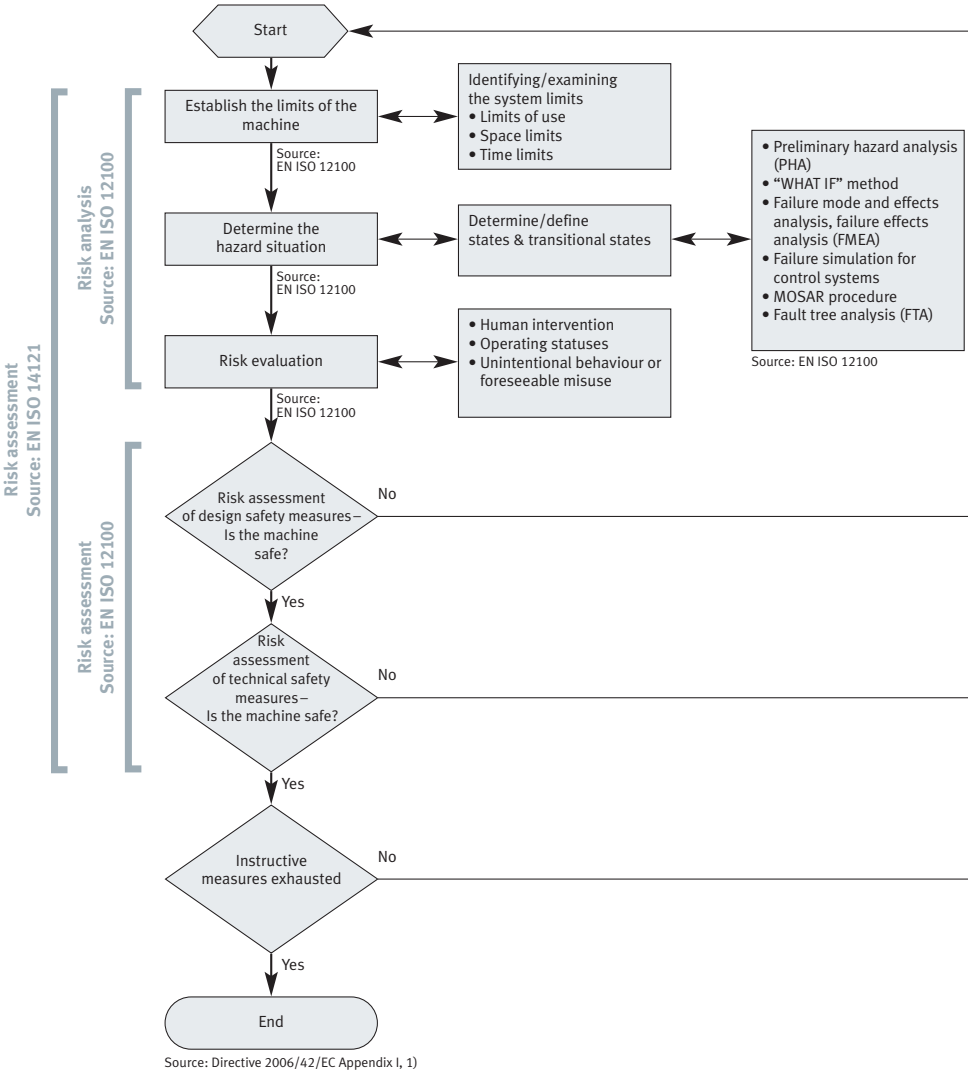
Risk in terms of the respective hazard = **Severity** of the possible damage + **Probability** of the damage occurring

- Frequency and duration of the exposure to hazard
- Options for avoiding or limiting the damage
- Probability of an event that could cause the damage occurring

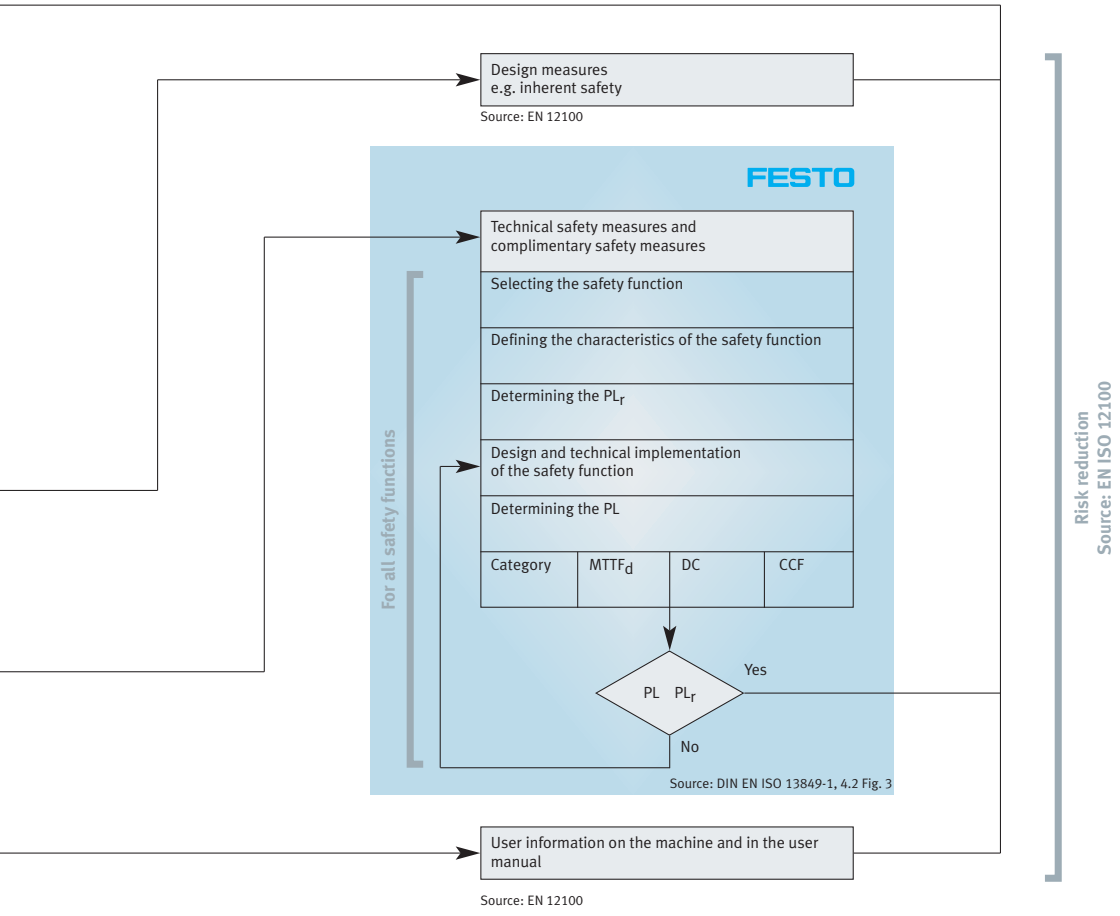
Risk assessment

Directives and standards describe the risk assessment process. All manufacturers are obligated to perform a risk assessment. This is followed by a risk evaluation and appropriate risk reduction measures must be implemented as required.

Focusing on risk reduction
This guide is primarily concerned with the area of risk reduction in the form of technical safety measures. We assume that all possible design measures for reducing risk have already been explored.



Source: Directive 2006/42/EC Appendix I, 1)



When assessing risk and identifying the necessary performance level, the degree of risk reduction is established. Whether or not the required risk reduction level has been achieved depends on the following parameters:

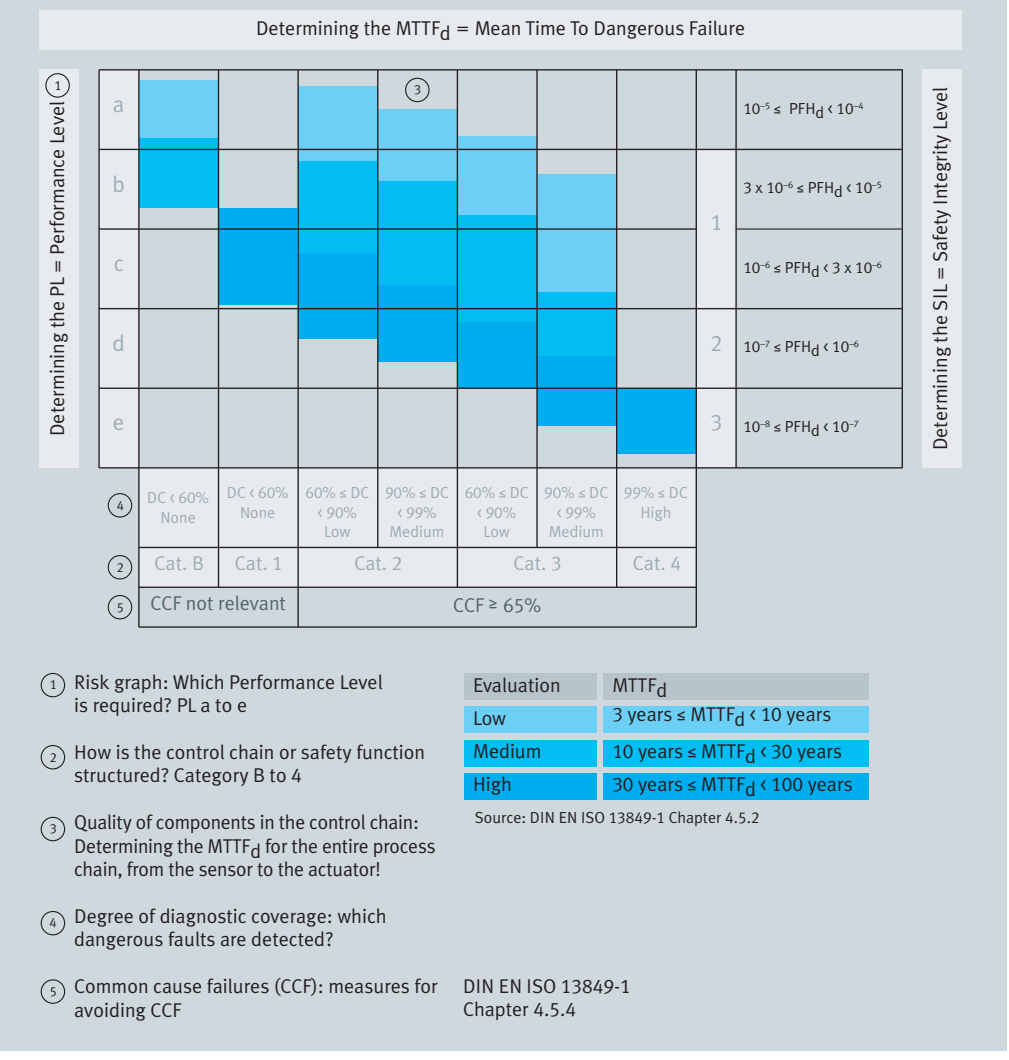
1) Control architecture
2) Mean time to dangerous failure ($MTTF_d$)
3) Diagnostic coverage (DC)
4) Common cause failures (CCF)

In all cases, the performance level (PL) must be equivalent to at least the required PL_r.

Evaluating technical safety measures – Determining the performance level

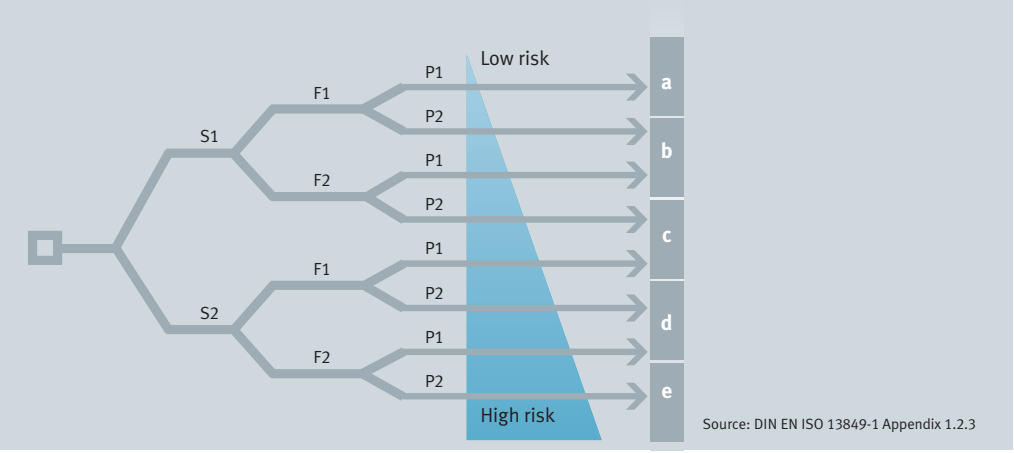
The figure shows the simplified procedure for determining the performance level (PL) of a safety function. The PL is a function of categories B to 4, diagnostic coverage “none to high”, various $MTTF_d$ areas and the Common Cause Failure.

The PL can be assigned to a specific SIL level. However, it is not possible to infer the PL from the SIL. Apart from the average probability of one dangerous failure per hour, other measures are needed to achieve a specific PL.



Application of 13849-1 Step 1: determining the required performance levels

The graph for determining the required performance level is based on identifying the risk and the resulting necessity for reducing this to an acceptable level.
Low risk results in PL = a (minimal measures for risk reduction).
High risk results in PL = e (comprehensive measures for risk reduction).



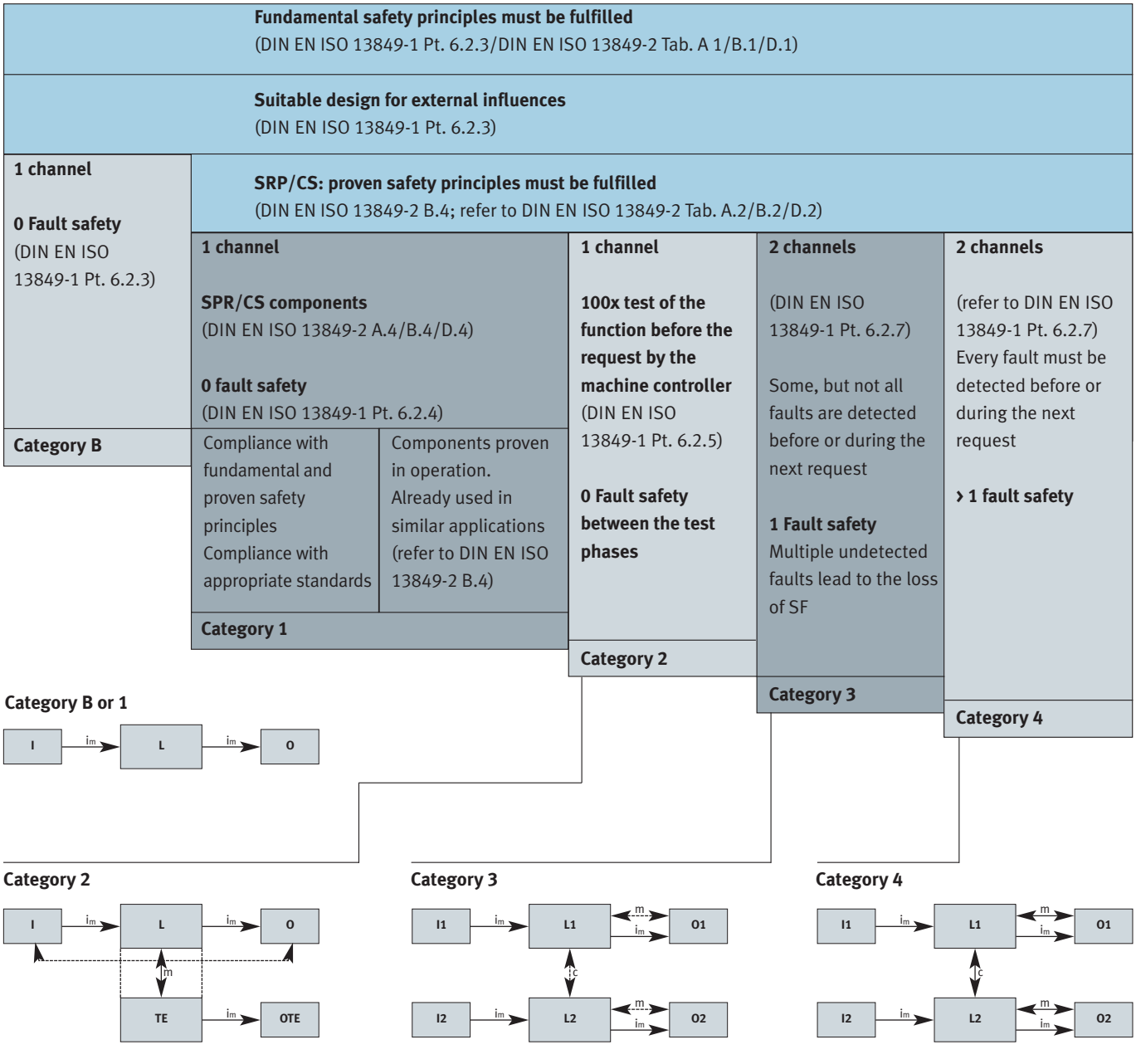
Source: DIN EN ISO 13849-1 Appendix 1.2.3

Technically speaking, PL_r (required) is a “nominal value”, which is the minimum that should be achieved by the real structure.

Statements from EN 62061 are also quoted here for a better assessment of risks. The risk is always evaluated in the same way, that is as the severity of possible damage and the probability that damage will occur.

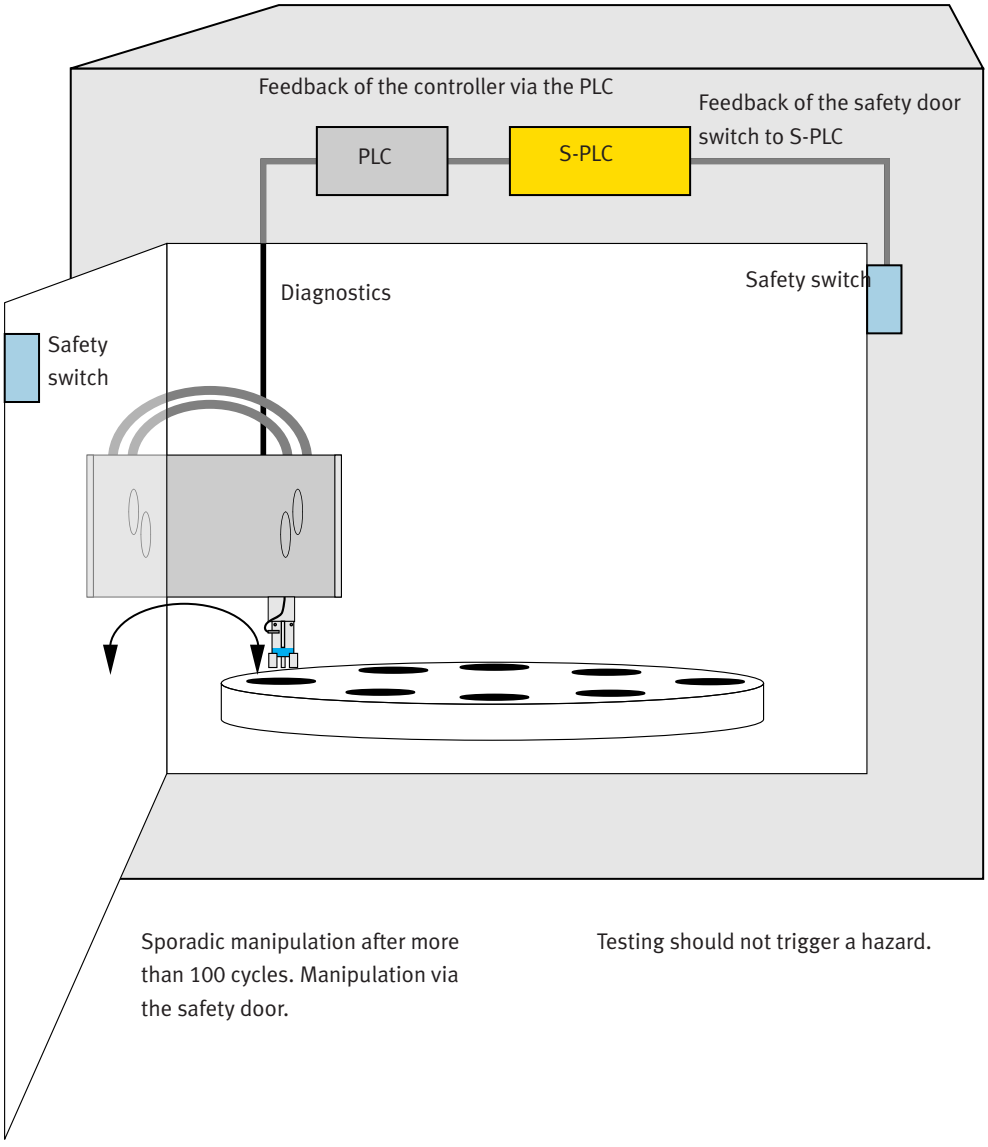
DIN EN ISO 13849-1	Statements from other standards EN 62061
S Severity of injury S1 Slight (normally reversible injury) S2 Serious (normally irreversible injury, or death)	Irreversible injury (4 points) (death, loss of eye or arm) Irreversible injury (3 points) (broken limb, loss of finger) Reversible injury (2 points) (requires further medical attention from a doctor) Reversible injury (1 point)
Frequency and/or duration of exposure to hazard F1 Seldom to less often and/or brief F2 Frequent to continuous and/or long	Frequency (with a duration > 10 min) < 1 h (5 points) > 1 h to < 1 day (5 points*) > 1 day < 2 weeks (4 points*) > 2 weeks to < 1 year (3 points*) > 1 year (2 points*) * If exposure lasts less than 10 min, this can be reduced one level
P Possibility of avoiding the hazard P1 Possible under specific conditions P2 Scarcely ever possible	Impossible (5 points) Seldom (3 points) Probable (1 point)

Overview of control architectures



Category 2 application: Pick & Place

Pneumatic implementation of a category 2 solution
In this example, the parts relevant for the safety function are also used for the normal controller of the system. This is used for testing. If this is not possible, it is easier to implement Category 3 for many solutions in pneumatic safety controls, even if a Category 2 would actually be sufficient, as the safety function for this is implemented via diversity and not using 100x testing.



Sporadic manipulation after more than 100 cycles. Manipulation via the safety door.

Testing should not trigger a hazard.

The circuit must be tested at least 100 times before the safety function is requested. This test of the pneumatic components must be performed without causing hazards.

Defining the diagnostic coverage (DC)

This table shows a summary of sources of error related to pneumatics, taken from DIN EN ISO 13849-2. Under certain conditions, it is possible to exclude faults.
The requirements for excluding a fault are described in detail in DIN EN ISO 13849-2. Faults must be examined and evaluated in the context of each application to establish whether the fault has a dangerous effect on the safety function. Depending on the construction principle and the design of components, different results may arise for different applications; in other words, a specific product may be suitable for one application but not for another. The design engineer for the installation is responsible for checking this.

Products \ Sources of error	Change to the response times	Non-switching/ not switching back	Auto-switching	Leakage	Change to the leakage over a long period of use	Cracking of the housing/ connecting piece/tubing	Change to the flow rate without assistance (adjustable)	Change to the flow rate without assistance (fixed)	Change to the behaviour without assistance	For proportional flow valves: unintentional change to the setting value	Automatic change to the adjusting device
Directional control valves											
Shut-off/non-return/quick exhaust/shuttle valves											
Flow control valves											
Pressure limiting valves											
Pipelines											
Tubing lines											
Connecting components											
Pressure intensifier and pressure medium converter											
Filters											
Lubricators											
Silencers											
Energy storage device and reservoir											
Sensors											
Logic elements (AND/OR)											
Delay elements											
Transformers (pressure switch, position switch and amplifier)											
Cylinders											

Unintentional loosening of the operating elements in the adjusting device	Fault in the connecting component (ripped off/out, leakage)	Clogging (blockage)	Bending	Change to the recording and output characteristics	Failure of the end-position cushioning	Loosening of the piston / piston rod connection	Pressure rise	Pressure failure	Electrical power failure	
								■	■	$DC_1 = \frac{\sum(\text{Recognised dangerous errors})}{\sum(\text{Total dangerous errors})}$
								■	■	
■								■	■	
■							■	■	■	
	■	■	■					■	■	
	■	■	■					■	■	
		■						■	■	
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					■	■		■	■	

Key

■ Not relevant for this component

■ Freedom from errors (see DIN EN ISO 13849-2)

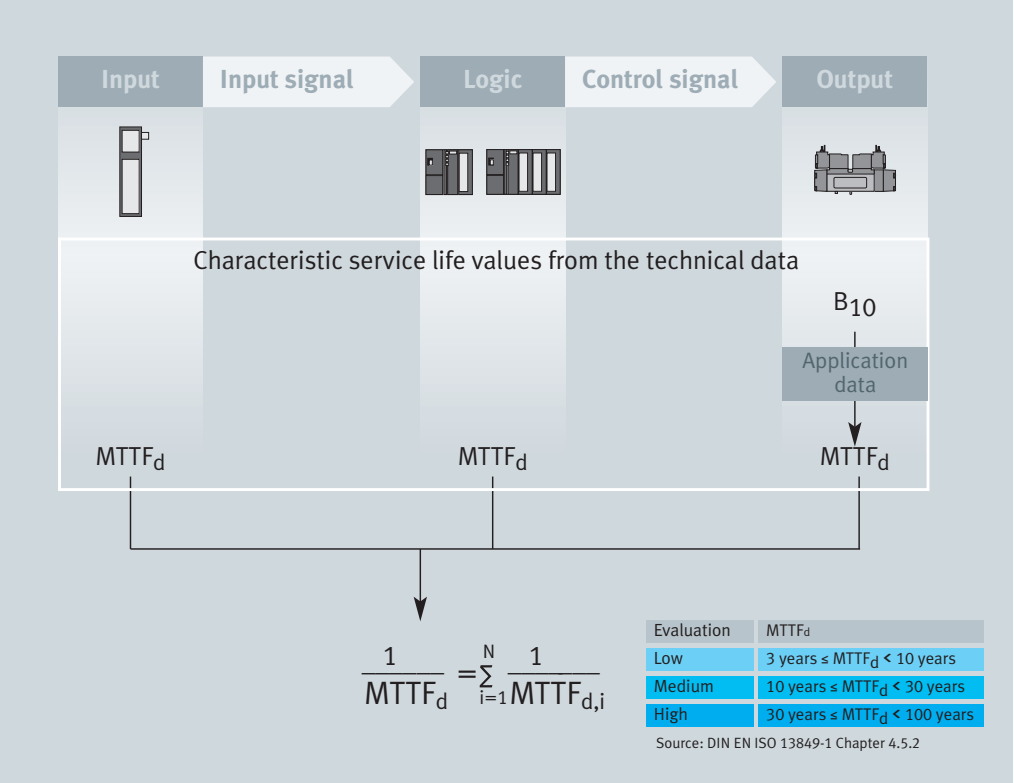
■ No error freedom guaranteed for this component

DC average

$$DC_{avg} = \frac{\frac{DC_1}{MTTF_{d1}} + \frac{DC_2}{MTTF_{d2}} + \ldots + \frac{DC_N}{MTTF_{dN}}}{\frac{1}{MTTF_{d1}} + \frac{1}{MTTF_{d2}} + \ldots + \frac{1}{MTTF_{dN}}}$$

Defining the mean time to dangerous failure ($MTTF_d$)

The mean time to dangerous failure ($MTTF_d$) is initially determined for each redundant channel. Next, a total $MTTF_d$ value is determined for both channels. This value is given in years and is a qualitative statement of the safety function. In line with the applicable standard, the technical safety measure is assessed and given one of three classifications: low, medium and high.



Evaluation	$MTTF_d$
Low	3 years ≤ $MTTF_d$ < 10 years
Medium	10 years ≤ $MTTF_d$ < 30 years
High	30 years ≤ $MTTF_d$ < 100 years

Source: DIN EN ISO 13849-1 Chapter 4.5.2

B10 value

Definition
Time at which statistically **10% of test specimens have failed** (determined per DIN EN ISO 19973).
›
Per definition, 10% of the test specimens have failed at this time. **A component can also fail before the B10 value is reached.** The service life cannot be guaranteed.
›
Dangerous failures:
In relation to the safety of machines/the EC Machinery Directive/ISO 13849-1, only dangerous failures are relevant.

It depends on the respective application whether the failure is a dangerous failure. If no information is possible/available on the number of dangerous failures, ISO 13849 permits the assumption that every second failure is dangerous. Therefore, it can be assumed that $B10_d = 2*B10$.

B10: Statistical probability of failure
$B10_d$: Statistical probability of failure due to dangerous faults

For which products do I require a $B10_d$ value?
For all products which are subject to wear, are used in safety-related parts of a controller and directly contribute to the execution of a safety function, such as valves, clamping cartridges, for example.
This does not apply to fittings, tubes, angle brackets, fixtures, etc.

For which products do I need an $MTTF_d$ value?
For all products which are used in safety-related parts of a controller and directly contribute to the execution of a safety function, such as controllers, fieldbus nodes which serve to detect dangerous situations, sensors (test channel Category 2).

Do I need an $MTTF_d$ value or $B10_d$ value for components which are used for monitoring purposes in safety-related parts of controllers?
No, for SRP/CS Category 3 and 4.
Yes, for SRP/CS Category 2 in the test channel.

Defining the $MTTF_d$
The $MTTF_d$ value is application-dependent and describes the mean period to a dangerous failure of a system part.

Formula for determining the $MTTF_d$ value for a mechanical element in a channel

$$MTTF_d = \frac{B10_d}{0.1 \bullet n_{op}}$$

Where:

$B10_d$ [cycles] = Mean number of cycles, up to 10% of the components fail dangerously
$B10_d = 2xB10$

Mean number of annual actuations n_{op} for the mechanical element

$$n_{op} = \frac{d_{op} \bullet h_{op} \bullet 3600s/h}{t_{cycle}}$$

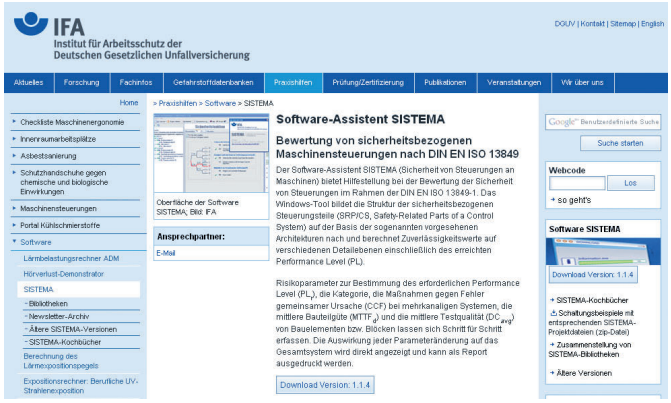
hop [h/d]: Operating hours/day
dop [d/anno]: Operating days/year
tcycle [s]: Cycle time

Calculating the total $MTTF_d$ for two different channels

$$MTTF_d = \frac{2}{3}\left[MTTF_{dC1} + MTTF_{dC2} - \frac{1}{\frac{1}{MTTF_{dC1}} + \frac{1}{MTTF_{dC2}}}\right]$$

$MTTF_{dC1}$ and $MTTF_{dC2}$:
Values for two different, redundant channels.
If the $MTTF_d$ of a channel is more than 100 years, 100 years is used for further calculation.

Safety engineering coefficients – Sistema library



Sistema software from the Institute for Occupational Health and Safety [Institut für Arbeitsschutz (IFA)]
The SISTEMA software assistant (safety of controllers in machinery) provides support in evaluating the safety of controllers as part of DIN EN ISO 13849-1. The Windows tool maps the structure of the safety-related control parts (SRP/CS, Safety-Related Parts of a Control System) on the basis of the designated architectures and calculates reliability values at various levels of detail, including the Performance Level (PL) reached. The software is available as a free download from the following link:
www.dguv.de/ifa/de/pra/softwa/sistema/index.jsp

Sistema database from Festo
The Sistema software is only the tool for performing the safety engineering evaluations. This is based on databases with safety-related specifications for products and solutions.
There are numerous libraries on the homepage of the IFA.

The library of Festo's safety engineering coefficients are available to download on Festo's homepage:
www.festo.com/sicherheitstechnik
www.festo.com/safety

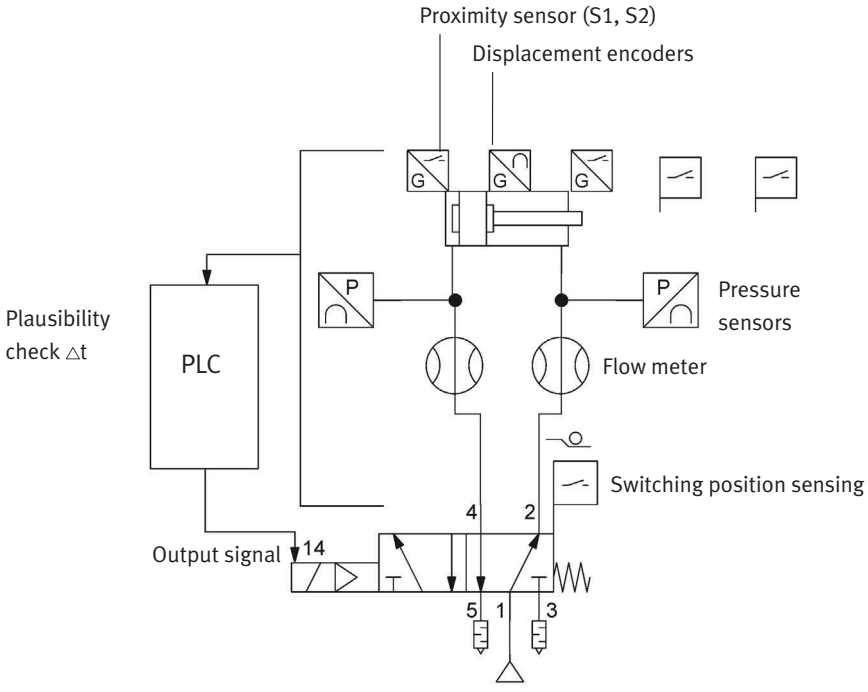
Pneumatic diagnostic options

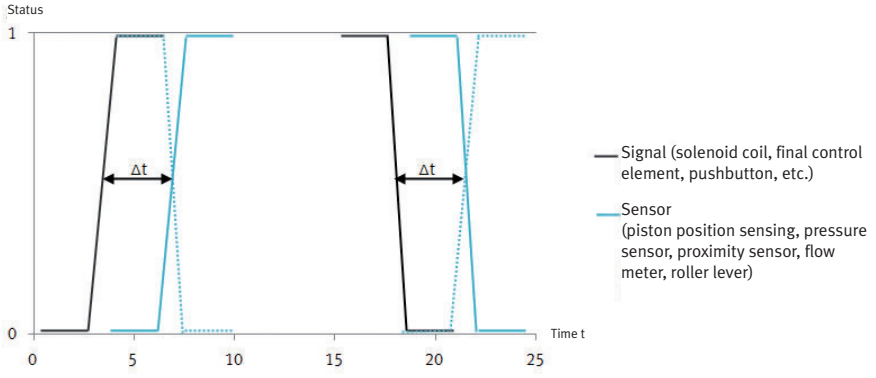
Plausibility check
The PLC checks whether a signal change has taken place within a specific period t, and if the desired change in status has occurred.

A plausibility check reveals faults with different causes
- Solenoid coils, final control element or pushbutton generate a signal
- Energy switching element, a valve in this case

Change of status
- From 0 to 1 or
- From 1 to 0

Sensors
E.g. piston position sensing, pressure sensor, proximity sensor, displacement encoder or flow meter must register the change of switching status





How test pulses affect solenoid valves

Fail-safe output modules of safety control systems and electronic safety switchgear connect test pulses to their outputs for diagnostic purposes. On the one hand, these test pulses help detect cross circuits or to check the function of the outputs relative to their deactivation efficiency. Depending on the manufacturer, these test pulses have varying pulse widths of up to several milliseconds. For example, a controller manufacturer deactivates their outputs for a period of several milliseconds in the event of an ON signal. In the event of an OFF signal, the outputs are switched on for up to 4 ms to check whether they can be deactivated safely if a safety function request is made.

How does a solenoid valve react to these test pulses?
If a solenoid valve is connected to a failsafe output, the test pulses often cause the LED on the solenoid valve to flicker at the same speed as the pulses and a clicking can be heard in the solenoid valve. That clearly shows that these test pulses have an effect on the solenoid valve. Many modern solenoid valves consist of a magnetic system, which actuates a pilot valve via an armature, which in turn actuates the main part, which then controls the actuators. Even if the switching times for activation or deactivation, which are listed in the technical data, are far higher than the duration of the test pulses, the armature reacts much earlier. In some solenoid valves, this occurs with blackout times of just 0.1 ms.

Does this result in accidental deactivation of a solenoid valve in the event of an ON signal?
This reaction in the armature generally indicates a reduction of the holding force for the armature. In turn, this means that unfavourable vibration-shock conditions on the machine could result in an unplanned deactivation of the pilot valve and thus of the power valve.

Does this result in accidental activation of the solenoid valve in the event of an OFF signal?
Although these positive test pulses of several milliseconds cause the LED on the solenoid valve to flicker at the same speed as the test pulses, it is extremely rare for it to cause the solenoid valve to switch.
In some solenoid valves, the armature already reacts after just 0.4 ms. This means that the armature in the solenoid system, which controls the pilot valve of the named solenoid valves, moves. This reaction in the magnetic system generally indicates a reduction of the break-away force for the armature. In turn, this means that unfavourable vibration-shock conditions could result in an unplanned activation of the pilot valve, and thus of the power valve.

Does my controller still comply with the EC Machinery Directive?
As long as the basic safety and health protection requirements from the EC Machinery Directive are complied with, it is in compliance with the EC Machinery Directive. If we assume that in SRP/CS, the deactivation of the solenoid valves represents the safe status of the function, hazards still will not result.

Summary:
All measurements at Festo were performed at worst case conditions. That means in the event of deactivation with minimal pressure and minimal output voltage. As the pressure and output voltage values approach the upper limits, the

sensitivity of the solenoid valves decreases. In the event of activation, the behaviour is reversed. In summary, operating our solenoid valves on failsafe outputs does not always comply with the intended use of our solenoid valves. The minimal movements caused by the test pulses could result in aging of the magnetic system. This, in turn, can adversely affect the service life of the solenoid valve.

What are the alternatives for safe operation of solenoid valves?

- In any case, you must ensure that the system complies with the specifications in the technical data and operating instructions.

- If possible, switch off the test pulses. Incorporate the MTTF values of the failsafe output when calculating the failure probability of the safety-related part of the controller (SRP/CS). Check whether the safety level of your SRP/CS is still reached despite the deactivation of the test pulses of the failsafe outputs. The MTTF of the entire control chain must comply with the required MTTF. This solution is simple, practical and, in particular, can be implemented without taking additional time.

- Actuate the solenoid valve via a non-pulsed output of a standard PLC. For example, connect a normally open contact of a safety shutdown relay between the solenoid valve and the output, which guarantees the safety function when needed.

- Disconnect the solenoid valve from the test pulses by actuating it via a relay contact, which is supplied by a non-pulsed supply voltage. The relay is actuated from a safe output (even here, the test pulses must be observed).

- Use filter clamps, as close as possible to the solenoid valve, to filter out the test pulses.

- The cable length or the cable diameter used (like a capacitor) has a damping effect on the test pulse reaction of the solenoid valve. A short cable has a negative effect (the test pulse reaches the coil of the solenoid valve in an attenuated state), a long cable has a positive effect (the test pulse is unattenuated when it reaches the coil of the solenoid valve).

Where can I find the maximum pulse length of a solenoid valve?

During the design phase of a safety-related part of a controller, always contact the manufacturer of the solenoid valve, and ask for the maximum pulse widths for test pulses.

Application 13849-1 Step 5: Defining Common Cause Failures

Common Cause Failures CCF

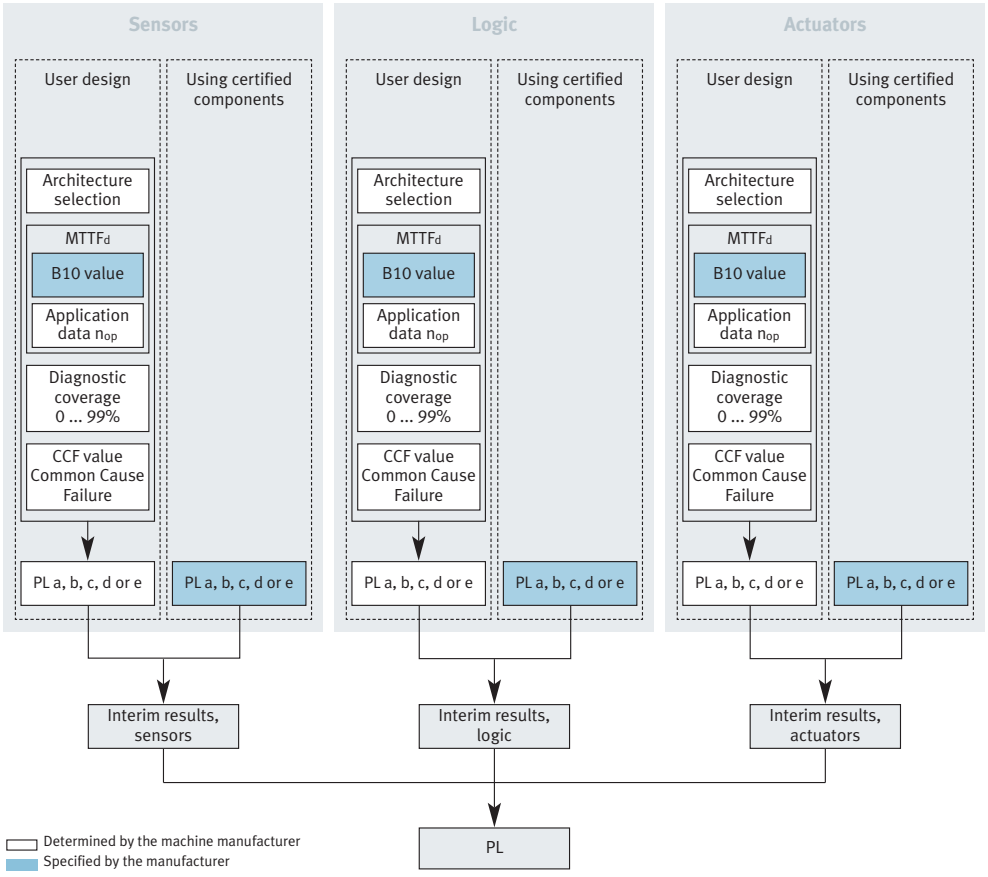
No.	Measure against CCF	Points S
1	Separation/ Segregation	
	Physical separation between signal paths: separation in wiring/piping, sufficient clearances and creepage distances on printed-circuit boards.	15
2	Diversity	
	Different technologies/design or physical principles are used, for example: first channel programmable electronic and second channel hardwired, kind of initiation, pressure and temperature, Measuring of distance and pressure, digital and analogue. Components of different manufacturers.	20
3	Design/application/experience	
3.1	Protection against over-voltage, over-pressure, over-current, etc.	15
3.2	Components used are well-tried and attention has been paid to the ambient conditions	5
4	Assessment/analysis	
	Are the results of a failure mode and effect analysis taken into account to avoid common-cause failuresin design.	5
5	Competence/training	
	Have designers/maintainers been trained to understand the causes and consequences of common-cause failures?	5
6	Environmental	
6.1	Electromagnetic Compatibility (EMC)	25
	Has the system been checked for electromagnetic immunity, e.g. as specified inrelevant standards against CCF?	
6.2	Other influences	10
	Have the requirements for immunity to all relevant environmental influences such as, temperature, shock, vibration, humidity (e.g. as specified in relevant standards) been considered?	
Total		[max. possible 100]
Measures to avoid CCF		Total points S
Requirements reached		65% or better
Process failed; select additional measures		less than 65%

Which common cause failures can arise? The measures against these failures should be recorded in a grid.
For each of the listed measures, either all the points are assigned or none. If a measure is only partially fulfilled, the number of points is zero.

Combination or series connection of SRP/CS to achieve an overall performance level

Safety functions can be implemented using multiple SRP/CS connected in series. The performance of each SRP/CS is either determined by the user or, ideally, specified by the manufacturer of the component in the technical data for the certified components.

The lowest performance level must be determined to establish the overall performance level, which in turn has to be determined based on the standard for the overall PL.



Simplified procedure for determining the PL for components with PL
For series connection, the number of the lowest PL is determined. This result can be used to determine the overall PL using the table.

Lowest PL PL_{low}	Number of the lowest PL N_{low}	Total system PL
a	>3	Not permitted
	≤3	a
b	>2	a
	≤2	b
c	>2	b
	≤2	c
d	>3	c
	≤3	d
e	>3	d
	≤3	e

Safety component

What is a safety component? Art. 2 c) 2006/42/EC

- It guarantees a safety function
- It is marketed separately
- Its failure and/or malfunction of the component endangers safety of persons and it can be replaced by standard components for the functioning of the machine.

The EC Machinery Directive defines whether a component is a safety component or not, and this depends on how it is marketed. The term safety component generally does not indicate the safety level or reliability of a component. The EC Machinery Directive does not prescribe the use of safety components. It only describes the conformity assessment procedure for components which correspond to the definition for safety components. Manufacturers of safety components must comply with the conformity assessment procedures to market the safety components in the EEA. For the user, it makes no difference whether a safety function is implemented via a purchased safety component or an internally developed and internally evaluated safety-related part of the controller to EN ISO 13849-1.

What is the difference between a safety component and a safety-related part of a controller (SRP/CS)?

- A safety component is evaluated by the manufacturer of the safety component for its safety function.
- A safety-related part of a controller (SRP/CS) is developed by the manufacturer of a machine, and evaluated for its safety level and function as part of the manufacturing of a machine.

Examples of safety components

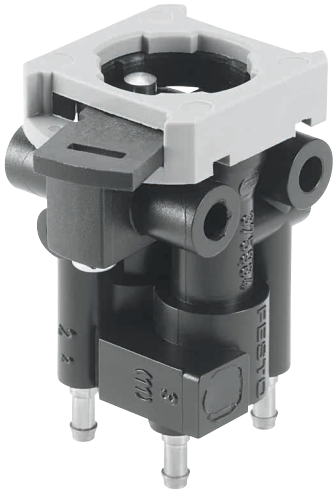
- Light curtain
- EMERGENCY STOP relay
- Safety door switch
- EMERGENCY STOP command device
- Safety relay

Do vales with switching position sensing come under the definition “Valve with failure detection? And do they have to be marketed as safety components?

- No – switching position sensing can be used to implement failure detection, but does not detect the failure without further circuitry or the evaluation via a PLC.

Can be used to implement a two-hand control device

Front panel valve SV/O



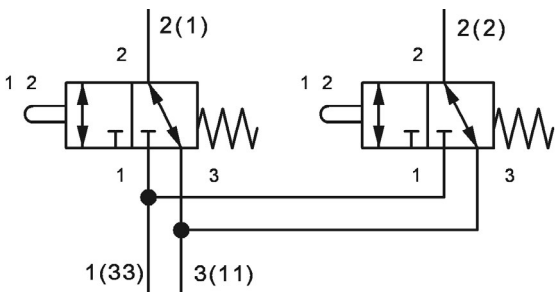
Notes
The front panel valve is not a complete safety solution. It can be used as part of a solution.

Special features
Can be combined with various actuator attachments
- Mushroom actuator PR
- Mushroom pushbutton with detent, lockable PRS
- Key actuator Q with key

Cat.	Can be used in higher category systems.
PL	
DC	
CCF	
Channels	2
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation and interconnection of the SRP/CS.

Part no.	Type
184135	SV/O-3-PK-3x2



See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

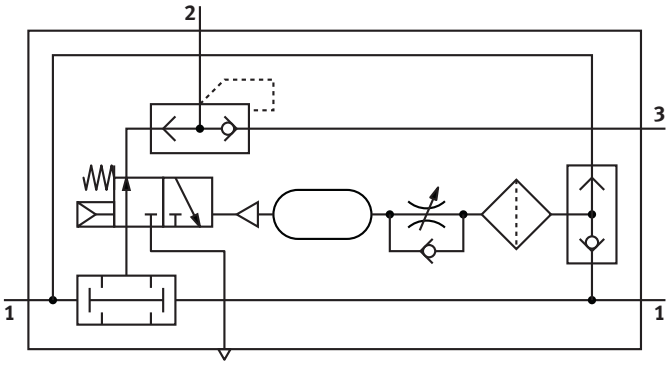
Two-hand operation

Two-hand control block

Notes
The two hand control block is not a complete safety solution. It can be used as part of a solution.

Cat.	Can be used in higher category systems.
PL	
DC	
Channels	1
DIN EN 574	IIIA
Safety component to MD 2006/42/EC	Yes

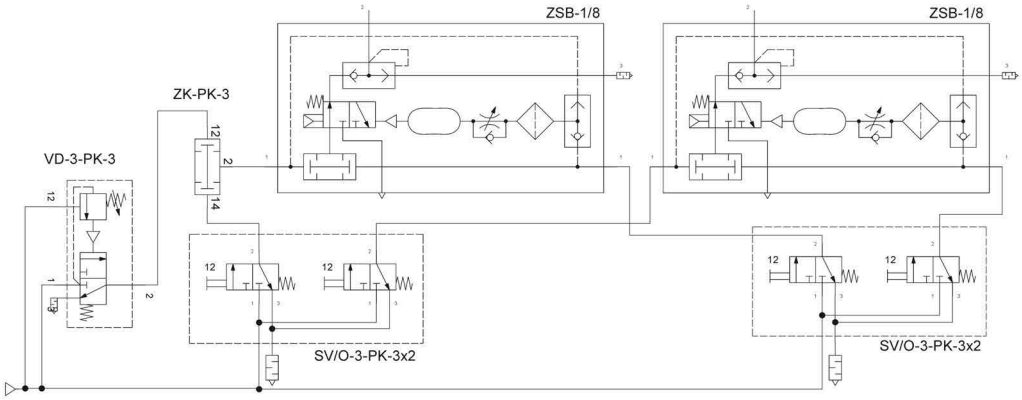
All specified values are maximum values, which can be achieved via correct operation and interconnection of the SRP/CS.



Part no.	Type
3527	ZSB-1/8

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Double two-hand control block



Double-channel
Always check that each channel in multi-channel solutions fulfils the safety function.

Diagnostics
Error detection is performed via internal diagnostics.

Cat.	3
PL	d
MTTF	High (assumption)
DC (internal)	Average
CCF	>65%
Channels	2
EN 574-1	IIIB
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation and interconnection of the SRP/CS.

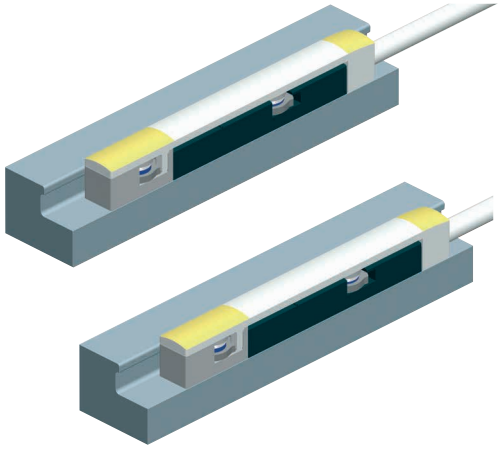
Part no.	Type
3527	ZSB-1/8
184135	SV/O-3-PK-3x2
9270	VD-3-PK-3
6680	ZK-1/8-B

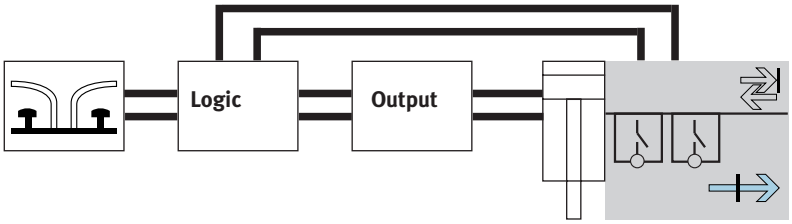
See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Safety function
Two-hand control – Reversing or stopping, holding, blocking a movement

Pneumatic Electrical

Reversing the safety function





Notes
The sensors permit reliable position sensing. It is then possible to switch between different safety functions.

Switches are mechanically connected, are protected against manipulation and securely mounted.

Sample application:
In two-hand operation, the cylinder advances to an uncritical position where the position of the hands no longer needs to be blocked. The two-hand switches can now be released.

Sensor function	
Cat.	3
PL	d
DC	Medium
CCF	>65%
Channels	2
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

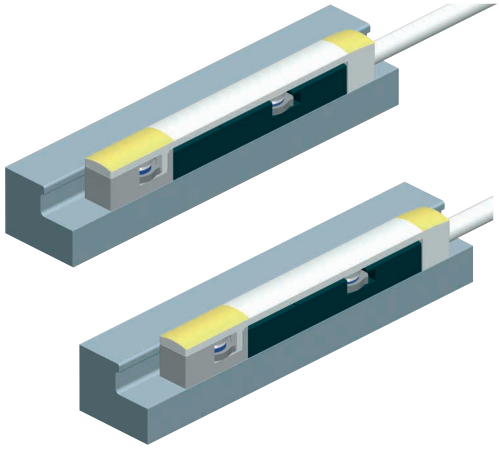
Part no.		Type
575815	SAMH-S-N8-S-MK	Mounting kit (complete)
575816	SAMH-S-N8-L-MK	Mounting kit (complete)
575817	SAMH-S-N8-S-SC	Cover (spare part)
575818	SAMH-S-N8-L-SC	Cover (spare part)

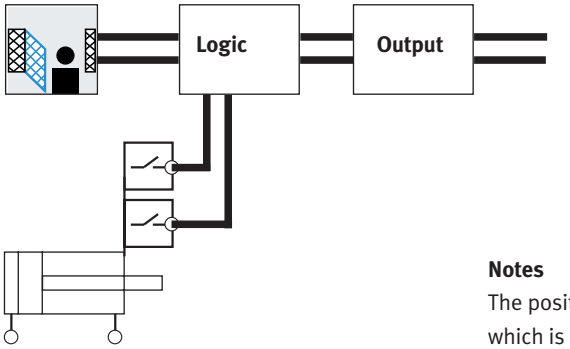
See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Safety function
Movable guard, holding, stopping, blocking a movement

Pneumatic Electrical

Cylinder as a door drive





Notes
The position of the guard door, which is pneumatically activated, can be reported reliably (SAMH-S) and directly via the drive. Additional sensing per EN 1088 is not necessary.

The guard door is opened by a cylinder.

If the door is open, the cylinder is not in the normal position. This is detected by the safe position encoders; the system remains at rest.

Switches are mechanically connected, are protected against manipulation and securely mounted.

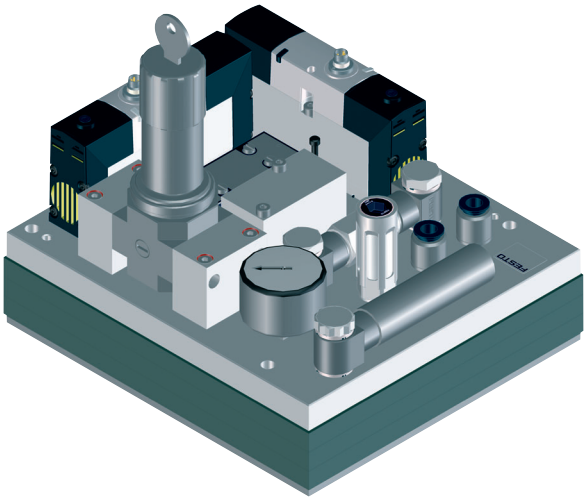
Sensor function	
Cat.	3
PL	d
DC	Medium
CCF	>65%
Channels	2
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Part no.		Type
575815	SAMH-S-N8-S-MK	Mounting kit (complete)
575816	SAMH-S-N8-L-MK	Mounting kit (complete)
575817	SAMH-S-N8-S-SC	Cover (spare part)
575818	SAMH-S-N8-L-SC	Cover (spare part)

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Reduce valve terminal pressure



Safety function
Protection against unexpected start-up (two-channel), with simultaneous actuation of both solenoid coils.

The time between the two actuating signals should not exceed 200 ms. This meets DIN EN 574 IIIB.

Cat.	3
PL	e
DC	Medium (integrated diagnostics)
CCF	>65%
Channels	2
DIN EN 574	IIIB
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

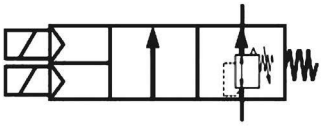
Technical data

Voltage
24 V DC

Pressure
3 ... 8 bar

Temperature range
0 ... +40°C

Flow rate ISO 1:
approx. 500 Nl/min



Part no.	Type	Flow rate
571887	ISO 1	500 l/min

Please observe the legal information on page 73.

Safety function
Reducing pressure and force

Dual-pressure regulator

Cat.	Can be used in higher category systems.
PL	
DC	
Channels	1
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation and interconnection of the SRP/CS.

Technical data

Regulator pressure P2
0.5 ... 7 bar

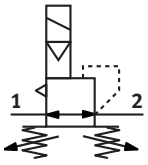
Supply pressure P1
1.5 ... 10 bar

Flow rate
up to 1300 l/min

Temperature range
-10 ... +60°C

Notes
The dual-pressure regulator is not a complete safety solution. It can be used as part of a solution.

Special features
Diaphragm pressure regulator with secondary venting for setting two different initial pressures in one device.
Switching from the lower to the higher value occurs electrically.



Part no.	Type
550588	LR-D-MINI-ZD-V24-SA
567841	LR-D-MINI-ZD-V24-UK-SA

Please observe the legal information on page 73.

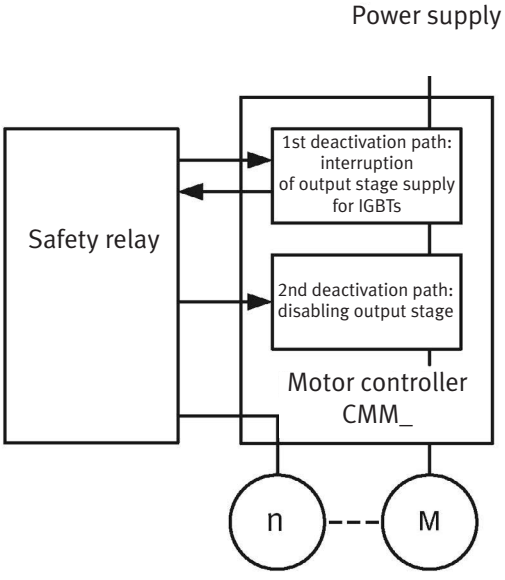
Safely limited speed

With external safety relay

	SLS
Cat.	1 or 2
PL	c
DC	Not relevant
CCF	Not relevant
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

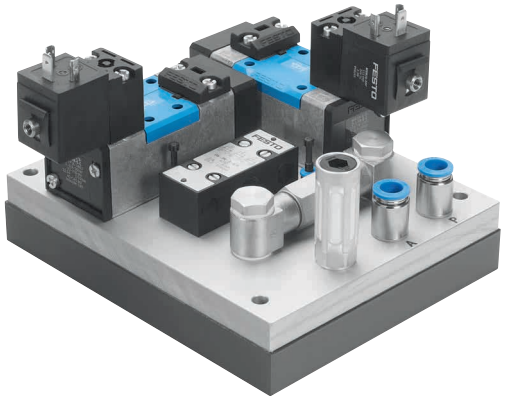
Part no.	Type
561406	CMMD-AS-C8-3A
550041	CMMP-AS-C2-3A
550042	CMMP-AS-C5-3A
551023	CMMP-AS-C5-11A-P3
551024	CMMP-AS-C10-11A-P3
1366842	CMMP-AS-C20-11A-P3
552741	CMMS-AS-C4-3A
547454	CMMS-ST-C8-7



See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Pneumatic Electrical

Valve block, exhausting



Safety functions
Safe exhausting (two-channel) when the coils are switched off.

The time between the two actuating signals should not exceed 200 ms. This meets DIN EN 574 IIIB.

Cat.	3
PL	e
DC	Medium (integrated diagnostics)
CCF	>65%
Channels	2
DIN EN 574	IIIB
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Part no.	Type
573619	ISO 1
572788	ISO 2

Technical data

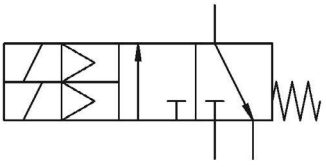
Voltage
24 V DC

Pressure
3 ... 8 bar

Temperature range
0 ... +40°C

Flow rate ISO 1:
approx. 500 Nl/min

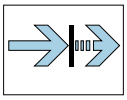
Flow rate for ISO 3:
approx. 1200 Nl/min



Please observe the legal information on page 73.

Safety function
Exhausting
Protection against unexpected start-up

Pneumatic Electrical



Safe pressure build-up

MS–6-SV-E

Cat.	4
PL	e
DC	**integrated** Internal sensing of the piston-position
Channels	2
Certificate	IFA
Safety component to MD 2006/42/EC	Yes

All specified values are maximum values, which can be achieved via correct operation of the component.

Part no.	Type
548713	MS6-SV
562580	MS6-SV-1/2-E-10V24-AD1
548715	MS6-SV-1/2-E-10V24-AG
548717	MS6-SV-1/2-E-10V24-SO-AG
552252	UOS-1
573695	Multi-pin plug NECA-S1G9-P9-MP3-SA
548719	Multi-pin plug NECA-S1G9-P9-MP1
552703	Multi-pin plug NECA-S1G9-P9-MP3

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Technical data

Voltage
24 V DV

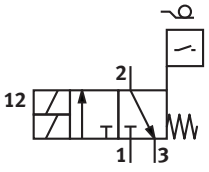
Operating pressure
3.5 ... 10 bar

Temperature range
-10 ... +50°C

Flow rate (exhausting)
Up to 9000 l/min

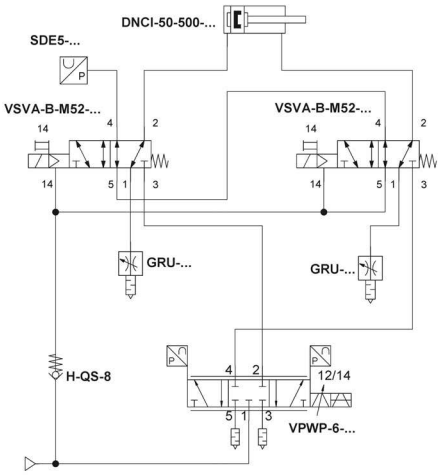
Special features
Electrical interface Sub-D 9-pin

Possible special plug NECA-MP3-SA
The NECA-MP3-SA permits actuation of the MS6-SV with signals, whereby the enable signals EN1 and EN2 are galvanically isolated from the supply of the MS6-SV. Galvanic isolation is guaranteed via 2 optocouplers.



Safety function for servopneumatics

Switching off power



Cat.	3
PL	d
DC	Medium
CCF	>65%
Channels	2
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Features

- Protection against unexpected start-up (2-channel)
- Safety measure: pressure release (1-channel)
- Safety measure: stop (1-channel)
- Stop category: “0” (EN 60204-1)
- Pressure supply not deactivated

Notes

- This set-up is only recommended for horizontal axes.
- The axis can still move after an emergency stop. The overtravel depends on the current speed and the moving mass.
- On reactivation, the drive can move, depending on the activation conditions.
- Use of a braking/clamping unit, together with the servopneumatic controller, can prevent a movement on restart.

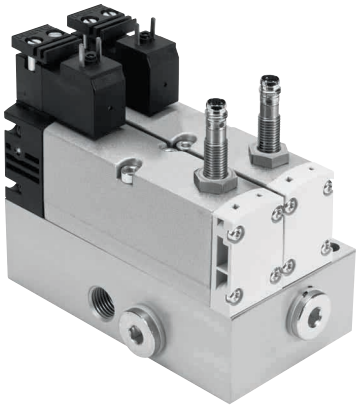
Part no.	Designation	Description
550 171	VPWP-6-L-5-...	Proportional valve, component of the servopneumatic system as a first channel
534 546 161 109	VSVA-B-M52-MZH-A1-1R5L NAS-1/4-01-VDMA	5/2 single solenoid switching valve, with spring return and external auxiliary pilot air as a 2nd channel. The size (flow rate) is based on the proportional valve.
535 413	DNCI-50-500-P-A	Standard cylinder with displacement encoder
542 897	SDE5-D10-FP-Q6E-P-M8	Pressure switch for diagnostics of the emergency stop valves (VSVA)
9 517	GRU-1/4-B	Flow control/silencer for defined exhausting of the cylinder
153 464	H-QS-8	Non-return valve

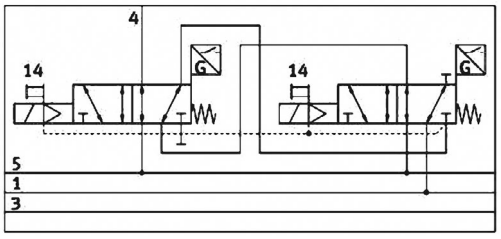
See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Safety function
Exhausting
Protection against unexpected start-up

Pneumatic Electrical

VOFA-3/2 Safety valves for presses





Diagnostics
Diagnostics via evaluation of the actuation and feedback signal must be carried out via software

Fault exclusion
Fault exclusion for valves that are jammed or haven't switched.

Cat.	4
PL	e
DC	Switching position sensing with inductive PNP/NPN proximity sensor
CCF	>65%
Channels	2
Certificate	IFA (applied for)
Safety component to MD 2006/42/EC	Yes

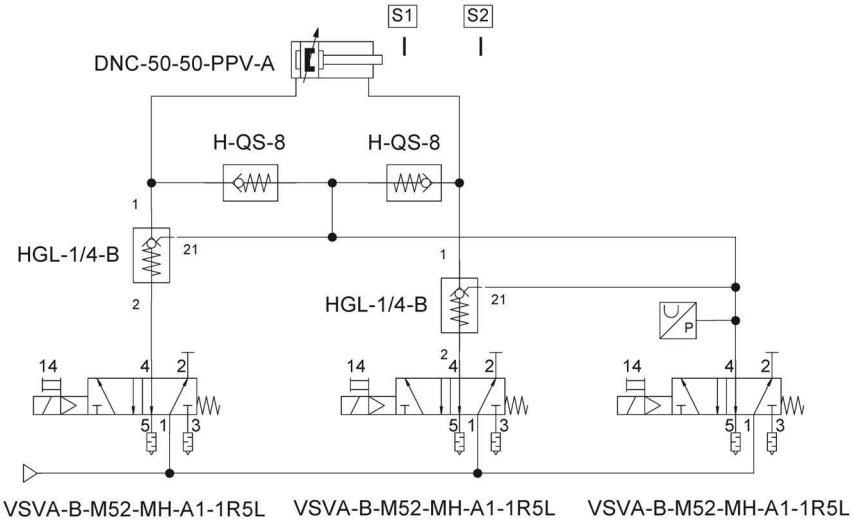
All specified values are maximum values, which can be achieved via correct operation of the component.

Part no.	Type	Version
574011	VOFA-L26-T32C-M-G14-1C1-APP	Complete 2 x 3/2 control block, individual electrical connection, PNP sensor
574012	VOFA-L26-T32C-M-G14-1C1-ANP	Complete 2 x 3/2 control block, individual electrical connection, NPN sensor

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

BG-PRÜFZERT (applied for)

Exhausting via non-return valves



Cat.	3
PL	d
DC	Medium
CCF	>65%
Channels	2
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Part no.	Type	
534556	VSVA-B-M52-MH-A1-1R5L	5/2-way valve
153464	H-QS-8	
530031	HGL-1/4-B	Non-return valve
163371	DNC-50-50-PPV-A	Cylinder
		Pressure switches
		Application-specific proximity sensors

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

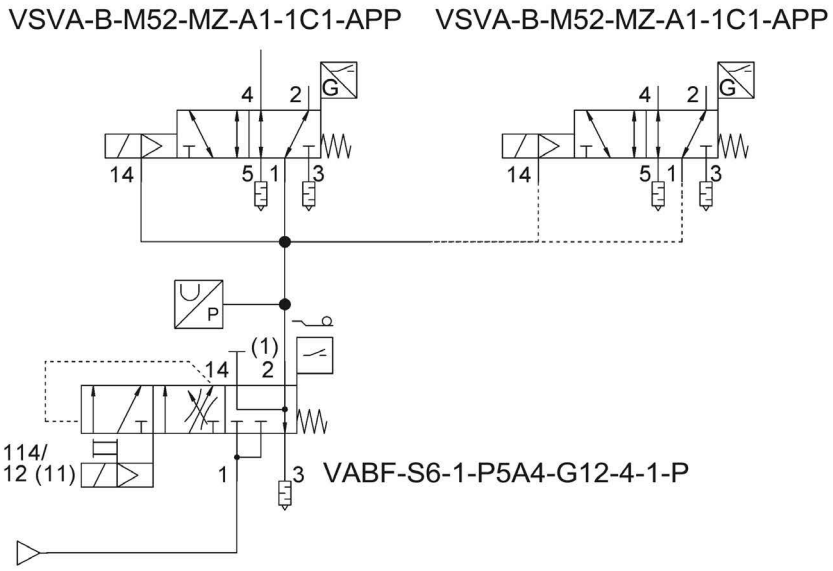
Double-channel
Always check that each channel in multi-channel solutions fulfils the safety function.

Diagnostics
Diagnostics for both channels must be carried out via software.

Special features
The non-return valves also need a differential pressure in order to exhaust. In the event of a fault, a residual pressure of approx. 0.5 bar cannot exhaust.

Safety function
With this set-up, both cylinder chambers are exhausted via 2 channels.

Soft-start and exhaust valve VTSA



	Safety function refers to connection 4 of the VSVA valve!	exhausting
Cat.	3	System protection for a restart
PL	d	
DC	Switching position sensing	
CCF	>65%	
Channels	2	
Safety component Per MD 2006/42/EC	No	

All specified values are maximum values, which can be achieved via correct operation of the component.

Part no.	Type
557377	VABF-S6-1-P5A4-G12-4-1-P
560726	VSVA-B-M52-MH-A1-1C1-APP

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Double-channel
Always check that each channel in multi-channel solutions fulfils the safety function.

Safety function
In conjunction with safe electrical disconnection and a pressure switch for diagnosing the exhausted status, “Exhausting in PL d Cat 3” can be achieved for connection 4.

The pneumatic diagram shown is only a basic example. The soft-start valve function and further valve functions can be configured in the valve terminal VTSA. The pressure switch must be screwed on separately. The calculations of the PL must be adjusted for this. The soft-start valve alone is not a complete safety solution.

Protection against accidental activation of the manual override must be guaranteed in all modes.

Diagnostics
Diagnostics for both channels must be carried out via software.

Safety function
Exhausting

On-off valve with piston position sensing

Cat.	Can be used in higher category systems.
PL	
DC	Switching position sensing
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via suitable integration of the component into the entire system.

Part no.	Type
533537	HEE-D-MIDI-...-SA207225
548535	HEE-D-MAXI-...-SA217173

Technical data

Voltage
24 V DC

Operating pressure
2.5 ... 16 bar

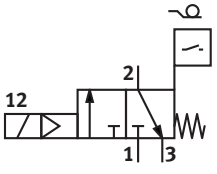
Temperature range
-10 ... +60°C

Notes
The on-off valve with piston position sensing is not a complete safety solution. It can be used as part of a solution.

Special features
With solenoid coil, without socket, 3 voltage ranges can be selected, position sensing

Standard sensors with reed contacts can be used for a T-slot: Type SME-8M, SMT-8M, SME-8, SMT-8

Switching output contactless or via reed contacts



Please observe the legal information on page 73.

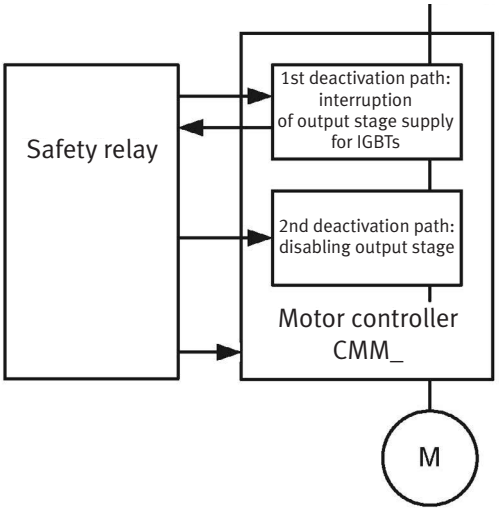
Safe stop 1

Notes
With an external safety relay, 2-channel safety requirement and monitoring of a deactivation path.

	SS1 STO
Cat.	3
Medium ()	e
DC	Medium
CCF	>65%
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via suitable integration of the component into the entire system.

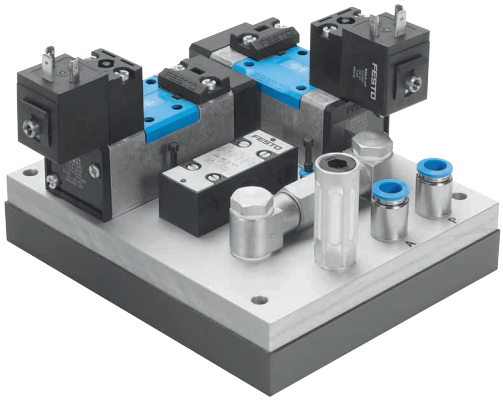
Power supply



Part no.	Type
561406	CMMD-AS-C8-3A
550041	CMMP-AS-C2-3A
550042	CMMP-AS-C5-3A
551023	CMMP-AS-C5-11A-P3
551024	CMMP-AS-C10-11A-P3
1366842	CMMP-AS-C20-11A-P3
552741	CMMS-AS-C4-3A
547454	CMMS-ST-C8-7

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Valve block, reversing



Safety functions
The time between the two actuating signals should not exceed 200 ms. This meets DIN EN 574 IIIB.

Cat.	3
PL	e
DC	Medium
Error diagnostics	Integrated
Channels	2
EN 574-1	IIIB
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Part no.	Type
570336	ISO 1
572244	ISO 2

Technical data

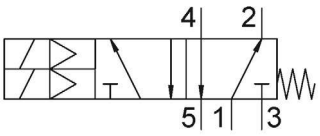
Voltage
24 V DV

Operating pressure
3 ... 8 bar

Temperature range
0 ... +40°C

Flow rate ISO 1
500 Nl/min

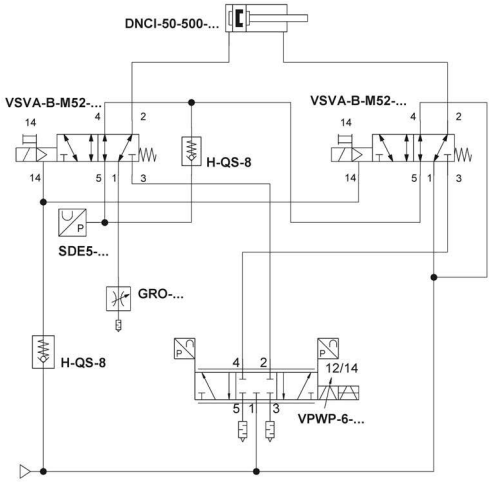
Flow rate for ISO 2
1100 Nl/min



Please observe the legal information on page 73.

Safety function for servopneumatics

Pneumatic reversing



Cat.	3
PL	d
DC	Medium
CCF	>65%
Channels	2
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Features

- Protection against unexpected start-up (2-channel)
- Safety measure: reversing (1-channel)
- Safety measure: travel at reduced speed (1-channel)
- Pressure supply not deactivated

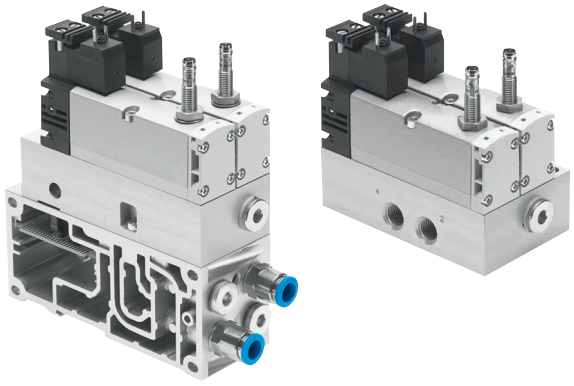
Notes

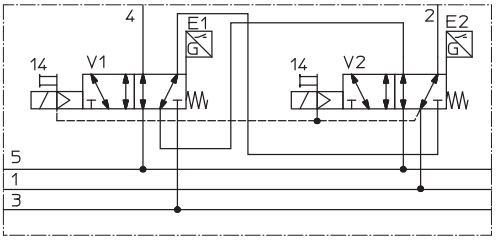
- Can also be used for vertical axes
- If an emergency stop is activated, the drive is pressurised.
- On reactivation, the drive can move, depending on the activation conditions.
- Use of a braking/clamping unit, together with the servopneumatic controller, can prevent a movement on restart.

Part no.	Designation	Description
550 171	VPWP-6-L-5-...	Proportional valve, component of the servopneumatic system as a first channel
534 546 161 109	VSVA-B-M52-MZH-A1-1R5L NAS-1/4-01-VDMA	5/2 single solenoid switching valve, with spring return and auxiliary pilot air as a 2nd channel. The size (flow rate) is based on the proportional valve.
535 413	DNCI-50-500-P-A	Standard cylinder
542 897	SDE5-D10-FP-Q6E-P-M8	Pressure switch for diagnostics of the emergency stop valves (VSVA)
193 973	GR0-QS-6	Flow control valve for regulating the repositioner speed
11 689	H-QS-8	Non-return valve

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

VOFA – 5/2 Safety valves for presses





Diagnostics
Diagnostics via evaluation of the actuation and feedback signal must be carried out via software

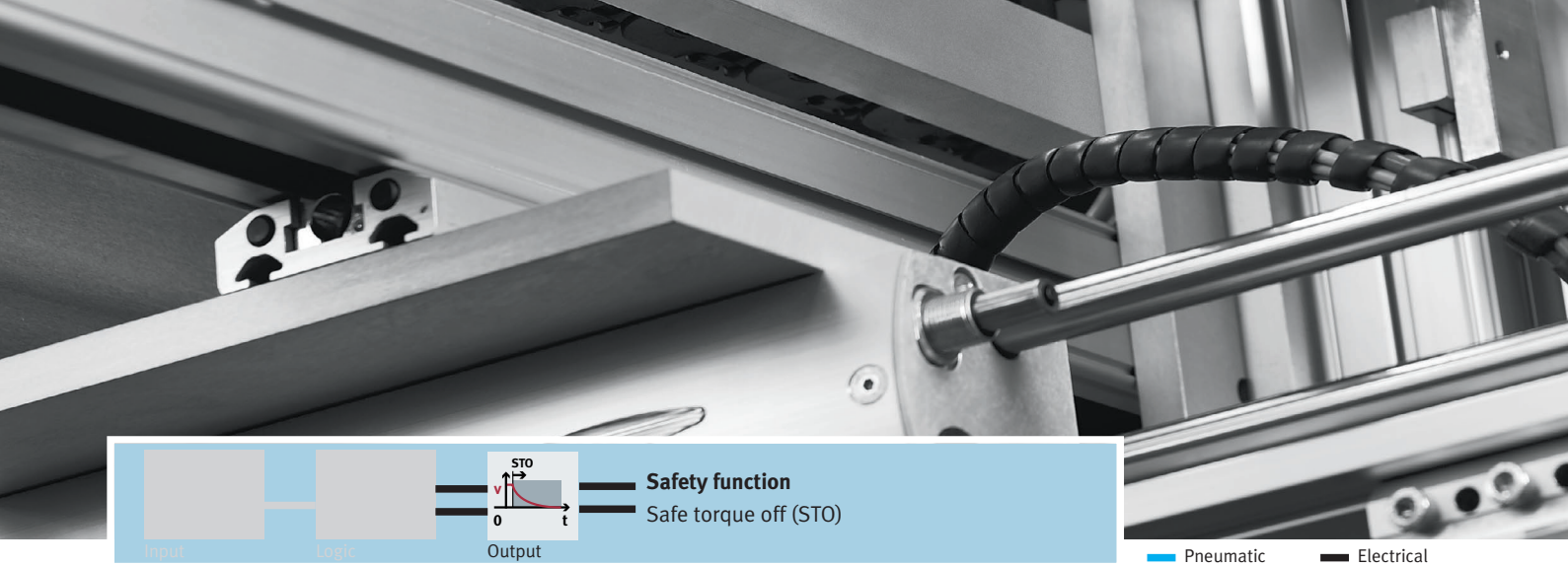
Fault exclusion
Fault exclusion for valves that are jammed or haven't switched.

Cat.	4
PL	e
DC	Switching position sensing with inductive PNP/NPN proximity sensor
CCF	>65%
Channels	2
Certificate	IFA
Safety component to MD 2006/42/EC	Yes

All specified values are maximum values, which can be achieved via suitable integration of the component into the entire system.

Part no.	Type	Version
569819	VOFA-L26-T52-M-G14-1C1-APP	Complete 2 x 5/2 control block, individual electrical connection, PNP sensor
569820	VOFA-L26-T52-M-G14-1C1-ANP	Complete 2 x 5/2 control block, individual electrical connection, NPN sensor
Property	"SP" in order code	Complete 2 x 5/2 control block, integration in valve terminal VTSA, PNP sensor
Property	"SN" in order code	Complete 2 x 5/2 control block, integration in valve terminal VTSA, NPN sensor

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

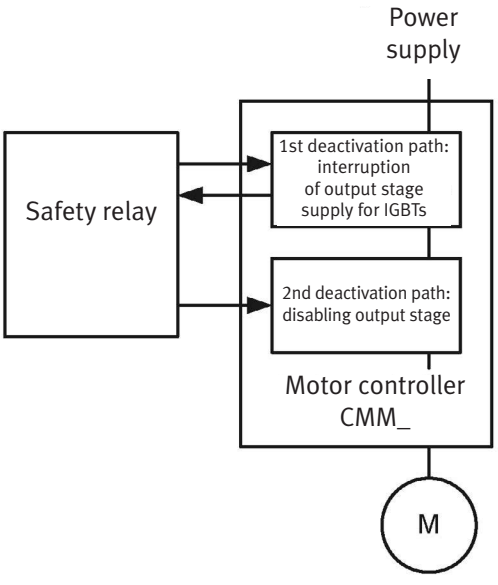


Safe torque off (STO)

Notes
With an external safety relay, 2-channel safety requirement and monitoring of a deactivation path.

	STO
Cat.	3
PL	e
DC	Medium
CCF	>65%
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via suitable integration of the component into the entire system.



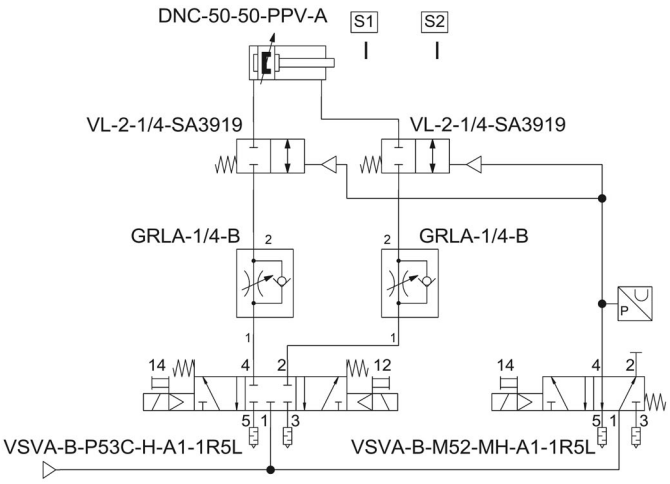
Part no.	Type
561406	CMMD-AS-C8-3A
550041	CMMP-AS-C2-3A
550042	CMMP-AS-C5-3A
551023	CMMP-AS-C5-11A-P3
551024	CMMP-AS-C10-11A-P3
1366842	CMMP-AS-C20-11A-P3
552741	CMMS-AS-C4-3A
547454	CMMS-ST-C8-7

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Safety function
Stopping, holding, blocking a movement **with power,** protection against unexpected start-up

Pneumatic Electrical

Stopping with shut-off valves



Cat.	3
PL	d
DC	Medium
CCF	>65%
Channels	2
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Notes

Always check that each channel in multi-channel solutions fulfils the safety function sufficiently.

The diagnostic evaluation must be performed by the software.

The cylinder is stopped via compressed air. Therefore, the system contains energy stored as compressed air. Additional measures must be taken to be able to exhaust the cylinder chambers if necessary.

If trapped compressed air can result in a danger, further measures are required.

When the safe status is set, there are no additional air inflows or outflows.

After the cylinder stops, it can move depending on the leakage of the individual components. This can result in exhausting the cylinder chambers. Please also note this for the restart.

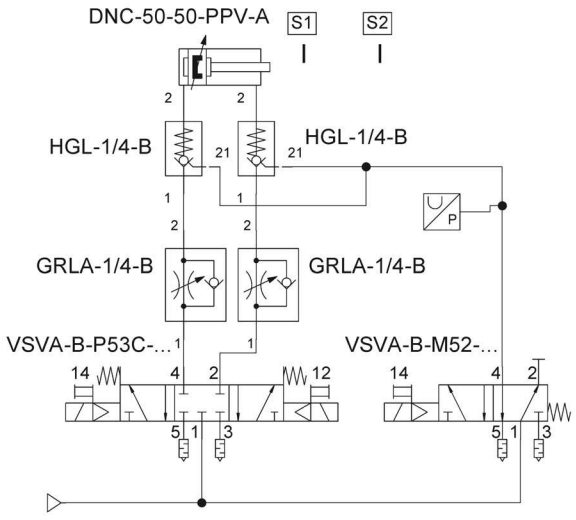
Part no.	Type	
534559	VSVA-B-P53C-H-A1-1R5L	5/3-way valve
534556	VSVA-B-M52-MH-A1-1R5L	5/2-way valve
25025	VL-2-1/4-SA	Stop valve
151172	GRLA-1/4-B	Flow control valve
163371	DNC-50-50-PPV-A	Cylinder
		Pressure switches
		Application-specific proximity sensors

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Safety function
Stopping, holding, blocking a movement **with power,** protection against unexpected start-up

Pneumatic Electrical

Stopping with non-return valves



Cat.	3
PL	d
DC	Medium
CCF	>65%
Channels	2
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Part no.	Type	
534559	VSVA-B-P53C-H-A1-1R5L	5/3-way valve
534556	VSVA-B-M52-MH-A1-1R5L	5/2-way valve
530031	HGL-1/4-B	Non-return valve
151172	GRLA-1/4-B	Flow control valve
163371	DNC-50-50-PPV-A	Cylinder
		Pressure switches
		Application-specific proximity sensors

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Notes
Always check that each channel in multi-channel solutions fulfils the safety function.

The diagnostic evaluation must be performed by the software.

The cylinder is stopped via compressed air. Therefore, the system contains energy stored as compressed air. Additional measures must be taken to be able to exhaust the cylinder chambers.

If trapped compressed air can result in a danger, further measures are required.

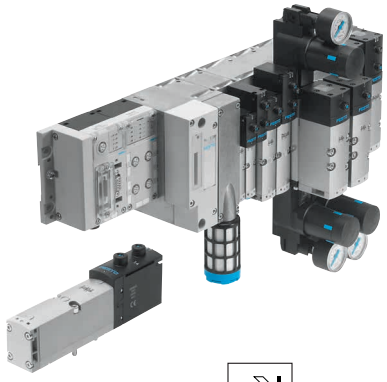
Please note that the technical values of the components are complied with during braking via dynamic energy (e.g. via resulting pressure peaks).

In the event of a fault of the 5/3-WV, compressed air can flow through the non-return valve HGL until the forces are balanced. That can lead to an increased overtravel time of the cylinder.

After the cylinder stops, it can move depending on the leakage of the individual components. This can result in exhausting the cylinder chambers. Please also note this for the restart.

Safety function
Stopping, holding, blocking a movement (mechanical)

ISO valve for lifting and rotary cylinders



Cat.	2
PL	d
DC	Low
CCF	>65%
Channels	1
Safety component to MD 2006/42/EC	No

Technical data

Voltage
24 V DC

Pressure
3 ... 10 bar

Temperature range
-5 ... +50°C

Flow rate
1000 l/min

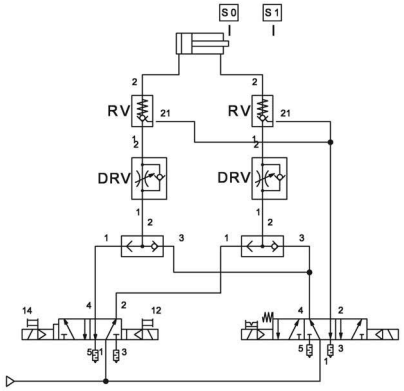
All specified values are maximum values, which can be achieved via correct operation of the component.

Description

- For lifting and rotary cylinders in the automotive industry

Application

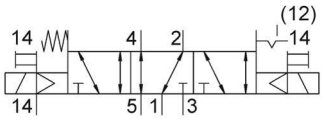
- Self-locking loop and subsequent pressure supply in both end positions
- During the stroke, the cylinder must be kept under pressure in the event of an emergency (e.g. if a safety shut-off mat is stepped on)



Order code

Part no.	Type	
560728	VSVA-B-P53AD-ZD-A1-1T1L	Size 01, 5/3 mid-position, 1 port pressurised and 1 port exhausted, switching position 14 detented

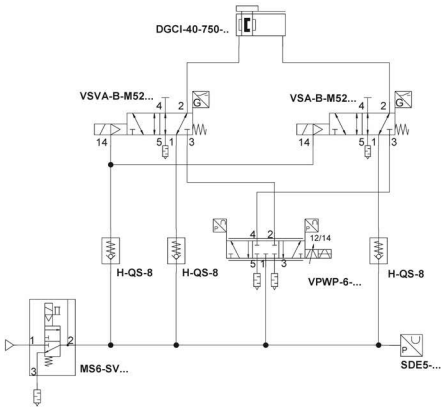
Function



Function	Normal operation	In the case of emergency off (electrical power is switched off)	Control
Retract clamping device	The 5/2-WV is used to retract the clamping device	The clamping device remains under pressure in both chambers. 5/3-WV normal position (14) 5/2-WV 12 connected	5/3-WV 12 switched (no automatic locking) 5/2-WV 12 connected
Advance clamping device	The clamping device is advanced via the 5/2 WV	The clamping device remains under pressure in both chambers. 5/3-WV 14 normal position 5/2-WV 14 switched	5/3-WV 12 switched (no automatic locking) 5/2-WV 14 switched
Spanner in end positions	The end positions remain pressurised	The pressure is maintained in the end positions 5/3-WV 12 automatic locking 5/2-WV 14 or 12 switched	5/3-WV is switched to 12 (automatic locking) 5/2-WV switched to 14 or 12

Safety function for servopneumatics

Pneumatic stopping



Cat.	3
PL	d
DC	High
CCF	>65%
Channels	2
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Features

- Protection against unexpected start-up (2-channel)
- Safety measure: stopping a movement (2-channel)
- Stop category: “1”
- The compressed air supply is switched off (2-channel)

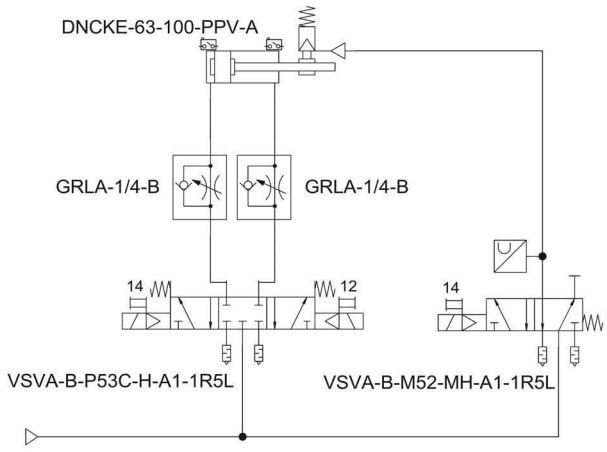
Element	Part no.	Designation	Description
V1	550 171	VPWP-6-L-5-...	Proportional valve, component of the servopneumatic system as a first channel
V2, V3	534 546 161 109	VSVA-B-M52-MZH-A1-1R5L NAS-1/4-01-VDMA	5/2 single solenoid switching valve with spring return and auxiliary pilot air and switching position sensing as a second channel. The size (flow rate) is based on the proportional valve.
V5	548 713	MS6-SV-1/2-E-10V24-SO	Soft-start/quick exhaust valve with 2-channel self monitoring and performance level e.
A3	544 428	DGCI-40-750-P-A	Rodless linear drive with displacement encoder
S1	542 897	SDE5-D10-FP-Q6E-P-M8	Pressure switch for monitoring the restarting pressure
	11 689	H-QS-8	Non-return valves

Notes

- This set-up can be used for horizontal and vertical axes.
- When the emergency stop is activated, the compressed air remains trapped in the drive; the drive is not free of compressed air.
- It is characteristic of pneumatic systems that the trapped compressed air in the cylinder does not lead directly to a standstill of the axis. The overtravel depends on the current speed and the moving mass.
- On restart, the drive can move, depending on the start conditions. If the valves VSVA are switched on with a delay depending on SDE5, this movement can be minimised.
- Use of a braking/clamping unit, together with the servopneumatic controller, can prevent a movement on restart.

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Mechanical and pneumatic stopping



Cat.	3
PL	d
DC	Medium
CCF	>65%
Channels	2
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Notes

Always check that each channel in multi-channel solutions fulfils the safety function.

The diagnostic evaluation must be performed by the software.

After the cylinder stops, it can vent depending on the leakage of the individual components. Please also note this for the restart.

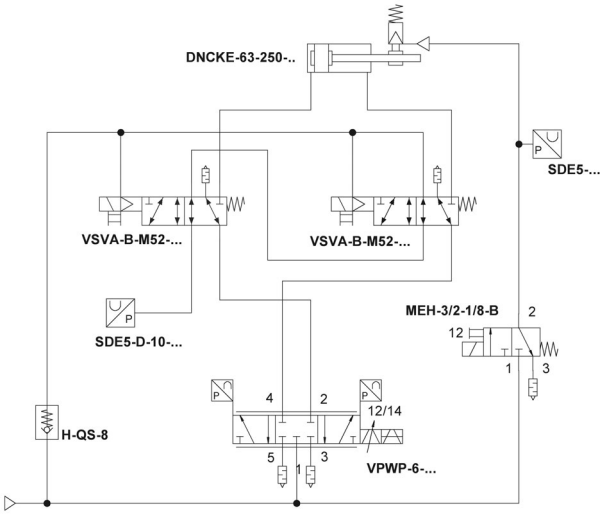
Part no.	Type
534559	VSVA-B-P53C-H-A1-1R5L
534556	VSVA-B-M52-MH-A1-1R5L
	Pressure switches
151172	GRLA-1/4-B
526483	DNCKE-63-100-PPV-A

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Pneumatic Electrical

Safety function for servopneumatics

Mechanical and pneumatic stopping



Cat.	3
PL	e
DC	Medium
CCF	>65%
Channels	3
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Features

- Protection against unexpected start-up (2-channel)
- Safety measure: stopping (2-channel)
- Safety measure: blocking (1-channel)
- Stop category: “1”
- Pressure supply not deactivated

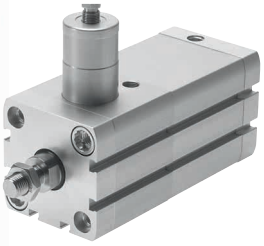
Notes

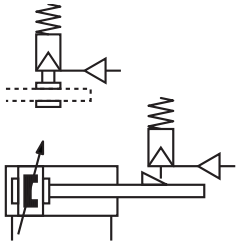
- Recommended for vertical axes
- When the emergency stop is activated, the compressed air remains trapped in the drive; the drive is not free of compressed air.
- The braking unit, together with the servopneumatic controller, can prevent a movement on restart.
- If only one clamping unit/cartridge is used, the axis must be at a standstill before it is clamped. This standstill can be generated via a STOP signal with the servopneumatic controller. The emergency stop valves VSVA are then deactivated with a time delay.

Part no.	Designation	Description
550 171	VPWP-6-L-5-...	Proportional valve, component of the servopneumatic system as a first channel
534 546 161 109	VSVA-B-M52-MZH-A1-1R5L NAS-1/4-01-VDMA	5/2 single solenoid switching valve, with spring return and auxiliary pilot air as a 2nd channel. The size (flow rate) is based on the proportional valve.
173 124	MEH-3/2-1/8-B	3/2 single solenoid switching valve with spring return
526 483	DNCKE-63-250-PPV-A	Standard cylinder with clamping unit, displacement encoder attached externally
542 897	SDE5-D10-FP-Q6E-P-M8	Pressure switch for monitoring the emergency stop valves VSVA and the clamping function
11 689	H-QS-8	Non-return valves

Safety function
Stopping, holding, blocking a movement (mechanically)

Clamping units





Cat.	Can be used in higher category systems.
PL	
DC	
CCF	
Channels	1
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Notes

The clamping cartridge is not a complete safety solution. It can be used as part of a solution.

The piston rod can be held or clamped in any position.

The piston rod can also be held for extended periods, alternating loads, fluctuations or leakage.

Part no.	Type
178455	KP-10-350
178456	KP-12-600
178457	KP-16-1000
178458	KP-20-1400
178459	KP-20-2000

Part no.	Type
178460	KP-25-5000
178461	KP-32-7500
178452	KP-4-80
178453	KP-6-180
178454	KP-8-350

Part no.	Type
178465	KPE-10
178466	KPE-12
178467	KPE-16
178468	KPE-20
178469	KPE-25

Part no.	Type
178470	KPE-32
178462	KPE-4
178463	KPE-6
178464	KPE-8

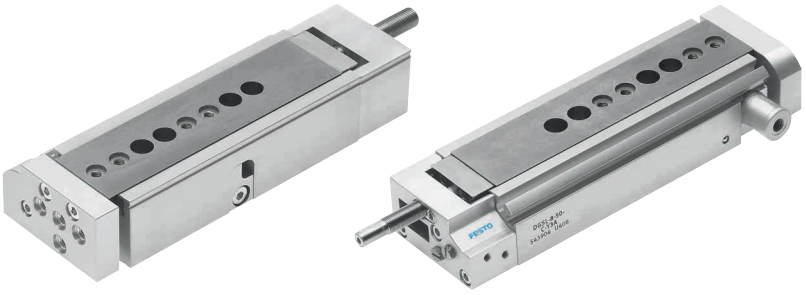
Part no.	DNC-KP	Emergency stop stroke
163302	Ø 32	10 ... 2000
163334	Ø 40	10 ... 2000
163366	Ø 50	10 ... 2000
163398	Ø 63	10 ... 2000
163430	Ø 80	10 ... 2000
163462	Ø 100	10 ... 2000
163494	Ø 125	10 ... 2000

Part no.	ADN-...-...-KP	Stroke	DNC-KP
548206	Ø 20	10-300	KP-10-350
548207	Ø 25	10-300	KP-10-350
548208	Ø 32	10-400	KP-12-1000
548209	Ø 40	10-400	KP-16-1400
548210	Ø 50	10-400	KP-20-1400
548211	Ø 63	10-400	KP-20-2000
548212	Ø 80	10-500	KP-25-5000
548213	Ø 100	10-500	KP-25-5000

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Safety function
Holding, blocking a movement (mechanical)

Mini-slide DGSL with clamping unit or end-position locking



Cat.	Can be used in higher category systems.
PL	
DC	
CCF	
Channels	1
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

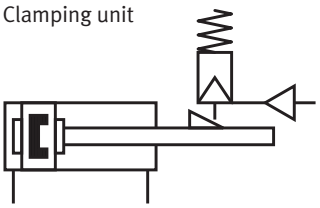
Notes
The clamping unit and the end-position locking are not complete safety solutions. They can be used as part of a solution.

Clamping unit
- For fixing the slide in any position
- Frictional locking
- Clamping via spring force, release via compressed air

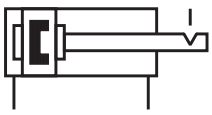
end-position locking
- Mechanical locking when the end position is reached
- Positive-locking
- Locking via spring force, release compressed air

Part no.	Type
543903	DGSL-6
543904	DGSL-8
543905	DGSL-10
543906	DGSL-12
543907	DGSL-16
543908	DGSL-20
543909	DGSL-25

Clamping unit



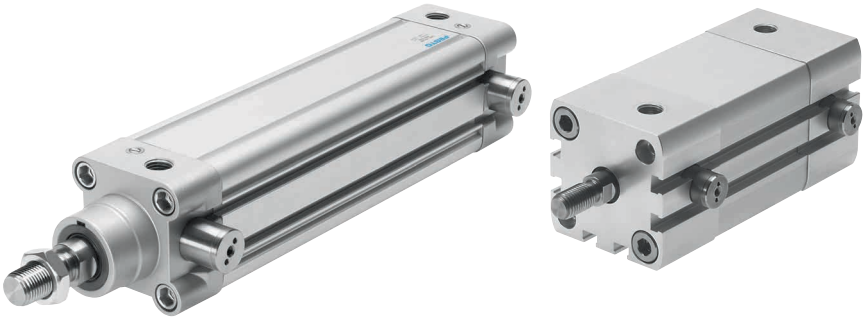
E3 end-position locking



See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Safety function
Blocking a movement (mechanical)

Cylinder with end-position locking



Cat.	Can be used in higher category systems.
PL	
DC	
CCF	
Channels	1
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Part no.	Type
163302	DNC-32-EL
163334	DNC-40-EL
163366	DNC-50-EL
163398	DNC-63-EL
163430	DNC-80-EL
163462	DNC-100-EL

Part no.	Type
548214	ADN-20-EL
548215	ADN-25-EL
548216	ADN-32-EL
548217	ADN-40-EL
548218	ADN-50-EL
548219	ADN-63-EL
548220	ADN-80-EL
548221	ADN-100-EL

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

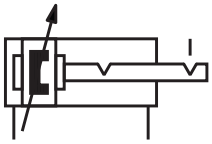
Notes
The mechanical lock is not a complete safety solution. It can be used as part of a solution.

Mechanical locking when the end position is reached.
The requirement for releasing is back pressure on the other side of the piston.

Positive-locking

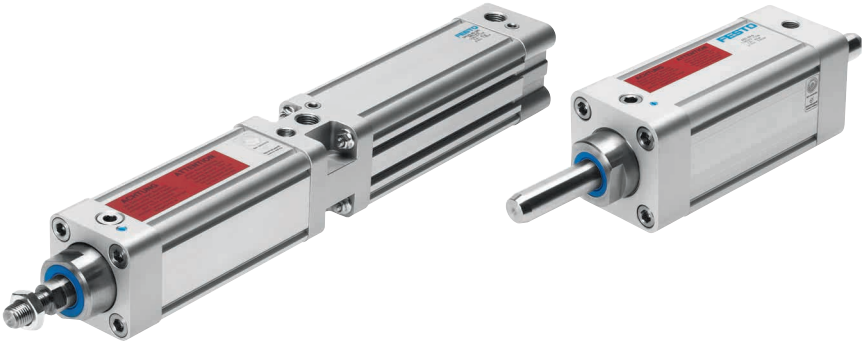
Locking is automatically released when pressure is applied to the cylinder

End-position locking at one or both ends



Safety function
Stopping, holding, blocking a movement (mechanical)

Brake unit DNCKE-S, KEC-S



Cat.	Can be used in higher category systems.
PL	
DC	
CCF	
Channels	1
Safety component to MD 2006/42/EC	Yes, if IFA certified

All specified values are maximum values, which can be achieved via correct operation of the component.

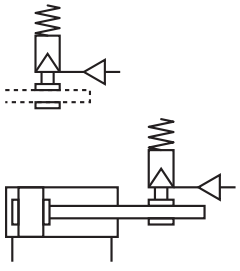
Part no.	Type	
526482	DNCKE-40- -PPV-A	
526483	DNCKE-63- -PPV-A	
526484	DNCKE-100- -PPV-A	
538239	DNCKE-40- -PPV-A-S	IFA-certified
538240	DNCKE-63- -PPV-A-S	IFA-certified
538241	DNCKE-100- -PPV-A-S	IFA-certified
527492	KEC-16	
527493	KEC-20	
527494	KEC-25	
538242	KEC-16-S	IFA-certified
538243	KEC-20-S	IFA-certified
538244	KEC-25-S	IFA-certified

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Notes
The clamping unit and the end-position locking are not complete safety solutions. They can be used as part of a solution.

As a holding device
- Holding and clamping in the event of a power failure
- Protection against pressure failure and pressure drop

As a braking device
- Braking or stopping movements
- Interruption of a movement if a danger area is entered



Safety function
Stopping, holding, blocking a movement

Stop valve VL-2-1/4-SA

Cat.	Can be used in higher category systems.
PL	
DC	
CCF	
Channels	1
Safety component to MD 2006/42/EC	No

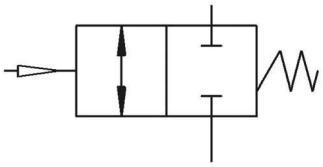
All specified values are maximum values, which can be achieved via correct operation of the component.

Technical data

Operating pressure
0 ... 10 bar

Temperature range
-20 ... 80°C

Notes
The stop valve is not a complete safety solution. It can be used as part of a solution.



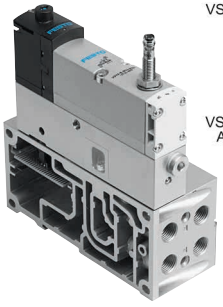
Part no.	Type
25025	VL-2-1/4-SA

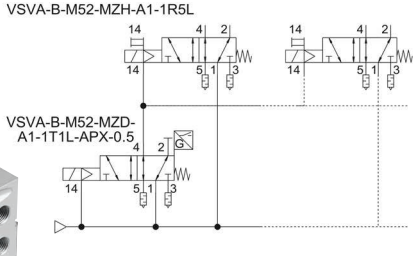
Please observe the legal information on page 73.

Safety function
Protection against unexpected start-up

Pneumatic Electrical

VTSA – pilot air switching valve





Cat.	3
PL	e
DC	Switching position sensing
CCF	> 65%
Channels	2
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Part no.	Type	
573201	VSVA-B-M52-MZD-A2-1T1L-APX-0.5	5/2-way valve, width 18 mm, single solenoid, mechanical spring return, with switching position sensing via inductive sensor with PNP output and 0.5 m cable with 4-pin sensor push-in connector M12x1
570850	VSVA-B-M52-MZD-A1-1T1L-APX-0.5	5/2-way valve, width 26 mm, single solenoid, mechanical spring return, with switching position sensing via inductive sensor with PNP output and 0.5 m cable with 4-pin sensor push-in connector M12x1
573200	VABF-S4-2-S	Vertical stacking manifold, width 18 mm, for connecting the pilot air from channel 1 to channel 14
570851	VABF-S4-1-S	Vertical stacking manifold, width 26 mm, for connecting the pilot air from channel 1 to channel 14
8000033	SPBA-P2R-G18-W-M12-0.25X	Mechanical pressure switch with a fixed switching point 0.25 bar Sensing the pilot air in channel 14 G1/8 threads, for screwing in VABF-S4-2-S or VABF-S4-1-S Sensor plug connector M12x1
8000210	SPBA-P2R-G18-2P-M12-0.25X	Electronic pressure switch with a fixed switching point 0.25 bar Sensing the pilot air in channel 14 G1/8 threads, for screwing in VABF-S4-2-S or VABF-S4-1-S Sensor plug connector M12x1

Notes

Always check that each channel in multi-channel solutions fulfils the safety function.

The diagnostic evaluation must be performed by the software.

The pneumatic diagram shown is only a basic example. The “connectable pilot air” function and further valve functions can be configured in the valve terminal VTSA. The calculations of the PL must then be adjusted.

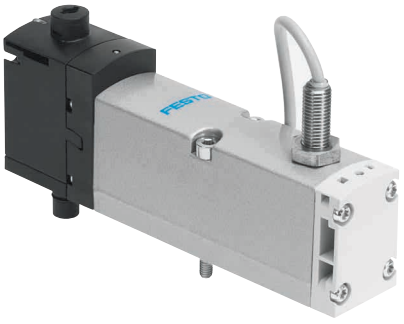
The pilot air switching valve alone is not a complete safety solution. It can be used as part of a solution.

Electrically reliable 2-channel deactivation must be guaranteed.

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Safety function
Protection against unexpected start-up

Valves with switching position sensing

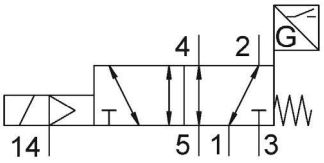


Cat.	
PL	
DC	Switching position sensing with inductive PNP/NPN proximity sensor
CCF	
Channels	1
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Description
- Solenoid valves to ISO 15407-1, plug type C, for individual electrical connection
- Solenoid valve to ISO 15407-2, for use with valve terminal VTSA
- Valve function: 5/2-way valve
- ISO size 1, other sizes on request
- Width: 26 mm
- Normal position of the piston spool is monitored by a proximity sensor
- For control architectures in higher categories
- Proximity sensor with M8 connection

Notes
The switching position sensing allows higher diagnostic coverage to be achieved for the valves.



Part no.		Type
560723	VSVA-B-M52-MZD-A1-1T1L-APC	Size 01, 5/2 single solenoid, return via mech. spring, plug-in valve, with PNP sensor and cable
560724	VSVA-B-M52-MZD-A1-1T1L-APP	Size 01, 5/2 single solenoid, return via mech. spring, plug-in valve, with PNP sensor and plug M8
560725	VSVA-B-M52-MZH-A1-1C1L-APC	Size 01, 5/2 single solenoid, return via mech. spring, Cnomo valve, with PNP sensor and cable
560726	VSVA-B-M52-MZH-A1-1C1L-APP	Size 01, 5/2 single solenoid, return via mech. spring, Cnomo valve, with PNP sensor and plug M8
560742	VSVA-B-M52-MZD-A1-1T1L-APC	Size 01, 5/2 single solenoid, return via mech. spring, plug-in valve, with NPN sensor and cable
560743	VSVA-B-M52-MZD-A1-1T1L-ANP	Size 01, 5/2 single solenoid, return via mech. spring, plug-in valve, with NPN sensor and plug M8
560744	VSVA-B-M52-MZH-A1-1C1L-APC	Size 01, 5/2 single solenoid, return via mech. spring, Cnomo valve, with NPN sensor and cable
560745	VSVA-B-M52-MZH-A1-1C1L-ANP	Size 01, 5/2 single solenoid, return via mech. spring, Cnomo valve, with NPN sensor and cable

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Safety function
Tamper-proof

Tamper-proof flow control valve GRLA-...-SA

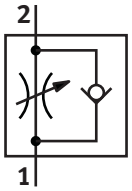
Cat.	Can be used in higher category systems.
PL	
DC	
CCF	
Channels	1
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Part no.	Type
539717	GRLA-M5-B-SA
539661	GRLA-1/8-B-SA
539662	GRLA-1/4-B-SA
539715	GRLA-3/8-B-SA
539716	GRLA-1/2-B-SA
539714	GRLA-3/4-B-SA

Notes
The flow control valve is not a complete safety solution. It can be used as part of a solution.

- Selection of a specified flow rate
- A spring pin protects against the unauthorised resetting of the volumetric flow rate.



See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Safety function
Tamper-proof
Protection against unauthorised pressurisation

Shut-off valve (European version)

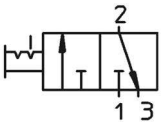
Cat.	Can be used in higher category systems.
PL	
DC	
CCF	
Channels	1
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

Notes
The shut-off valve is not a complete safety solution.
It can be used as part of a solution.

- Switching off and venting pneumatic systems
- Can be shut off up to 6 times
- Free of PWIS

The shut-off valve may not be used as an emergency stop valve



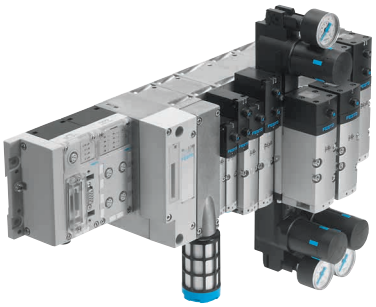
Part no.	Type
187026	HE-3/8-D-MIDI-NOT-SA
187027	HE-1/2-D-MIDI-NOT-SA
187028	HE-3/4-D-MIDI-NOT-SA
186688	HE-3/4-D-MAXI-SA
186689	HE-1-D-MAXI-SA

Part no.	Type
197136	HE-G1-LO
197135	HE-G3/4-LO
197134	HE-G1/2-LO
197133	HE-G3/8-LO
197132	HE-N1-LO-NPT
197131	HE-N3/4-LO-NPT
197130	HE-N1/2-LO-NPT
197129	HE-N3/8-LO-NPT

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Safety function (3 phases)
Switching off power, self-locking, pneumatic operation

ISO valve for pneumatic manual clamping devices



Technical data

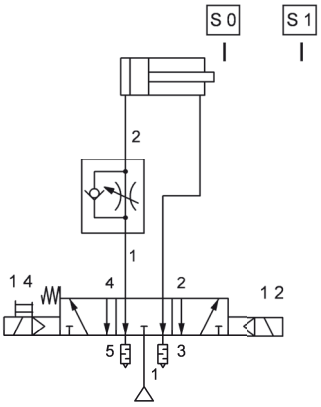
Voltage
24 V DC

Pressure
3 ... 10 bar

Temperature range
-5 ... +50°C

Flow rate
1000 l/min

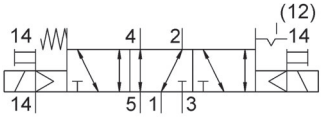
Description
Pneumatic manual clamping device for use in car body construction (inserting stations)



Cat.	2
PL	d
DC	Low
CCF	>65%
Channels	1
Safety component to MD 2006/42/EC	No

All specified values are maximum values, which can be achieved via correct operation of the component.

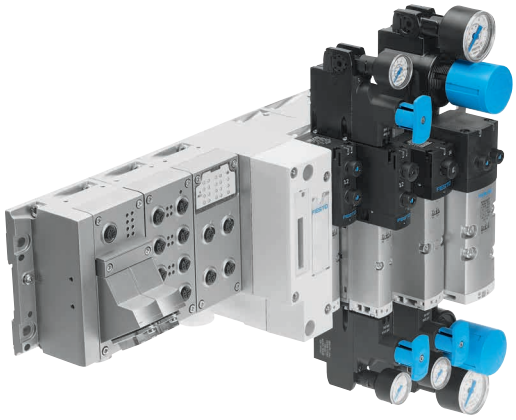
Function

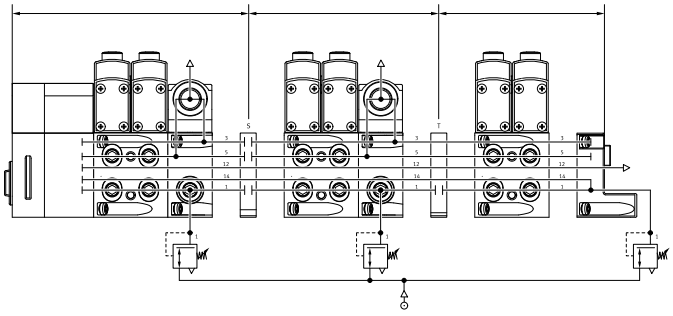


Part no.	Type	
560727	VSVA-B-P53ED-ZD-A1-1T1L	Size 01, 5/3 mid-position exhausted, switching position 14 detenting

Function	Normal operation	In the case of emergency off (electrical power is switched off)	Control
Clamping device is closed manually	The 5/2-WV is used to retract the clamping device	Unpressurised	Valve is in the mid-position
Clamping device is in the end position (metal sheet is clamped)	The clamping device is advanced via the 5/2 WV	Supporting force via air pressure (self-locking); valve remains in position 12	Coil 12 is switched
Clamping device opens automatically	Pneumatically operated	Valve returns to the mid-position	Coil 14 is switched

Pressure zones for valve terminal type 44 VTSA





The illustration shows an example of how three pressure zones are built up and connected with duct separation, with internal pilot air.

Creating pressure zones and separating exhaust air

- With the VTSA, pressure zones with different working pressures can be easily created
- A pressure zone can be created by separating the internal supply ducts between the series manifolds using appropriate duct separation
- Compressed air supply and exhaust via the supply plate
- Free positioning of the supply plates and separating seals in the VTSA
- Channel separations integrated ex works as per the order, differences can be indicated via the coding system for assembled valve terminals

VTSA with CPX terminal connection

- Up to 16 pressure zones possible with VTSA (if only size 1, ISO 5599-2, is used, up to 32 pressure zones are possible)

Further examples of pressure supply and pilot air via an end plate

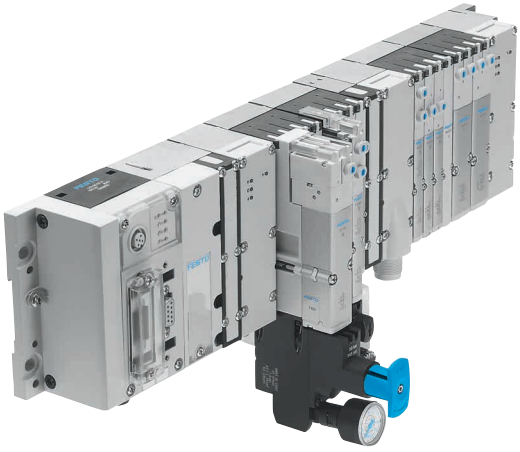
- Internal pilot air, ducted exhaust air/silencer
- External pilot air, silencer/ducted exhaust air

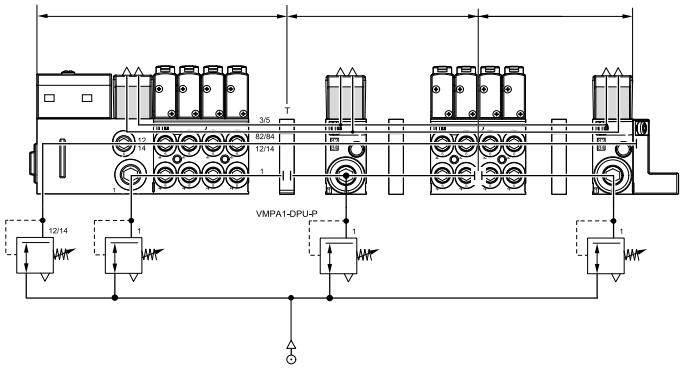
Reliable exhausting of valves or pressure zones

If used together with the MS6-SV valve, certain areas can be exhausted safely whilst the pressure is retained for specific valves or pressure zones.
This is a common requirement for protective circuits.

See the technical data of the individual products for detailed information.
Please observe the legal information on page 73.

Pressure zones for valve terminal type 32 MPA





The illustration shows an example of how three pressure zones are built up and connected with separating seals, with external pilot air supply.

Creating pressure zones and separating exhaust air

- With the MPA, pressure zones with different working pressures can be easily created.
- A pressure zone can be created by separating the internal supply ducts between the sub-bases, with a corresponding separating seal or via a separator integrated into the sub-base (code I)
- Compressed air supply and exhaust via the supply plate.
- Free positioning of the supply plates and separating seals in MPA with CPX and MPM (multiple connector plate)
- Separating seals integrated ex works as per the order, differences can be indicated via the coding system for assembling valve terminals

MPA with CPX terminal connection

Example of pressure zones

- Up to 8 pressure zones possible with MPA and CPX

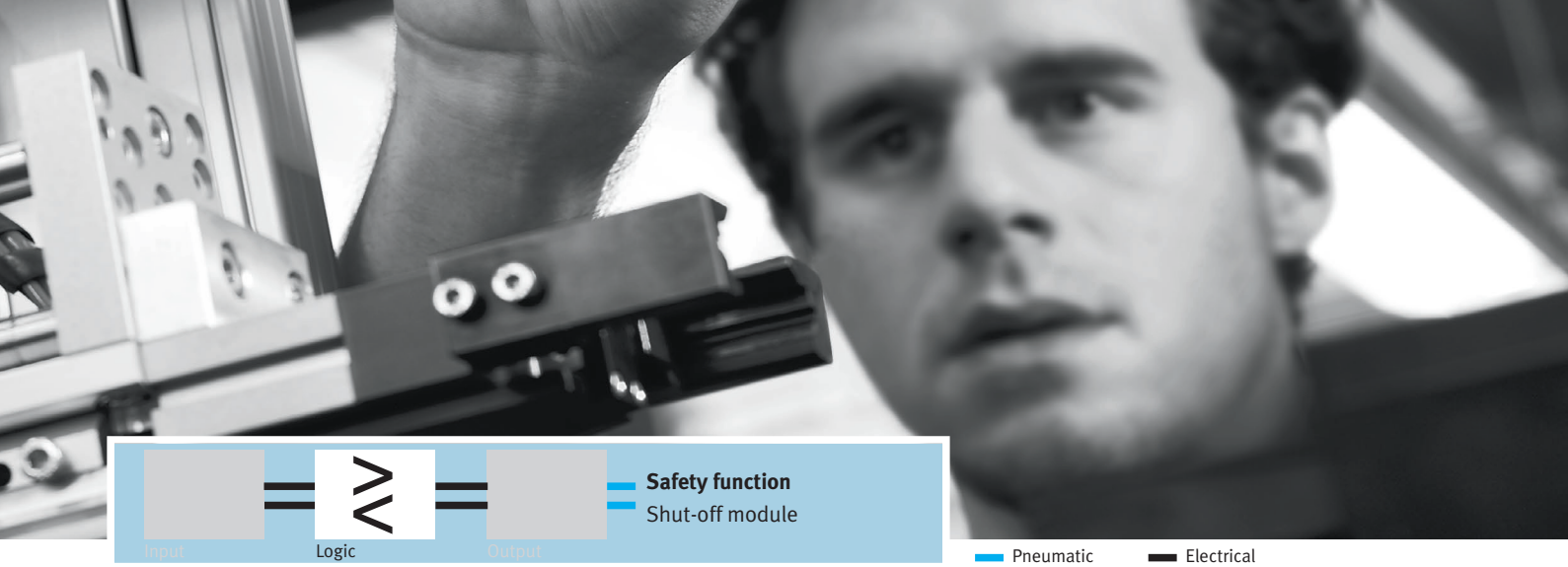
Further examples of compressed air supply and pilot air supply

- External pilot air supply, flat plate silencer
- Internal pilot air supply, ducted exhaust air
- External pilot air supply, ducted exhaust air

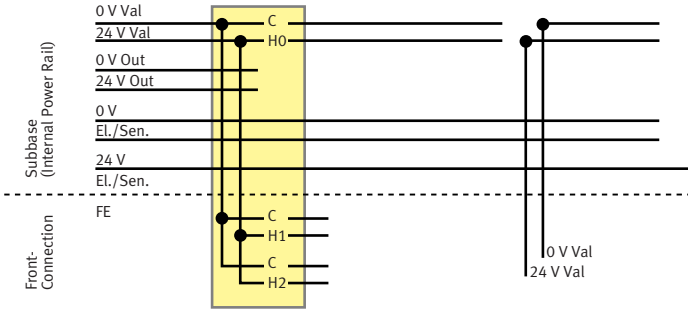
Reliable exhausting of valves or pressure zones

If used together with the MS6-SV valve, specific areas can be exhausted safely whilst the pressure is retained for specific valves or pressure zones. This is a common requirement for protective circuits.

Please observe the legal information on page 73.



CPX Profisafe



Cat.	3
PL	e
DC	99 %
CCF	>65%
Channels	2
Certified	TÜV
Safety component to MD 2006/42/EC	Yes

All specified values are maximum values, which can be achieved via correct operation of the component.

Part no.	Type
Select according to order code	CPX-FVDA-P

Notes

The CPX Profisafe module is a safety component.

All channels are self-monitoring for the safety function and for protection against short circuits.

Galvanic isolation of the voltage concepts.

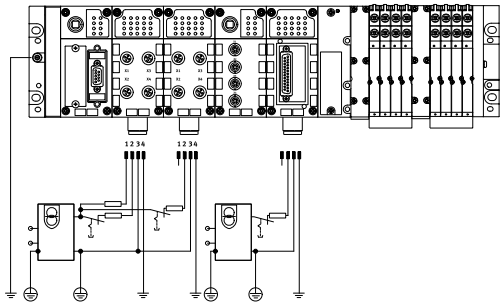
CPX-FVDA-P can work with every Profisafe-capable controller.

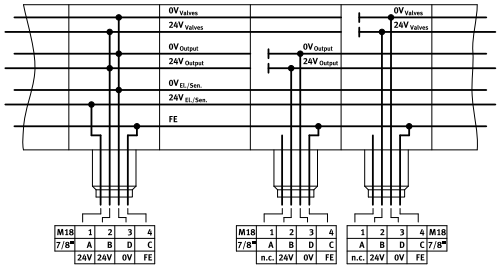
Two channel, self-monitoring, electrical switch off.

M12- or Cage Clamp connection block.

The ProfiSafe module is always ordered in a fixed configuration; see part printed in bold in the example:
51E-F33GCQPEK**ANFKAQF**-Z

CPX terminal – power supply concept





Description
The use of decentralised devices on the fieldbus – particularly with high protection for direct machine mounting – demands a flexible power supply concept.

A valve terminal with CPX can generally be supplied via a socket for all voltages. Here, we distinguish between supplying the
- Electronics plus sensors
- Valves plus actuators.

The following connection types can be selected
- 7/8“, 4 or 3-pin
- M18, 4-pin
- Push-Pull

Interlinking blocks, together with all the power supply rails, are the backbone of the CPX terminal. They provide the power supply for the CPX modules and their fieldbus connection.

Many applications require the CPX terminal to be separated into voltage zones.
This is particularly true for switching off the solenoid coils and the ports separately. The interlinking blocks can either be designed as an installation-saving centralised power supply for the entire CPX terminal, or they can be designed as galvanically isolated, all-pin disconnectable potential groups/voltage segments.

The voltage concept of the CPX terminal permits safe deactivation via external safety devices, safety control outputs or via the integrated ProfiSafe deactivation module.

Please observe the legal information on page 73.

Knowledge provides greater safety

Safety is always more than simply the hardware and the appropriate circuit diagrams. Safety starts at the concept stage, for example by identifying necessary performance levels. For comprehensive training on the subject of safety, Festo Didactic provides numerous courses on various topics.

Over 40 years of experience in training and consulting, courses in 40 languages, over 40,000 participants each year, and approx. 230 ongoing national and international projects with 200 experienced trainers and consultants speak for themselves. Our trainers place their wealth of expertise at your disposal and prepare you or your employees for the specific safety responsibilities in the best possible manner.

Our web-based training course Safety Engineering is ideal for independent and flexible learning.

In addition to the various seminars on safety technology, we also provide on-site support to our customers.

For example, SMS Meer GmbH in Mönchengladbach with the seminar series on the new EC Machinery Directive 2006/42/EC and the new standard EN ISO 13 849-1: “Although the specifications have been implemented by the EC machinery directory for some time, questions still arise in day-to-day work. They must be answered and all employees must be at the same level and have the same understanding that was the objective of the seminars. For example, the discussion of the details took quite a lot of time, which resulted in very high satisfaction ratings in the seminar evaluation.

Many participants wanted follow-up events, particularly on DIN EN ISO 13849. The varied global relevance of safety engineering issues now requires a broad range of expertise. It is almost impossible for design or sales departments to keep up-to-date. SMS Meer now has a new central department for strategic and operational support for product areas and can provide design and sales departments with exactly the training they need. The significant global changes necessitate regular broad training courses, and keeping the overall qualifications of the employees up to date.” Andreas Dröttboom, Documentation and Product Safety Manager, SMS Meer GmbH Mönchengladbach

Or Stanzwerk Salzwedel about the project “Supervisory support in obtaining the CE mark per MD 2006/42/EC”:

Stanzwerk Salzwedel produces assembly systems for building operating equipment, and requires CE marks for these machines. This is subject to the EC Machinery Directive 2006/42/EC.

Festo Training and Consulting supported the company during the conformity process for an assembly system for motors, from drawing up a risk assessment to issuing the declaration of conformity.

The team listed specific hazards on the machine and the resulting risks were documented in the risk assessment. Then, specific technical solutions – both in terms of design and functionality – were found and documented. The components used were checked and documented. In the operating instructions, the team also described and explained possible residual risks.

The implemented technical control solutions were reviewed in accordance with the new standard 13849-1 and their safety engineering functions were demonstrated mathematically.

Overview of training courses

Focus course “Calculating with EN ISO 13 849-1 (FOKUS-3)”

While EN 954-1 only described safety switches quantitatively, the new standard adds a qualitative aspect. It takes the safety in all phases of a machine’s service life as well as safety-relevant software into consideration. There are different classifications for the control category, which permits lower-cost solutions. The new standard raises many questions.
How can we calculate with EN ISO 13 849-1 and how is it used to confirm the required Performance Level? Which components are taken into consideration and how are they assigned to the individual channels?

Content:
- Risk assessment as per EN ISO 13 849-1
- Differences from EN 954-1
- Terms in EN ISO 13 849: Performance Level PL, probability of failure per hour PFH, diagnostic coverage DC, common cause failures CCF, mean time to failure MTTF
- Determining the individual values based on selected pneumatic and electro-pneumatic circuits
- Checking prescribed safety switches
- Insight into the software SISTEMA
- Practical exercises

Target group: design engineers and design managers from mechanics, electrical engineering and control technology, as well as project managers

Duration: 1 day

Focus course “EC Machinery Directive and the German industrial safety regulations (Betriebssicherheitsverordnung) – CE, modification, expansion and liability (FOKUS-4)”

The EC Machinery Directive describes the requirements a machine manufacturer must fulfil when building a machine. In particular, the aspects of liability and documentation must be clarified.

CE certification for interlinked or incomplete machines which are integrated in other machines is particularly important. In this case, the safety at transition points must be clarified, while the control and emergency stop concepts are also important. After being sold, machines are generally modified, sold on or “refitted” and often operated for many years. What safety standard is provided for these phases? What is the liability situation if a machine is returned to a manufacturer for reworking?

Content:
- Responsibilities of the documentation officer
- Liability for managing directors, design engineers and signees of the declaration of conformity
- CE marking and interlinked machines
- What does the term “incomplete machine” mean?
- Operational safety regulation
- Old machines and protecting existing machinery
- Checking machine safety over time
- Expansion and modification of a machine - is recertification required?
- What is a major modification?

Target group: design engineers and design managers from mechanics, electrical engineering and control technology, as well as project managers

Duration: 1 day

For dates and other information, see **www.festo-tac.de**

Seminar
“Safety in pneumatics and electro-pneumatics for design engineers (SAFETY2)”

After this seminar, participants will understand the connection between pneumatic and electric components, be able to evaluate the behaviour of pneumatic drives and design safety circuits up to control category 4. They will work in accordance with DIN EN ISO 13849-1 and other standards required to fulfil the EC Machinery Directive.

Content:
- Structure and function of safety-related circuits to DIN EN ISO 13849-1
- Identification of the safety categories of circuits
- Selecting spare parts
- Power failure and restore
- Reliable pressurising and exhausting
- Safe opening of brakes and clamps
- Fundamental and proven safety principles of pneumatics per DIN EN ISO 13849-2
- Selected safety measures of safety-oriented pneumatics (unexpected restart; blocking, braking and reversing of movements; switching off power and free mobility; reduced force and speed; two-hand operation)
- Error analysis and exclusion per DIN EN ISO 13849-2
- Effect of tube length, diameter and fittings on the speed of cylinders
- Information on operating instructions and maintenance

Target group: mechanical, electrical and control technology engineers

Duration: 2 days

Seminar
“Calculating safety circuits to DIN EN ISO 13849-1 using the software SISTEMA (SAFETY3)“

This course will enable participants to specify the components in a protection circuit and calculate the performance level of this circuit using the SISTEMA software. They will be able to understand the qualitative aspect of DIN EN ISO 13849-1.

- Risk assessment to DIN EN ISO 13849-1
- Terms in EN ISO 13849-1: Performance Level (PL), probability of failure per hour (PFH), mean time to failure (MTTF), service life characteristics of components (B10), diagnostic coverage (DC), common cause failures (CCF)
- Safety functions and control categories
- Determining the components in the safety chain
- Structure of the software SISTEMA
- Calculations based on many examples
- Calculation with complex structures (multiple guards, multiple drives)
- Calculations with safety components and error exclusion
- Creation of own libraries
- Integration of own documentation
- Many practical computer exercises using the software SISTEMA

Target group: mechanical, electrical and control technology engineers

Duration: 2 days

For dates and other information, see **www.festo-tac.de**

Seminar
“Safe switching technology for maintenance technicians (P141)”

Participants will be able to troubleshoot, repair and recommission systems, taking into consideration the applicable safety regulations and safety measures. To this end they learn about the respective control categories and their stipulations. They observe the potential hazards in pneumatic circuits and choose the right spare parts. In this way they acquire the knowledge they need to observe the applicable safety specifications in their working environment.

Content:
- Introduction to safety engineering and EN ISO 13849-1
- Fundamental and proven safety principles for pneumatics
- Control and stop categories and their effects
- Safe handling of potential dangers in pneumatic circuits
- Selected safety measures of safety-oriented pneumatics (unexpected restart; blocking, braking and reversing of movements; switching off power and free mobility/ reduced force and speed; two-hand operation)
- Explaining and eliminating errors in safety-related circuits
- Selecting the right spare parts by taking the failure characteristics into account
- Safe pressurisation and exhausting of drives and systems
- Influences of the overtravel time of pneumatic drives on the working range of safe light barriers
- Safe handling of brakes and clamps
- Practical exercises

Target group: maintenance employees and mechanics and electricians

Duration: 4 days

Seminar
“Safety-relevant circuits in pneumatics and electro-pneumatics for vocational training (SAFETY-AL)”

After this seminar, participants can teach their trainees the core and specialised skills required in the training curriculum with a focus on safety engineering, preparing them ideally for the vocational qualification examinations. They will be familiar with the standards and regulations which must be observed and can apply them in their training and when supervising trainees as part of their company responsibilities.

Content:
- Directives and standards on safety in machine construction
- Structure of safety-related circuits to EN ISO 13849-1
- Terms in EN ISO 13849-1
- Fundamental and proven safety principles of pneumatics per DIN EN ISO 13849-2
- Selected safety measures of safety-oriented pneumatics (unexpected restart/blocking, braking and reversing of movements; switching off power and free mobility/ reduced force and speed; two-hand operation)
- Methodical and learning-oriented implementation tools for trainers in the business process
- Information on producing documentation and test reports required in accordance with the training plan, which are a part of the final examination
- Practical exercises, structure, tests and troubleshooting

Target group: all trainers and company supervisors in the metal and electronics industries or in mechatronic engineering

Duration: 4 days

For dates and other information, see **www.festo-tac.de**

Machine safety services by Festo in Austria

Festo Austria offers services for machine safety engineering, such as employee qualification, planning support, technical support, etc.

Machine safety training at the customer's premises
Festo Didactic has organised comprehensive training courses at Fill as a general contractor. Other specialists and trainers came from Siemens, Pilz, SEW Eurodrive, Sick, TÜV Austria Services and IBF Automatisierungs- und Sicherheitstechnik. The training courses took place on site at Fill's technology park in the north of Austria. That was a major advantage for the customer, as the employees did not have to travel long distances to and from a training location.

From standards to circuits
Selected targets of Fill's training concept included the ability to understand and apply specific standards, planning safe electrical, hydraulic and pneumatic circuits, using software for optimal design, programming safety-related control units and creating and dimensioning bus concepts – of course all in the light of the new EC Machinery Directive.

Rudolf Reiter, Head of Safety Engineering at Fill: "Continuity of evaluating safety functions regardless of the technology and energy used (electric, hydraulic, pneumatic, mechanical, etc.) was important for us and that was completely achieved with Festo's fluid technical background."

"Thanks to the specific training concept customised for Fill, spread out over several weeks, our employees are now perfectly equipped for new safety engineering requirements."

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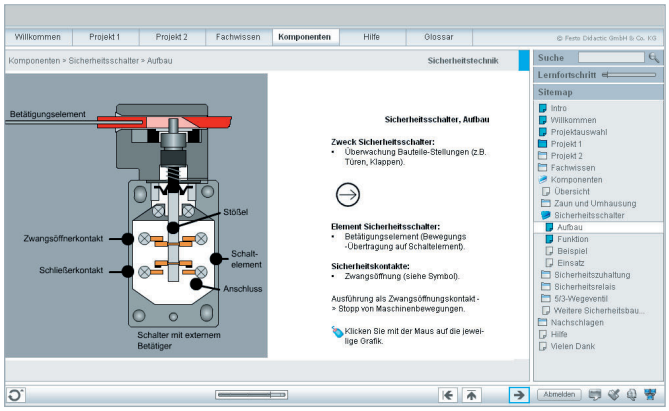
WBT – Web-based training for safety engineering



This training program provides an introduction to the complex subject of safety engineering in industrial machines and systems.

The aim is to make participants more aware of the problems in the design aspects of safety engineering and help them understand safety engineering equipment and hazard analysis methods.

The training program is based on an amended version of the EC Machinery Directive 2006/42/EC, which came into force on 29 December 2009. Until then, 98/37/EC was valid. There is no transitional period.

How is the overall performance level of a technical safety measure determined? The training program explains concepts such as probability of failure (POF), diagnostic coverage (DC), common cause failure (CCF), redundancy and diversity. There is also a detailed explanation of all the components for safety equipment.

From the contents

- Introduction to machine safety
- The question of liability (who is liable in the case of an accident?)
- European directives
- The relationship between directives and standards
- The new EU Machinery Directive 2006/42/EC
- The hierarchy of the European standards for machine safety
- Machine safety in the USA
- Risk assessment procedure according to EN ISO 14121 and EN ISO 12100
- Definitions
- Risk estimation: determining the Performance Level required
- Risk reducing measures: design measures, technical safety measures, instructive measures
- Selecting the safety function
- Determining the control category

We can meet your needs

Available as a CD-ROM version or alternatively a WBT version for installation on networks and learning management systems, with as many licences as you need.

Duration

About 4 hours

For more information, see the Festo Didactic homepage: www.festo-didactic.com

Legal notice

This guideline is intended only for information for everyone who uses or wants to use safety engineering. All information contained in this guideline was drafted and compiled according to our best knowledge and conscience as a support on the topic of safety engineering. This applies in particular to the guidelines and norms mentioned and makes no claim of completeness.

The solutions, illustrated assemblies, product compositions and arrangements shown in this guide in the form of technical and/or schematic sketches are only application examples for our products/ assemblies. They are non-binding solution and application suggestions for the customer's concrete application. The respective customer/user must check and observe the laws, guidelines and standards relevant for the construction, manufacture and product information, independently and on his own responsibility for the respective application, and must observe and comply with them during conversion. They are therefore addressed to sufficiently trained and qualified personnel.

In this context, we assume no responsibility or liability for the solution conceived, drafted and implemented by the customer for the respective, concrete application.

List of abbreviations

Abbreviation	German name	English name	Source
a, b, c, d, e	Bezeichnung für die Performance Level	Denotation of performance levels	DIN EN ISO 13849-1
AB	Anzeige-Bediengeräte	Display and operating units	Festo
AC/DC	Wechsel-/Gleichstrom	Alternating current/direct current	IEC 61511
AE	Anfahr- und Entlüftungsventile	Start-up and exhaust valves	Festo
ALARP	So niedrig wie vernünftigerweise möglich	As low as reasonable practicable	IEC 61511
ANSI	US-amerikanische Normungsorganisation	American National Standards Institute	IEC 61511
AOPD/AOPDDR	Aktive optoelektronische Schutzeinrichtung	Active optoelectronic protection device	ISO 12100, DIN EN ISO 13849-1
AS-Interface	Aktuator Sensor Interface	Aktuator Sensor Interface	
B, 1, 2, 3, 4	Bezeichnung für die Kategorien	Denotation of categories	DIN EN ISO 13849-1
B10	Anzahl von Zyklen, bis 10 % der Komponenten ausgefallen sind (u.a. für pneumatische und elektromechanische Komponenten)	Number of cycles until 10% of the components fail (for pneumatic and electromechanical compnents)	DIN EN ISO 13849-1
$B10_d$	Anzahl von Zyklen, bis 10 % der Komponenten gefährlich ausgefallen sind (u.a. für pneumatische und elektromechanische Komponenten)	Number of cycles until 10% of the components fail dangerously (for pneumatic and electomechanical components)	DIN EN ISO 13849-1
BPCS	Betriebs- und Überwachungseinrichtungen	Basic process control system	IEC 61511
BPCS	Betriebs- und Überwachungseinrichtungen als ein System	Basic process control system	IEC 61511
BSL	Bootstraploader	Bootstrap loader	
BTB/RTO	Betriebsbereit	Ready-to-operate	
BWP	Berührungslos wirkende Positionsschalter	Electro-sensitive position switch	
BWS	Berührungslos wirkende Schutzeinrichtung	Electro-sensitive protective equipment	EN 61496
Cat.	Kategorie	Category	DIN EN ISO 13849-1
CC	Stromrichter	Current converter	DIN EN ISO 13849-1
ccd	Kommando-Code, Teil einer SDO-Nachricht	Command-code	
CCF	Ausfall in Folge gemeinsamer Ursache	Common cause failure	IEC 61508, IEC 62061, prEN ISO 12849-1EN 61511-1:2004, DIN EN ISO 13849-1
CEN	Europäisches Komitee für Normung	European Commttee for Standardization	
CENELEC	Europäisches Komitee für elektrotechnische Normung	European Commttee for Electrotechnical Standardization	
CMF	Ausfall in Folge gemeinsamer Ausfallart	Common mode failure	EN 61511-1:2004
CRC	Prüfsumme in einem Daten-Telegramm, Signatur durch zyklische Redundanzprüfung	Cyclic redundancy check	
DC	Diagnosedeckungsgrad	Diagnostic coverage	DIN EN ISO 13849-1, IEC 62061(IEC 61508-2:2000
DC	Gleichstrom	Direct current	
DC_{avg}[%]	Diagnosedeckungsgrad (von Tests)	Average diagnostic coverage	DIN EN ISO 13849-1
DPV0			
DPV1	Funktionsversionen von PROFIBUS		
DR	Druckventile	Pressure control valves	Festo
DS	Druckschalter	Pressure switch	Festo
DV	Druckverstärker	Pressure amplifier	Festo
E	Externe Einrichtung zur Risikominderung	External risk reduction facilities	EN 61511-1:2004
E/A	Eingabe/Ausgabe	Input/output	
E/E/EP	Elektrisch/elektronisch/programmierbar elektronisch	Electrical/electronic/programmable electronic	IEC 61511, IEC 61508
E/E/PE	Elektrisch/elektronisch/programmierbar elektronisch	Electrical/electronic/programmable electronic	IEC 61511, IEC 61508
E/E/PES	Elektrisches/elektronisches/programmierbares elektronisches System	Electrical/electronic/programmable electronic system	IEC 61511
EDM	Schützkontrolle, Rückführkreis	External device monitoring	
EDS	Elektronisches Datenblatt	Electronic data sheet	

Abbreviation	German name	English name	Source
F, F1, F2	Häufigkeit und/oder Dauer der Gefährdungsexposition	Frequency and/or time of exposure to the hazard	DIN EN ISO 13849-1
FB	Funktionsblock	Function block	DIN EN ISO 13849-1
FMEA	Ausfallarten und Effekt-Analyse	Failure modes and effects analysis	DIN EN ISO 13849-1, EN ISO 12100
FO	Funktionsorientierte Antriebe	Function-oriented drives	Festo
FR	Filterregler	Filter-regulator unit	Festo
FTA	Fehlerbaumanalyse/Fehlerzustandsbaumanalyse	Fault tree analysis	EN ISO 12100
Gefährdung	Potenzielle Quellen von Verletzungen oder Gesundheitsschäden	Potential source of injury or damage to health	Maschinenrichtlinie 2006/42/EG
Gefährdungsbereich	Jeder Bereich in einer Maschine und/oder um eine Maschine herum, in dem eine Person einer Gefährdung ausgesetzt sein kann	Any zone within and/or around machinery in which a person is subject to a risk to his health or safety	EN ISO 12100
H & RA	Gefährdungs- und Risikobeurteilung	Hazard and risk assessment	IEC 61511
H/W	Hardware	Hardware	IEC 61511
HFT	Hardware-Fehlertoleranz	Hardware fault tolerance	IEC 61511
HMI	Mensch-Maschine-Schnittstelle	Human machine interface	IEC 61511
HRA	Analyse menschlicher Zuverlässigkeit	Human reliability analysis	IEC 61511
I, I1, I2	Eingabegerät, z.B. Sensor	Input device, e.g. sensor	DIN EN ISO 13849-1
i, j	Index für Zählung	Index for counting	DIN EN ISO 13849-1
I/O	Eingänge/Ausgänge	Inputs/outputs	DIN EN ISO 13849-1
iab, ibc	Verbindungsmittel	Interconnecting means	DIN EN ISO 13849-1
Inhärente sichere Konstruktion	Schutzmaßnahme, die entweder Gefährdungen beseitigt oder die mit den Gefährdungen verbundenen Risiken vermindert, indem ohne Anwendung von trennenden oder nicht trennenden Schutzeinrichtungen die Konstruktions-Betriebseigenschaften der Maschine verändert werden	Inherently safe design measure Safety measure, which either eliminates hazards or minimises the risks associated with the hazards, by changing the design operating properties of the machine without using disconnecting/ non-disconnecting protective devices	EN ISO 12100
KL	Kolbenstangenloser Zylinder	Rodless cylinders	Festo
Konformitätserklärung	Verfahren, bei dem der Hersteller oder sein in der Gemeinschaft niedergelassener Bevollmächtigter erklärt, dass die in den Verkehr gebrachten Maschine allen einschlägigen grundlegenden Sicherheits- und Gesundheitsanforderungen entspricht	Declaration of conformity Process in which the manufacturer or their authorised representative established in the community declares that the machine markets complies with all relevant fundamental safety and health requirements	Maschinenrichtlinie 2006/42/EG
KS	Kolbenstangenzylinder	Cylinders with position rod	Festo
L, L1, L2	Logik	Logic	DIN EN ISO 13849-1
Lambda	Ausfallrate bei ungefährlichen und Gefahr bringenden Fehlern	Rate to failure	IEC 62061
MTBF	Mittlere Ausfallzeit eines Gerätes	Mean time between failure	DIN EN ISO 13849-1
MTTF/$MTTF_d$	Mittlere Zeit bis zu einem Ausfall bzw. gefährlichen Ausfall	Mean time to failure/ Mean time to dangeous failure	DIN EN ISO 13849-1
MTTR	Mittlere Reparaturzeit eines Gerätes	Mean time to repair	DIN EN ISO 13849-1
NMT	Service-Dienste des CAN-Application Layers	Network management	
$N_{niedrig}$	Anzahl von SRP/CS mit PLniedrig in einer Kombination von SRP/CS	Number of SRP/CS with PLlow in a combination of SRP/CS	DIN EN ISO 13849-1
NOT-AUS	Ausschalten im Notfall	Emergency switching off	EN 418 (ISO 13850) EN 60204-1 Anhang D
NOT-HALT	Stillsetzen im Notfall	Emergency stop	ISO 13850 EN 60204-1 Anhang D
NP	Nicht programmierbares System	Non-programmable system	EN 61511-1:2004

Abbreviation	German name	English name	Source
O, O1, O2, OTE	Ausgabegerät, z.B. Antriebselement	Output device, e.g. actuator	DIN EN ISO 13849-1
OE	Öler	Lubricator	Festo
OSHA			
OSI	Referenzmodell zur Datenkommunikation, Darstellung als Schichtenmodell mit verteilten Aufgaben für jede Schicht	Open System Interconnection	
OSSD	Ausgangsschaltelement, Sicherheits-Schaltausgang	Output signal switching device	EN 61496-1
P, P1, P2	Möglichkeit zur Vermeidung der Gefährdung	Possibility of avoiding the hazard	DIN EN ISO 13849-1
Pdf	Wahrscheinlichkeit gefahrbringender Ausfälle	Probability of dangerous failure	IEC 61508, IEC 62061
PE	Programmierbare Elektronik	Programmable electronics	EN 61511-1
PES	Programmierbares elektronisches System	Programmale electronic system	EN 61511-1, DIN EN
PFD	Ausfallwahrscheinlichkeit bei Auslösen/ Anfrage der Sicherheitsfunktion	Probability of failure on demad	IEC 61508, IEC 62061
PFH	Ausfallwahrscheinlichkeit pro Stunde	Probability of failure per hour	IEC 62061
PFH_d	Wahrscheinlichkeit gefahrbringender Ausfälle pro Stunde	Probability of dangerous failure per hour	IEC 62061
PHA	Vorläufige Untersuchung von Gefährdungen	Preliminary hazard analysis	EN ISO 12100
PL/Performance Level	Diskreter Level, der die Fähigkeit von sicherheitsbezogenen Teilen einer Steuerung spezifiert, eine Sicherheitsfunktion unter vorhersehbaren Bedingungen auszuführen	Discrete level used to specify the ability of safety-related parts of control systems to perform a safety function under foreseeable condtions	DIN EN ISO 13849-1
PL_r	Angewandter Performance Level(PL), um die erforderliche Risikominderung für jede Sicherheitsfunktion zu erreichen	Performance level (PL) applied in order to achieve the required risk reduction for each safety function	DIN EN ISO 13849-1
PLC	Speicherprogrammierbare Steuerung (SPS)	Programmable logic contoller	IEC 61511, DIN EN ISO 13849-1
$PL_{niedrig}$	Niedrigster Performance Level einer SRP/CS in einer Kombination von SRP/CS	Lowest performance level of a SPR/CS in a combination of SPR/CS	DIN EN ISO 13849-1
PR	Proportionalventile	Proportional valves	Festo
RE	Regler	Regulator	Festo
Restrisiko	Risiko, das nach Ausführung der Schutzmaßnahme verbleibt	Risk remaining after safety measures have been taken	EN ISO 12100
Risiko	Kombination der Wahrscheinlichkeit	Combination of the probability	EN ISO 12100
Risikoanalyse	Kombination aus Festlegung der Grenzen einer Maschine, Identifizierung einer Gefährdung und Risikoeinschätzung	Combination of the specification of the limits of the machine, hazard identification and risk estimation	EN ISO 12100
Risikobeurteilung	Gesamtheit des Verfahrens, das eine Risikoanalyse und Risikobewertung umfasst	Overall process comprising a risk analysis and a risk evaluation	EN ISO 12100
Risikobewertung	Auf der Risikoanalyse beruhende Beurteilung, ob die Ziele zur Risikominderung erreicht wurden	Judgement, on the basis of risk analysis, of whether the risk reduction objectives have been achieved	EN ISO 12100
Risikoeinschätzung	Bestimmung des wahrscheinlichen Ausmaßes eines Schadens und der Wahrscheinlichkeit seines Eintritts	Defining the likely severity of harm and probability of its occurrence	EN ISO 12100
S, S1, S2	Schwere der Verletzung	Severity of injury	DIN EN ISO 13849-1
SA	Schwenkantriebe	Semi-rotary drives	Festo
SAT	Vor-Ort-Abnahme	Site acceptance test	IEC 61511
Schaden	Physische Verletzung und/oder Schädigung von Gesundheit oder Sachen	Physical injuy or damage to health	EN 61511-1
Schutzmaßnahme	Maßnahme zur Beseitigung einer Gefährdung oder zur Minderung eines Risikos	Means that eliminates a hazard or reduces a risk	EN ISO 12100, EN 61511-1
SIF	Sicherheitstechnische Funktion	Safety instrumental function	EN 61511-1

Abbreviation	German name	English name	Source
SIL	Sicherheits-Integritätslevel	Safety integrity level	IEC 61511, DIN EN ISO 13849-1
SIS	Sicherheitstechnisches System	Safety instrumented system	EN 61511-1
SP	Sperrventile	Shut-off valves	Festo
SPE	Sensitive Schutzeinrichtung mechanisch behaftetes Betriebsmittel	Sensitive protection equipment	EN ISO 12100
SRASW	Sicherheitsbezogene Anwendungssoftware	Safety related application software	DIN EN ISO 13849-1
SRECS	Sicherheitsbezogenes elektrisches Steuerungssystem	Safety related electrical control system	IEC 62061
SRESW	Sicherheitsbezogene Embedded-Software	Safety related embedded software	DIN EN ISO 13849-1
SRP	Sicherheitsbezogenes Teil	Safety related part	DIN EN ISO 13849-1
SRP/CS	Sicherheitsbezogenes Teil von Steuerungen	Safety related part of control systems	DIN EN ISO 13849-1
SRS	Spezifikation der Sicherheitsanforderungen	Safety requirements specification	IEC 61511
ST	Stromventile	Flow control valves	Festo
SW1A, SW1B, SW2	Positionsschalter	Position switces	DIN EN ISO 13849-1
SYNC	Objekt zur Synchronisierung von Teilnehmern im Netzwerk	Synchronisation objects	
TE	Testeinrichtung	Test equipment	DIN EN ISO 13849-1
Techn. Schutz-maßnahmen	Schutzmaßnahmen, bei denen Schutzein-richtungen zur Anwendung kommen, um Personen vor Gefährdungen zu schützen, die durch inhärent sichere Konstruktion nicht in angemessener Weise beseitigt werden können, oder vor Risiken zu schützen, die dadurch nicht ausreichend vermindert werden können	Protective measure using safeguards to protect persons from the hazard which cannot reasonably be eliminated or from the risks which cannot be sufficiently reduced by inherently safe design measures	EN ISO 12100
TM	Gebrauchsdauer	Mission time	DIN EN ISO 13849-1

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