Safety engineering guidelines
Pneumatic and electric solutions
Overview of technical safety measures

- Emergency stop
- Two-hand operation:
- Moving guard: safety door
- Safety shut-off
- Light curtain
- Laser scanner
- Enabling switch
- Operating mode selector switch
- Vision system

Wiring
Safe, pneumatic solution
Safety relay
Safety PLC

Initial position, standstill
Set-up and service operation
Normal operation
Emergency operation

Please observe the legal information on page 76.
You will see these symbols frequently on the following pages. They clearly and quickly point to the respective safety function.
Your partner for safety

Quality has many aspects at Festo, one of which is working safely with machines. This has led to 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-orientated pneumatics?
• How can I identify the risk posed by a system or machine to the operator or user?
• Which standards and directives apply?
• What safety measures are derived from these?
• What are the most common safety measures?

Simple and helpful:
The directives and standards are dealt with in the first part of the brochure. The second part offers an overview of the most commonly used safety functions in connection with pneumatic and electric drives, as well as the corresponding solutions from Festo. These can be used to implement many safety functions.

If you require more information, our specialists worldwide will be happy to help.

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Reduce risk – think preventively

Machines have to be designed in a way that protects people, animals, property and the environment from harm. The objective is to prevent physical damage of any type. Using safety-oriented pneumatic and electrical components from Festo provides you with the security of implementing safety measures that are compliant with the EC Machinery Directive.

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

The EC Machinery Directive 2006/42/EC specifies a risk analysis and assessment for machines. These have helped to develop and define safety objectives.

The safety objectives are achieved using various safety functions.

Safety-oriented solutions in the form of
• Components
• Circuits
• Engineering
make it easy to achieve your safety objectives. Reliable 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 stopping, safe exhausting.
• Restarting -> protection against unexpected start-up
• Servicing/maintenance

In addition to this, if faults 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 application, drive systems need to be included in the risk analysis and assessment for each machine, depending on the application.
Technical safety conditions

There are legal requirements globally 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.

**Laws, e.g. EU Machinery Directive 2006/42/EC**

- Risk assessment
  - Risk analysis → Risk assessment → Risk reduction
  - Design measures
  - Technical measures
  - User information

**Safety function**

- Input → Logic → Output

**Evaluation:**

- $PL \geq PL_r$
- $SIL \geq SIL_r$

**Objective:**
- Safe machines
- Standardised process + "check list"
- Risk reduction
- Evaluation and assessment of technical safety measures
- Evaluation whether risk reduction is sufficient
Basic safety requirements in the manufacturing industry

At the same time as 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 support for compliance with the EC Machinery Directive. These are listed in the Offcial Journal of the European Communities. Applying these results is 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 help to reduce safety risks to an acceptable minimum, as per the EC Machinery Directive.

- Design and risk assessment of machinery: EN ISO 12100
  - Safety of machinery
  - General principles for design

- Electrical safety aspects: EN 60204-1
  - Safety of machinery
  - Electrical equipment of machines, Part 1: General requirements

- Functional and safety-oriented requirements for safety-related control systems

- Designing and implementing safety-related control systems: EN 62061
  - Safety of machinery
  - Functional safety of electrical/electronic/programmable safety-related electronic control systems

- Any architectures:
  - Safety integrity level (SIL)
  - SIL 1, SIL 2, SIL 3

- DIN EN ISO 13849-1
  - Safety of machinery
  - Safety-related parts of control systems, Part 1 – General principles for design

- Designated architectures (categories):
  - Performance level (PL)
  - PL a, PL b, PL c, PL d, PL e
Risks are the result of hazards and relate to the gravity of possible damage and the probability of the damage occurring.

**Definition of risk**

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

**Risk** in terms of the respective hazard

Safety = accepted residual risk
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.
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 (MTTFd)
3) Diagnostic coverage (DC)
4) Common cause failures (CCF)

In all cases, the Performance Level PL must correspond at least to the required PL°.
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 MTTFd 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, DIN EN ISO 13849-1 requires other measures to be taken (e.g. architecture) to achieve a specific PL.

Determining the performance level (PL)

- **DC**: Diagnostic Coverage
- **MTTFd**: Mean Time To Failure (Dangerous)
- **PFH**: Probability of Failure per Hour

**Evaluation**
- Low: 3 years ≤ MTTFd ≤ 10 years
- Medium: 10 years ≤ MTTFd ≤ 30 years
- High: 30 years ≤ MTTFd ≤ 100 years

Source: DIN EN ISO 13849-1 Chapter 4.5.2

<table>
<thead>
<tr>
<th>Cat. B</th>
<th>DC ≤ 60%</th>
<th>DC ≤ 60%</th>
<th>60% ≤ DC &lt; 90%</th>
<th>90% ≤ DC &lt; 99%</th>
<th>99% ≤ DC</th>
<th>99% ≤ DC</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>None</td>
<td>60% ≤ DC Low</td>
<td>90% ≤ DC Medium</td>
<td>60% ≤ DC Low</td>
<td>90% ≤ DC Medium</td>
<td>99% ≤ DC High</td>
</tr>
<tr>
<td>Cat. 1</td>
<td>10⁻¹ ≤ PFH ≤ 10⁻⁰</td>
<td>10⁻⁰ ≤ PFH ≤ 3 × 10⁻¹</td>
<td>10⁻¹ ≤ PFH ≤ 3 × 10⁻¹</td>
<td>10⁻² ≤ PFH ≤ 10⁻¹</td>
<td>10⁻³ ≤ PFH ≤ 10⁻²</td>
<td>10⁻⁴ ≤ PFH ≤ 10⁻³</td>
</tr>
<tr>
<td>Cat. 2</td>
<td>10⁻² ≤ PFH ≤ 3 × 10⁻²</td>
<td>10⁻³ ≤ PFH ≤ 10⁻²</td>
<td>10⁻³ ≤ PFH ≤ 10⁻²</td>
<td>10⁻⁴ ≤ PFH ≤ 10⁻³</td>
<td>10⁻⁵ ≤ PFH ≤ 10⁻⁴</td>
<td>10⁻⁶ ≤ PFH ≤ 10⁻⁵</td>
</tr>
<tr>
<td>Cat. 3</td>
<td>10⁻³ ≤ PFH ≤ 10⁻¹</td>
<td>10⁻⁴ ≤ PFH ≤ 10⁻³</td>
<td>10⁻⁴ ≤ PFH ≤ 10⁻³</td>
<td>10⁻⁵ ≤ PFH ≤ 10⁻⁴</td>
<td>10⁻⁶ ≤ PFH ≤ 10⁻⁵</td>
<td>10⁻⁷ ≤ PFH ≤ 10⁻⁶</td>
</tr>
<tr>
<td>Cat. 4</td>
<td>10⁻⁴ ≤ PFH ≤ 10⁻²</td>
<td>10⁻⁵ ≤ PFH ≤ 10⁻⁴</td>
<td>10⁻⁵ ≤ PFH ≤ 10⁻⁴</td>
<td>10⁻⁶ ≤ PFH ≤ 10⁻⁵</td>
<td>10⁻⁷ ≤ PFH ≤ 10⁻⁶</td>
<td>10⁻⁸ ≤ PFH ≤ 10⁻⁷</td>
</tr>
</tbody>
</table>

Source: DIN EN ISO 13849-1 Chapter 4.5.4
Determining the required performance level

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).

Technically speaking, PLr (required) is a "nominal value", which is the minimum that should be achieved by the technical measures.

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.

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**DIN EN ISO 13849-1**

- **S** Severity of injury
  - S1 Slight (normally reversible injury)
  - S2 Serious (normally irreversible injury, including death)

- **F** Frequency and/or duration of exposure to the hazard
  - F1 Seldom to less often and/or brief
  - F2 Frequent to continuous and/or long

- **P** Possibility of avoiding the hazard
  - P1 Possible under specific conditions
  - P2 Scarcely ever possible

**Statements from other standards**

- **EN 62061**
  - Irreversible injury (4 points) (death, loss of eye or arm)
  - Irreversible injury (3 points) (broken limbs, loss of finger)
  - Reversible injury (2 points) (requires further medical attention from a doctor)
  - Reversible injury (1 point)

  - Frequency (with a duration > 10 min)
    - > 1 h (5 points)
    - > 1 h to < 1 day (5 points*)
    - > 1 day to < 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

  - Impossible (5 points)
  - Seldom (3 points)
  - Probable (1 point)
## Overview of control architectures

<table>
<thead>
<tr>
<th>Category</th>
<th>Fault Safety</th>
<th>Channels</th>
<th>Functions</th>
</tr>
</thead>
<tbody>
<tr>
<td>B or 1</td>
<td>Fault Safety</td>
<td>1</td>
<td>100x test of the function before the request by the machine control system (DIN EN ISO 13849-1 Pt. 6.2.7)</td>
</tr>
<tr>
<td>B</td>
<td>Fault Safety</td>
<td>2</td>
<td>Every fault must be detected before or during the next request</td>
</tr>
<tr>
<td>2</td>
<td>1 Fault Safety</td>
<td></td>
<td>Multiple undetected faults lead to the loss of SF</td>
</tr>
</tbody>
</table>

### Category B
- **Fundamental safety principles must be fulfilled** (DIN EN ISO 13849-1 Pt. 6.2.3/DIN EN ISO 13849-2 Tab. A1/B1/D1)
- **Suitable design for external influences** (DIN EN ISO 13849-1 Pt. 6.2.3)

#### 1 channel
- **SRP/CS: proven safety principles must be fulfilled** (DIN EN ISO 13849-2 B.4; refer to DIN EN ISO 13849-2 Tab. A2/B2/D2)
- **0 Fault safety** (DIN EN ISO 13849-1 Pt. 6.2.4)

#### Category B
- Compliance with fundamental and proven safety principles. Compliance with appropriate standards.

#### Category 1
- Components proven in operation. Already used in similar applications (refer to DIN EN ISO 13849-2 B.4)

#### Category 2
- **1 Fault safety**

#### Category 3
- **2 channels** (DIN EN ISO 13849-1 Pt. 6.2.7)
- Some, but not all faults are detected before or during the next request

#### Category 4
- **1 channel**
- **0 Fault safety** (DIN EN ISO 13849-1 Pt. 6.2.4)

### Category C or 1
- **Compliance with fundamental and proven safety principles. Compliance with appropriate standards**

### Category 2
- Components proven in operation. Already used in similar applications (refer to DIN EN ISO 13849-2 B.4)
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.

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 normal control 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.

Sporadic manipulation after more than 100 cycles.
Manipulation via the safety door.
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. 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.
<table>
<thead>
<tr>
<th>Unintentional loosening of the operating elements in the adjusting device</th>
<th>Fault in the connecting component (ripped off/out, leakage)</th>
<th>Clogging (blockage)</th>
<th>Bending</th>
<th>Change to the recording and output characteristics</th>
<th>Failure of the end-position cushioning</th>
<th>Loosening of the piston/piston rod connection</th>
<th>Pressure rise</th>
<th>Pressure failure</th>
<th>Electrical power failure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Freedom from faults partially guaranteed in the component (see DIN EN ISO 13849-2)</td>
<td>No freedom from faults guaranteed for this component</td>
<td>Not relevant for this component</td>
<td>Freedom from faults guaranteed for this component</td>
<td>Freedom from faults partially guaranteed in the component</td>
<td>Freedom from faults</td>
<td>Freedom from faults</td>
<td>Freedom from faults</td>
<td>Freedom from faults</td>
<td>Freedom from faults</td>
</tr>
</tbody>
</table>

\[
\begin{align*}
DC_{avg} &= \frac{1}{MTTF_{d1} + MTTF_{d2} + \cdots + MTTF_{dn}} \\
DC_{i} &= \frac{1}{MTTF_{di}}
\end{align*}
\]
The mean time to dangerous failure (MTTFd) is initially determined for each redundant channel. An overall MTTFd value is then determined using the values from both channels. This value has a unit (e.g. 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.

Determining the Mean Time To Dangerous Failure (MTTFd)

\[
\frac{1}{\text{MTTF}_{\text{d}}} = \sum_{i=1}^{N} \frac{1}{\text{MTTF}_{\text{d},i}}
\]

<table>
<thead>
<tr>
<th>Evaluation</th>
<th>MTTFd</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>3 years ≤ MTTFd &lt; 10 years</td>
</tr>
<tr>
<td>Medium</td>
<td>10 years ≤ MTTFd ≤ 30 years</td>
</tr>
<tr>
<td>High</td>
<td>30 years ≤ MTTFd ≤ 100 years</td>
</tr>
</tbody>
</table>

Source: DIN EN ISO 13849-1 Chapter 4.5.2
**B\textsubscript{10} value**

**Definition**
Time at which statistically 10% of test specimens have failed (the values are determined according to DIN EN ISO 19973).

Per definition, 10% of the test specimens have failed at this time. A component can thus also fail before the \( B\textsubscript{10} \) value is reached. The service life cannot be guaranteed.

**Dangerous failures:**
In relation to the safety of machines/the EC Machinery Directive/DIN 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. It can be assumed that \( B\textsubscript{10\textsubscript{d}} = 2 \times B\textsubscript{10} \):

- \( B\textsubscript{10} \): Statistical probability of failure
- \( B\textsubscript{10\textsubscript{d}} \): Statistical probability of failure due to dangerous faults

For which products do I require a \( B\textsubscript{10\textsubscript{d}} \) value?
For all products which are subject to wear, are used in safety-related parts of a control system 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 require a \( \text{MTTF}_{\text{d}} \) value?
For all products which are used in safety-related parts of a control system 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 \( \text{MTTF}_{\text{d}} \) value or \( B\textsubscript{10\textsubscript{d}} \) value for components which are used for monitoring purposes in safety-related parts of control systems?
No, for SRP/CS Category 3 and 4. Yes, for SRP/CS Category 2 in the test channel.

### Determining \( \text{MTTF}_{\text{d}} \) from \( B\textsubscript{10\textsubscript{d}} \)

The \( \text{MTTF}_{\text{d}} \) value is application-dependent and describes the mean period to a dangerous failure of a system part.

#### Formula for determining the \( \text{MTTF}_{\text{d}} \) value for a mechanical element in a channel

\[
\text{MTTF}_d = \frac{B_{10\textsubscript{d}}}{0.1 \times n_{op}}
\]

Where:

- \( B_{10\textsubscript{d}} \) [cycles] = Mean number of cycles, up to 10% of the components fail dangerously
- \( n_{op} \) = \( \frac{d_{op} \times h_{op} \times 3600s/h}{t_{cycle}} \)
- \( d_{op} \): Operating days/year
- \( h_{op} \): Operating hours/day
- \( t_{cycle} \): Cycle time

#### Calculation of overall \( \text{MTTF}_{\text{d}} \) for two different channels

\[
\text{MTTF}_d = \frac{2}{3} \left[ \frac{1}{\text{MTTF}_{\text{d1}}} + \frac{1}{\text{MTTF}_{\text{d2}}} \right]
\]

Where:

- \( \text{MTTF}_{\text{d1}} \) and \( \text{MTTF}_{\text{d2}} \): Values for two different, redundant channels.

If the \( \text{MTTF}_{\text{d}} \) value of a channel is more than 100 years, a value of 100 years is used for further calculation.
Sistema software from the Institute for Occupational Safety and Health [Institut für Arbeitsschutz (IFA)]

The SISTEMA software assistant (safety of control systems in machinery) provides support in evaluating the safety of SRP/CS 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. Databases with safety-related specifications for products and solutions provide support with the evaluation.

There are numerous libraries on the homepage of the IFA.

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

Safety engineering coefficients – Sistema libraries
Pneumatic diagnostic options

Plausibility check
A PLC checks whether a signal change has taken place within a specific period $t$, and whether 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
For example piston position sensing, pressure sensor, proximity sensor, displacement encoder, flow meter or the sensors must register the change of the 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, 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 deactivated 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?
The 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 activation of the pilot valve, and thus the power valve.

Does my control system 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. 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 control system (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 control system, always contact the manufacturer of the solenoid valve, and ask for the maximum pulse widths for test pulses.
## Defining common cause failures

### Common cause failure CCF

<table>
<thead>
<tr>
<th>No.</th>
<th>Measure to avoid CCF</th>
<th>S points</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Isolation/disconnection Physical separation between the signal paths, e.g., isolating the wiring, sufficient air gaps and creepage distances on printed circuit boards</td>
<td>15</td>
</tr>
<tr>
<td>2</td>
<td>Diversity Different technologies/designs or physical principals are used e.g., the first channel in programmable electronics and the second channel hard-wired, type of initiation e.g., pressure and temperature: measurement of the distance and pressure e.g., digital and analogue: components by various manufacturers</td>
<td>20</td>
</tr>
<tr>
<td>3</td>
<td>Design/application/experience</td>
<td></td>
</tr>
<tr>
<td>3.1</td>
<td>Protection against overvoltage, excess pressure, overload current etc.</td>
<td>15</td>
</tr>
<tr>
<td>3.2</td>
<td>Components used have been operated for several years in consideration of ambient conditions.</td>
<td>5</td>
</tr>
<tr>
<td>4</td>
<td>Assessment/analysis Have the results of a failure type and effects analysis been taken into account to avoid common cause failures in the design?</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>Competence/training Have engineers/installation technicians been trained to recognise the causes and effects of failures resulting from common cause?</td>
<td>5</td>
</tr>
<tr>
<td>6</td>
<td>Environment</td>
<td></td>
</tr>
<tr>
<td>6.1</td>
<td>Electromagnetic compatibility (EMC) Was the system checked for EMC immunity (e.g., as specified in the relevant product standards)?</td>
<td>25</td>
</tr>
<tr>
<td>6.2</td>
<td>Other influences Have all requirements for insensitivity to all relevant ambient conditions such as temperature, impacts, vibration, humidity been taken into consideration (e.g., as specified in the relevant standards)?</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Total</th>
<th>Measures to avoid CCF Total S points</th>
<th>Requirements fulfilled</th>
<th>Process failed; select additional measures</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Total S points</td>
<td>65% or better</td>
<td>Less than 65%</td>
</tr>
</tbody>
</table>

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 level 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 SRP/CL 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.

<table>
<thead>
<tr>
<th>Lowest PL</th>
<th>Number of lowest PL</th>
<th>Overall system PL</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL_{low}</td>
<td>N_{low}</td>
<td>PL</td>
</tr>
<tr>
<td>a</td>
<td>&gt;3</td>
<td>Not permitted</td>
</tr>
<tr>
<td></td>
<td>≤3</td>
<td>a</td>
</tr>
<tr>
<td>b</td>
<td>&gt;2</td>
<td>a</td>
</tr>
<tr>
<td></td>
<td>≤2</td>
<td>b</td>
</tr>
<tr>
<td>c</td>
<td>&gt;2</td>
<td>b</td>
</tr>
<tr>
<td></td>
<td>≤2</td>
<td>c</td>
</tr>
<tr>
<td>d</td>
<td>&gt;3</td>
<td>c</td>
</tr>
<tr>
<td></td>
<td>≤3</td>
<td>d</td>
</tr>
<tr>
<td>e</td>
<td>&gt;3</td>
<td>d</td>
</tr>
<tr>
<td></td>
<td>≤3</td>
<td>e</td>
</tr>
</tbody>
</table>
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 the 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 European Economic Area (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 control system (SRP/CS)?

- A safety component is evaluated by its manufacturer for its safety function.
- A safety-related part of a control system (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 valves 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.
Two-hand control block

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

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

Notes

<table>
<thead>
<tr>
<th>Cat.</th>
<th>PL</th>
<th>dc</th>
<th>Channels</th>
<th>DIN EN 574</th>
<th>Safety component to MD 2006/42/EC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>IIIA</td>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>576656</td>
<td>ZSB-1/8-B</td>
</tr>
</tbody>
</table>

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
Switching between safety functions

<table>
<thead>
<tr>
<th>Sensor function</th>
<th>When using two sensors with the correct diagnostics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat.</td>
<td>3</td>
</tr>
<tr>
<td>PL</td>
<td>d</td>
</tr>
<tr>
<td>dC</td>
<td>Medium</td>
</tr>
<tr>
<td>CCF</td>
<td>&gt;65 %</td>
</tr>
<tr>
<td>Channels</td>
<td>2</td>
</tr>
<tr>
<td>Safety component to MD 2006/42/EC</td>
<td>No</td>
</tr>
</tbody>
</table>

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

Notes
Safe position sensing is possible when using two sensors with the correct diagnostics. 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.

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>575815</td>
<td>SAMH-S-NB-....-MK:</td>
<td>Mounting kit (complete)</td>
</tr>
<tr>
<td>575816</td>
<td>SAMH-S-NB-L-MK</td>
<td>Mounting kit (complete)</td>
</tr>
<tr>
<td>575817</td>
<td>SAMH-S-NR-S-SC</td>
<td>Cover (spare part)</td>
</tr>
<tr>
<td>575818</td>
<td>SAMH-S-NB-L-SC</td>
<td>Cover (spare part)</td>
</tr>
</tbody>
</table>

See the technical data of the individual products for detailed information. Please observe the legal information on page 76.
Cylinder as a door drive

When using two sensors with the correct diagnostics, the position of the pneumatically actuated safety door can be reported reliably (SAMH-S) and directly via the drive. Additional sensing per EN 1088 is not necessary.

The safety 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 protected against manipulation and securely mounted.

<table>
<thead>
<tr>
<th>Sensor function</th>
<th>When using two sensors with the correct diagnostics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cat.</td>
<td>3</td>
</tr>
<tr>
<td>PL</td>
<td>d</td>
</tr>
<tr>
<td>dC</td>
<td>Medium</td>
</tr>
<tr>
<td>CCF</td>
<td>≥65 %</td>
</tr>
<tr>
<td>Channels</td>
<td>2</td>
</tr>
<tr>
<td>Safety component to MD 2006/42/EC</td>
<td>No</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>575815</td>
<td>SAMH-S-N8-S-MK</td>
</tr>
<tr>
<td>575816</td>
<td>SAMH-S-N8-L-MK</td>
</tr>
<tr>
<td>575817</td>
<td>SAMH-S-N8-S-SC</td>
</tr>
<tr>
<td>575818</td>
<td>SAMH-S-N8-L-SC</td>
</tr>
</tbody>
</table>

See the technical data of the individual products for detailed information.

Please observe the legal information on page 76.
Dual-pressure regulator

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 two secondary venting ports for setting two different initial pressures in one device. Switching from the lower to the higher value occurs electrically.

Technical data
- Output 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
Can be used in higher category systems with additional measures.

Circuit symbol

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>550588</td>
<td>LR-D-MINI-ZD-V24-SA</td>
</tr>
<tr>
<td>567841</td>
<td>LR-D-MINI-ZD-V24-UK-SA</td>
</tr>
</tbody>
</table>

Please observe the legal information on page 76.
Safety valve MS6-SV-E and MS6-SV-E-ASIS

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

### Technical data

- **Voltage**: 24 V DC
- **Operating pressure**: 3.5 ... 10 bar
- **Temperature range**: –10 ... +50 °C
- **Flow rate (exhaust)**: up to 9000 l/min

### Possible special plug

**NECA-MP3-SA**

The NECA-MP3-SA permits activation of the MS6-SV with safety-related outputs. The enable signals EN1 and EN2 are galvanically isolated from the supply of the MS6-SV. Galvanic isolation is guaranteed via 2 optocouplers.

### Circuit symbol

- **Channels**: 2
- **Certificate**: IFA
- **Safety component to MD 2006/42/EC**: Yes

### 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
548719 | Multi-pin plug NECA-S1G9-P9-MP1
552703 | Multi-pin plug NECA-S1G9-P9-MP3
573695 | Multi-pin plug NECA-S1G9-P9-MP3-SA
8001481 | MS6-SV-1/2-E-ASIS-SO-AG

See the technical data of the individual products for detailed information. Please observe the legal information on page 76.
Safety valves MS6-SV-C and MS9-SV-C

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

<table>
<thead>
<tr>
<th>Cat.</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL</td>
<td>c</td>
</tr>
<tr>
<td>dC</td>
<td>Depending on diagnostics</td>
</tr>
<tr>
<td>Channels</td>
<td>1</td>
</tr>
<tr>
<td>Safety component to MD 2006/42/EC</td>
<td>No</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>8001469</td>
<td>MS6-SV-1/2-C-10V24</td>
</tr>
<tr>
<td>570737</td>
<td>MS9-SV-G-C-V24-S-VS</td>
</tr>
<tr>
<td>570739</td>
<td>MS9-SV-NG-C-V24-S-VS</td>
</tr>
</tbody>
</table>

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
On-off valve with piston position sensing

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, type MSSD-EB, plug design A, 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

Technical data
- Voltage: 24 V DC
- Operating pressure: 2.5 ... 16 bar
- Temperature range: -10 ... +60 °C

Cat. | Can be used in higher category systems with additional measures
PL  | Switching position sensing
dC | Channels
Channels | 1
Safety component to MD 2006/42/EC | No

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

Circuit symbol

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

Please observe the legal information on page 76.
Exhausting via non-return valves

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 can remain in the system. The suitability of the set-up must be tested in the application.

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

<table>
<thead>
<tr>
<th>Cat.</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL</td>
<td>d</td>
</tr>
<tr>
<td>dC</td>
<td>Medium</td>
</tr>
<tr>
<td>CCF</td>
<td>&gt;65 %</td>
</tr>
<tr>
<td>Channels</td>
<td>2</td>
</tr>
<tr>
<td>Safety component to MD 2006/42/EC</td>
<td>No</td>
</tr>
</tbody>
</table>

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

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
Soft-start and exhaust valve type VABF

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

Safety function
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 for monitoring the exhausted condition must be screwed on separately. The calculations of the PL must then be adjusted. The soft-start valve alone is not a complete safety solution.

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

Diagnostics
Diagnostics for both channels must be carried out via software in the customer’s machine control system.

<table>
<thead>
<tr>
<th>Cat.</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL</td>
<td>d</td>
</tr>
<tr>
<td>dC</td>
<td>Switching position sensing</td>
</tr>
<tr>
<td>CCF</td>
<td>&gt;65%</td>
</tr>
<tr>
<td>Channels</td>
<td>2</td>
</tr>
<tr>
<td>Safety component to MD 2006/42/EC</td>
<td>No</td>
</tr>
</tbody>
</table>

In combination with a second directional control valve

Pressurising

System protection for a restart

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

Diagnostics for both channels must be carried out via software in the customer’s machine control system.

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>557377</td>
<td>VABF-S6-1-P5A4-G12-4-1-P</td>
</tr>
</tbody>
</table>

See the technical data of the individual products for detailed information. Please observe the legal information on page 76.
VOFA – 5/2 Safety valves for presses

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

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Designation</th>
<th>Version</th>
</tr>
</thead>
<tbody>
<tr>
<td>569819</td>
<td>VOFA-L26-T52-M-G14-1C1-APP</td>
<td>Complete 2 x 5/2 control block, individual electrical connection, PNP sensor</td>
</tr>
<tr>
<td>569820</td>
<td>VOFA-L26-T52-M-G14-1C1-ANP</td>
<td>Complete 2 x 5/2 control block, individual electrical connection, NPN sensor</td>
</tr>
<tr>
<td>Characteristic</td>
<td>“SP” in the order code</td>
<td>Complete 2 x 5/2 control block, integration in valve terminal VTSA, PNP sensor</td>
</tr>
<tr>
<td>Characteristic</td>
<td>“SN” in the order code</td>
<td>Complete 2 x 5/2 control block, integration in valve terminal VTSA, NPN sensor</td>
</tr>
</tbody>
</table>

Diagnostics
Diagnostics via evaluation of the actuation and feedback signals must be carried out in a safety switching device. A machine control system must be integrated for evaluation of the feedback signals.
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 individual components. This can result in exhausting the cylinder chambers. Please also note this for the restart.

All specified values are maximum values, which can be achieved via correct operation of the component.
Stopping with non-return valves

Notes
Always check that each channel in multi-channel solutions fulfills 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-way valve, 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 individual components. This can result in exhausting the cylinder chambers. Please also note this for the restart.

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

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
ISO valve for lifting and rotary cylinders

**Description**
- For lifting and rotary cylinders in the automotive industry

**Application**
- Self-holding and subsequent pressure supply at 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).

**Technical data**
- **Voltage**: DC 24 V
- **Pressure**: 3 ... 10 bar
- **Temperature range**: -5 ... +50 °C
- **Flow rate**: 1000 l/min

**Order code**

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>560728</td>
<td>VSVA-B-P53AD-ZD-A1-1T1L</td>
<td>Size 01, 5/3 mid-position, 1 port pressurised and 1 port exhausted, switching position 14 detented</td>
</tr>
</tbody>
</table>

**Circuit symbol**

**Function**
- Retract clamping device
- Advance clamping device
- Clamping device in end position

**Normal operation**
- The 5/2-WV is used to retract the clamping device
- The 5/2-WV is used to retract the clamping device
- The end positions remain pressurised

**In the case of emergency off (electrical power is switched off)**
- The clamping device remains under pressure in both chambers. 5/3-WV normal position (14) 5/2-WV 12 switched
- The clamping device remains under pressure in both chambers. 5/3-WV normal position (14) 5/2-WV 12 switched
- The pressure is maintained in the end positions 5/3-WV 12 automatic locking 5/2-WV 14 or 12 switched

**Actuation**
- 5/3-WV 12 switched (no automatic locking)
- 5/2-WV 12 switched (no automatic locking)
- 5/3-WV is switched to 12 (automatic locking)
- 5/2-WV switched to 14 or 12

WV = way valve
Always check that each channel in multi-channel solutions fulfills the safety function.

The diagnostic evaluation must be performed by the software.

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

### Mechanical and pneumatic stopping

<table>
<thead>
<tr>
<th>Cat.</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL</td>
<td>d</td>
</tr>
<tr>
<td>dC</td>
<td>Medium</td>
</tr>
<tr>
<td>CCF</td>
<td>&gt;65%</td>
</tr>
<tr>
<td>Channels</td>
<td>2</td>
</tr>
<tr>
<td>Safety component to MD 2006/42/EC</td>
<td>No</td>
</tr>
</tbody>
</table>

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

See the technical data of the individual products for detailed information.

Please observe the legal information on page 76.
Clamping cartridges

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

Function

• 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.

Clamping cartridges

<table>
<thead>
<tr>
<th>Category</th>
<th>Part no.</th>
<th>Type</th>
<th>Stroke</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL</td>
<td>178455</td>
<td>KP-10-350</td>
<td>10 ... 2000</td>
</tr>
<tr>
<td>dC</td>
<td>178456</td>
<td>KP-12-600</td>
<td>10 ... 2000</td>
</tr>
<tr>
<td>CCF</td>
<td>178457</td>
<td>KP-16-1000</td>
<td>10 ... 2000</td>
</tr>
<tr>
<td></td>
<td>178458</td>
<td>KP-20-1400</td>
<td>10 ... 2000</td>
</tr>
<tr>
<td></td>
<td>178459</td>
<td>KP-20-2000</td>
<td>10 ... 2000</td>
</tr>
</tbody>
</table>

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
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 via compressed air

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

<table>
<thead>
<tr>
<th>Cat.</th>
<th>Can be used in higher category systems with additional measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL</td>
<td>dC</td>
</tr>
<tr>
<td>CCF</td>
<td>Channels 1</td>
</tr>
<tr>
<td>Safety component to MD 2006/42/EC</td>
<td>No</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>543903</td>
<td>DGSL-6</td>
</tr>
<tr>
<td>543904</td>
<td>DGSL-8</td>
</tr>
<tr>
<td>543905</td>
<td>DGSL-10</td>
</tr>
<tr>
<td>543906</td>
<td>DGSL-12</td>
</tr>
<tr>
<td>543907</td>
<td>DGSL-16</td>
</tr>
<tr>
<td>543908</td>
<td>DGSL-20</td>
</tr>
<tr>
<td>543909</td>
<td>DGSL-25</td>
</tr>
</tbody>
</table>

Circuit symbols

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
DGC with clamping unit

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

Function
Unpressurised state = Clamped state
Pressurised = Opened state

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

Clamping units for DGC axes

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>532447</td>
<td>DGC-25-...-1H...-PN</td>
</tr>
<tr>
<td>532448</td>
<td>DGC-32-...-1H...-PN</td>
</tr>
<tr>
<td>532449</td>
<td>DGC-40-...-1H...-PN</td>
</tr>
<tr>
<td>532450</td>
<td>DGC-50-...-1H...-PN</td>
</tr>
<tr>
<td>544426</td>
<td>DGC-25-...-1H...-PN</td>
</tr>
<tr>
<td>544427</td>
<td>DGC-32-...-1H...-PN</td>
</tr>
<tr>
<td>544428</td>
<td>DGC-40-...-1H...-PN</td>
</tr>
</tbody>
</table>

See the technical data of the individual products for detailed information. Please observe the legal information on page 76.
Cylinders with end-position locking

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

Function
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

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

<table>
<thead>
<tr>
<th>Cat.</th>
<th>Can be used in higher category systems with additional measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL</td>
<td></td>
</tr>
<tr>
<td>dC</td>
<td></td>
</tr>
<tr>
<td>CCF</td>
<td></td>
</tr>
<tr>
<td>Channels</td>
<td>1</td>
</tr>
<tr>
<td>Safety component to MD 2006/42/EC</td>
<td>No</td>
</tr>
</tbody>
</table>
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

Brake unit DNCKE-S, KEC-S

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
<th>Remark</th>
</tr>
</thead>
<tbody>
<tr>
<td>526482</td>
<td>DNCKE-40-PPV-A</td>
<td></td>
</tr>
<tr>
<td>526483</td>
<td>DNCKE-63-PPV-A</td>
<td></td>
</tr>
<tr>
<td>526484</td>
<td>DNCKE-100-PPV-A</td>
<td></td>
</tr>
<tr>
<td>538239</td>
<td>DNCKE-40-PPV-A-S</td>
<td>IFA-certified</td>
</tr>
<tr>
<td>538240</td>
<td>DNCKE-63-PPV-A-S</td>
<td>IFA-certified</td>
</tr>
<tr>
<td>538241</td>
<td>DNCKE-100-PPV-A-S</td>
<td>IFA-certified</td>
</tr>
<tr>
<td>527492</td>
<td>KEC-16</td>
<td></td>
</tr>
<tr>
<td>527493</td>
<td>KEC-20</td>
<td></td>
</tr>
<tr>
<td>527494</td>
<td>KEC-25</td>
<td></td>
</tr>
<tr>
<td>538242</td>
<td>KEC-16-S</td>
<td>IFA-certified</td>
</tr>
<tr>
<td>538243</td>
<td>KEC-20-S</td>
<td>IFA-certified</td>
</tr>
<tr>
<td>538244</td>
<td>KEC-25-S</td>
<td>IFA-certified</td>
</tr>
</tbody>
</table>

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

Input

Logic

Output

See the technical data of the individual products for detailed information. Please observe the legal information on page 76.
Stop valve VL-2-1/4-SA

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

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

Technical data
- Operating pressure: 0 ... 10 bar
- Temperature range: -20 ... 80 °C

Circuit symbol

Part no. | Type
--- | ---
25025 | VL-2-1/4-SA
Pilot air switching valve type VSVA

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 fulfills the safety function.
- Diagnostics must be carried out via software in the customer’s machine control system.
- The pneumatic diagram shown is only a basic example. The "switchable 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.

### Part no. | Type | Description |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>573201</td>
<td>VSVA-B-M52-MZD-A2-1T1L-APX-0.5</td>
<td>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 3-pin sensor push-in connector M12x1</td>
</tr>
<tr>
<td>570850</td>
<td>VSVA-B-M52-MZD-A1-1T1L-APX-0.5</td>
<td>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</td>
</tr>
<tr>
<td>573200</td>
<td>VABF-S4-2-S</td>
<td>Vertical stacking manifold, width 26 mm, for connecting the pilot air from channel 1 to channel 14</td>
</tr>
<tr>
<td>570851</td>
<td>VABF-S4-1-S</td>
<td>Vertical stacking manifold, width 26 mm, for connecting the pilot air from channel 1 to channel 14</td>
</tr>
<tr>
<td>800033</td>
<td>SPBA-P2R-G18-W-M12-0.25X</td>
<td>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</td>
</tr>
<tr>
<td>8000210</td>
<td>SPBA-P2R-G18-2P-M12-0.25X</td>
<td>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</td>
</tr>
</tbody>
</table>

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
Valves with switching position sensing

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 with spring return
- 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.

### Circuit symbol

---

### Part no. | Type | Size 01, 5/2 single solenoid, return via mech. spring, plug-in valve, with PNP sensor and cable
| 560723 | VSSA-B-M52-MZD-A1-1T1L-APC |
| 560724 | VSSA-B-M52-MZD-A1-1T1L-APP |
| 560725 | VSSA-B-M52-MZ-A1-1C1-APC |
| 560726 | VSSA-B-M52-MZ-A1-1C1-APP |
| 560742 | VSSA-B-M52-MZD-A1-1T1L-APC |
| 560743 | VSSA-B-M52-MZD-A1-1T1L-ANP |
| 560744 | VSSA-B-M52-MZ-A1-1C1-APC |
| 560745 | VSSA-B-M52-MZ-A1-1C1-ANP |

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
Valve with switching position sensing

Description
- The position of the piston spool is sensed directly
- Senses position, not pressure
- Suitable for circuits with a higher diagnostic coverage
- Suitable for higher category circuits to DIN EN ISO 13849-1

Sensors from Festo
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
- Wide range of mounting and connection options
- Heat and corrosion-resistant versions
- Copper and PTFE-free versions

Please note: sensors must be ordered separately.

Technical data
- Voltage: 24 V DC
- Pressure: 3 ... 10 bar
- Temperature range: -10 ... +50 °C
- Flow rate: 1200 ... 4500 l/min

Circuit symbol

<table>
<thead>
<tr>
<th>Cat.</th>
<th>Channels</th>
<th>Safety component to MD 2006/42/EC</th>
<th>dC</th>
<th>CCF</th>
<th>Can be used in higher category systems with additional measures</th>
</tr>
</thead>
<tbody>
<tr>
<td>PL</td>
<td>No</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Order code

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>185994</td>
<td>MDH-5/2-D1-FR-S-C-A-SA27102</td>
</tr>
<tr>
<td>188005</td>
<td>MDH-5/2-D2-FR-S-C-A-SA23711</td>
</tr>
<tr>
<td>188006</td>
<td>MDH-5/2-D3-FR-S-C-A-SA23712</td>
</tr>
</tbody>
</table>

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
The flow control valve is not a complete safety solution. It can be used as part of a solution.

**Function**
- Selection of a specified flow rate
- Secured with a spring pin against readjustment of the volumetric flow rate.

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

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
**Shut-off valve**

![Shut-off valve image]

**Notes**

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

**Function**

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

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

**Circuit symbol**

![Circuit symbol image]

**Table: Specifications**

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>197136</td>
<td>HE-G1-LO</td>
</tr>
<tr>
<td>197135</td>
<td>HE-G3/4-LO</td>
</tr>
<tr>
<td>197134</td>
<td>HE-G1/2-LO</td>
</tr>
<tr>
<td>197133</td>
<td>HE-G3/8-LO</td>
</tr>
<tr>
<td>197132</td>
<td>HE-N1-LO-NPT</td>
</tr>
<tr>
<td>197131</td>
<td>HE-N3/4-LO-NPT</td>
</tr>
<tr>
<td>197130</td>
<td>HE-N1/2-LO-NPT</td>
</tr>
<tr>
<td>197129</td>
<td>HE-N3/8-LO-NPT</td>
</tr>
</tbody>
</table>

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

---

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
ISO valve for pneumatic manual clamping devices

Technical data
- **Voltage**: DC 24 V
- **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)

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

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

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
<th>Size 01, 5/3 mid-position exhausted, switching position 14 detenting</th>
</tr>
</thead>
<tbody>
<tr>
<td>560727</td>
<td>VSYA-B-P53ED-ZD-A1-1T1L</td>
<td></td>
</tr>
</tbody>
</table>

**Function** | **Normal operation** | **In the case of emergency off (electrical power is switched off)** | **Actuation** |
--- | --- | --- | --- |
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 | Force supported by 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

Creating pressure zones and separating exhaust air
- With VTSA, pressure zones with different working pressures can be 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

Further examples of compressed air 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.

VTSA with CPX terminal connection
- Up to 16 pressure zones possible with VTSA (only with size 1, ISO 5599-2, up to 32 pressure zones are possible)

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

See the technical data of the individual products for detailed information. Please observe the legal information on page 76.
Creating pressure zones and separating exhaust air
- With 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 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 supply air, 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, 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.

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.

Please observe the legal information on page 76.
Safety function for servopneumatics

Switching off power

| Cat. | 2 | 3 |
| PL | d | d |
| dC | Medium | Medium |
| CCF | >65% | >65% |
| Channels | 1 | 2 |
| Safety component to MD 2006/42/EC | No | No |

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

Functions
- Protection against unexpected start-up (2-channel)
- Venting (1-channel)
- Stop category: “0” (EN 60204-1)
- Compressed air supply not deactivated

Notes
- This circuit 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 at the time of the request.
- On restart, the drive can move, depending on the start conditions.
- 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 76.
Safety function for servopneumatics

Mechanical and pneumatic stopping

- Protection against unexpected start-up (2-channel)
- Safety measure: stopping (2-channel)
- Stop category: "1"
- Compressed air 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.

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

Properties
- Protection against unexpected start-up (2-channel)
- Safety measure: stopping (2-channel)
- Stop category: "1"
- Compressed air 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.

See the technical data of the individual products for detailed information.

Please observe the legal information on page 76.
Safety function for servopneumatics

Pneumatic stopping

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.
- Use of a braking/clamping unit, together with the servopneumatic controller, can prevent a movement on restart.

Properties

- Protection against unexpected start-up (2-channel)
- Safety measure: stopping the movement (2-channel)
- Stop category: "1"
- Compressed air supply is switched off (2-channel)

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

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Designation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>550171</td>
<td>VPWP-6-L-5-...</td>
<td>Proportional valve, component of the servopneumatic system as a first channel</td>
</tr>
<tr>
<td>536546 161109</td>
<td>VSSV-B-M52-MZH-A1-1RS5L NAS-1/4-01-VDMA</td>
<td>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</td>
</tr>
<tr>
<td>548713</td>
<td>MS6-SV-1/2-E-10V24-50</td>
<td>Soft-start/quick exhaust valve with 2-channel self monitoring and performance level e</td>
</tr>
<tr>
<td>544428</td>
<td>DGCI-40-750-P-A</td>
<td>Rodless linear drive with displacement encoder</td>
</tr>
<tr>
<td>11689</td>
<td>H-QS-B</td>
<td>Non-return valve</td>
</tr>
</tbody>
</table>

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
### Safety function for servopneumatics

**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 and VPWP are switched or activated at the same time, this movement can be minimised.
- Use of a braking/clamping unit, together with the servopneumatic controller, can prevent a movement on restart.

**Properties**
- Protection against unexpected start-up (2-channel)
- Safety measure: stopping the movement (2-channel)
- Stop category: "1"
- Compressed air supply is switched off (2-channel)

### Properties

<table>
<thead>
<tr>
<th>Cat.</th>
<th>PL</th>
<th>dC</th>
<th>CCF</th>
<th>Channels</th>
<th>Safety component to MD 2006/42/EC</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>d</td>
<td>High</td>
<td>≥65%</td>
<td>2</td>
<td>No</td>
</tr>
</tbody>
</table>

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

### Part no. Designation Description

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Designation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>550171</td>
<td>VPWP-6-L-5-...</td>
<td>Proportional valve, component of the servopneumatic system as a first channel</td>
</tr>
<tr>
<td>560726</td>
<td>VSVA-B-M52-MZ-A1-1C1-APP NAS-1/4-O1-VDMA</td>
<td>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</td>
</tr>
<tr>
<td>161109</td>
<td>VSVA-B-M52-...</td>
<td></td>
</tr>
<tr>
<td>544428</td>
<td>DGCI-40-750-...</td>
<td>Rodless linear drive with displacement encoder</td>
</tr>
</tbody>
</table>

See the technical data of the individual products for detailed information. Please observe the legal information on page 76.
Safety function for servopneumatics

Properties

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

Notes

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

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

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Designation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>550171</td>
<td>VPWP-6-L-5-...</td>
<td>Proportional valve, component of the servopneumatic system as a first channel</td>
</tr>
<tr>
<td>534546</td>
<td>VSVB-M52-MZH-A1-1R5L NAS-1/4-01-VDMA</td>
<td>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.</td>
</tr>
<tr>
<td>161109</td>
<td>DNBCI-50-500-P-A</td>
<td>Standard cylinder</td>
</tr>
<tr>
<td>535413</td>
<td>DNCI-50-500-P-A</td>
<td>Standard cylinder</td>
</tr>
<tr>
<td>542897</td>
<td>SDE5-D10-FP-Q6E-P-M8</td>
<td>Pressure switch for diagnostics of the emergency stop valves (VSSA)</td>
</tr>
<tr>
<td>193973</td>
<td>GRO-QS-6</td>
<td>Flow control valve for regulating the repositioner speed</td>
</tr>
<tr>
<td>11689</td>
<td>H-QS-8</td>
<td>Non-return valve</td>
</tr>
</tbody>
</table>

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
The linear measuring system is a component of the modular axis system and can be configured in the following axes:

### Toothed belt axes

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>556813</td>
<td>EGC-70-...-M...</td>
</tr>
<tr>
<td>556814</td>
<td>EGC-80-...-M...</td>
</tr>
<tr>
<td>556815</td>
<td>EGC-120-...-M...</td>
</tr>
<tr>
<td>556817</td>
<td>EGC-185-...-M...</td>
</tr>
</tbody>
</table>

### Spindle axes

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>556807</td>
<td>EGC-70-...-M...</td>
</tr>
<tr>
<td>556808</td>
<td>EGC-80-...-M...</td>
</tr>
<tr>
<td>556809</td>
<td>EGC-120-...-M...</td>
</tr>
<tr>
<td>556811</td>
<td>EGC-185-...-M...</td>
</tr>
</tbody>
</table>

See the technical data of the individual products for detailed information. Please observe the legal information on page 76.
Comment

The linear measuring system is not a complete safety solution. It can be used as part of a solution.

A 2-channel solution is possible together with a motor encoder and a suitable safety switching device.

The position of the slide is measured directly – without additional mechanical influences.

Measuring directly on the carriage increases absolute accuracy.

Clamping unit for EGC axles

<table>
<thead>
<tr>
<th>Toothed belt axes</th>
<th>Spindle axes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Part no.</strong></td>
<td><strong>Type</strong></td>
</tr>
<tr>
<td>556814</td>
<td>EGC-80...-...H...-PN</td>
</tr>
<tr>
<td>556815</td>
<td>EGC-120...-...H...-PN</td>
</tr>
<tr>
<td>556817</td>
<td>EGC-185...-...H...-PN</td>
</tr>
</tbody>
</table>

See the technical data of the individual products for detailed information. Please observe the legal information on page 76.
Safety module CAMC-G-S1

Comment
The safety module CAMC-G-S1 is a plug-in card for the motor controller CMMP-AS-_-M3 and integrates the safety function of safe torque off (STO) up to PL e, category 4, in the motor controller. With an external safety switching device, it is possible to implement the safe stop 1 safety function (SS1), i.e. decelerate and then safe torque off (STO) with a time delay, in a straightforward manner.

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

| Cat. | 6 |
| PL | e |
| dC | High |
| CCF | >65% |
| Channels | 2 |
| Safety component acc. to MD 2006/42/EC | Yes |
| Part no. | Type |
| 1501330 | CAMC-G-S1 |

See the technical data of the individual products for detailed information. Please observe the legal information on page 73.
Safety module CAMC-G-S3

The safety module CAMC-G-S3 has been developed so that functional safety can be integrated into the motor controllers of the CMMP-AS-...-M3 series. This safety module integrates the following safety and logic functions in the motor controller:

- Safe torque off, STO
- Safe stop 1, SS1
- Safe operation stop, SOS
- Safe stop 2, SS2
- Safely limited speed, SLS
- Safe speed range, SSR
- Safe brake control, SBC
- Safe speed monitor, SSM
- Safe logic function (additional logic function, ALF), e.g. AND, OR, NOT, etc.

Using this plug-in card makes it possible to dispense with external safety switching devices in many applications, resulting in simplified wiring, reduced number of components and lower costs of the system solution.

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

| Cat. | 4 |
| PL  | e |
| dC  | High |
| CCF | >65% |
| Channels | 2 |
| Safety component acc. to MD 2006/42/EC | Yes |

Part no. | Type
---|---
1501331 | CAMC-G-S3

See the technical data of the individual products for detailed information. Please observe the legal information on page 76.
Safety module CMGA

Comment
The safety system CMGA permits one or two-channel monitoring of safety command devices (e.g. emergency stop switch, safety door, light curtain, operating mode selection switch, etc.), of speed and position sensors, their signal processing as well as one or two-channel triggering of a suitable safety measure.

This is a programmable system, which means it can be optimally adapted to the corresponding safety-oriented application. Programming examples in these guidelines allow the complexity of this programmable safety system to be reduced to downloading a user program, and wiring.

Safety functions:
- Safe stop 1 (SS1, decelerate and then safe torque off (STO))
- Safe stop 2 (SS2, delay and then safe operating stop (SOS))
- Safe operating stop (SOS)
- Safely limited speed (SLS)
- Safely-limited position (SLP)
- Safe brake control (SBC)
- Safe direction (SDI)
- Safe speed monitor (SSM)
- Safely-limited increment (SLI)
- Position deviation muting (PDM)
- Encoder status (ECS)
- Safely-limited acceleration (SLA)
- Safe acceleration range (SCA)
- Safe speed range (SSR)

CAT. 4
PL e
DC High
CCF ≥65%
Channels 2
Safety component to MD 2006/42/EC Yes

<table>
<thead>
<tr>
<th>Part no.</th>
<th>Type</th>
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</thead>
<tbody>
<tr>
<td>1680823</td>
<td>CMGA-B1-M0-L0-A0</td>
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<td>1680824</td>
<td>CMGA-B1-M1-L1-A0</td>
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<tr>
<td>1680825</td>
<td>CMGA-B1-M2-L2-A0</td>
</tr>
<tr>
<td>1680826</td>
<td>CMGA-E1</td>
</tr>
<tr>
<td>1680827</td>
<td>CMGA-E1-PB</td>
</tr>
<tr>
<td>1680828</td>
<td>CMGA-E1-CO</td>
</tr>
<tr>
<td>1680829</td>
<td>CMGA-E1-DN</td>
</tr>
</tbody>
</table>

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

See the technical data of the individual products for detailed information. Please observe the legal information on page 76.
Safety module CMGA

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

See the technical data of the individual products for detailed information. Please observe the legal information on page 76.
CPX Profisafe

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-F33GCGPEKANGKAQF-Z

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
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, in principle, supply all voltages via a single socket. A distinction is made between supplying the:
- electronics plus sensors
- valves plus actuators.

The following connection types can be selected:
- 7/8”, 4-pin 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 shut-off module.
Application examples

Notes
The sample applications show the circuitry of the motor controller CMM for safety switching devices from various manufacturers.

The sample applications use an emergency off switch to show how the safety functions safe torque off (STO) or safe stop 1 (SS1) can be implemented. As well as the description, circuit diagram, and parts list, it also includes an evaluation of the described safety functions with Sistema.

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
No more programming – just parameterisation

The application programs contained in these programming examples reduce the complexity of a programmable safety system to straightforward configuration and wiring, as with a simple safety relay.

Notes
The programming examples comprise the usual configurations of the safety system CMGA or the safety module CAMC-G-S3.

• Emergency stop switch trips the STO safety function in drives
• Emergency stop switch trips the SS1 safety function in drives
• Emergency stop switch and safety doors trip the SS1 safety function in drives, automatic and manual operating mode
• Emergency stop switch and safety doors trip the SS1 safety function in drives, automatic and manual operating mode (with enabling switch and safely limited speed (SLS))
• Emergency stop switch, safety doors and light curtains trip the SS1 safety function in drives, automatic and manual operating mode (with enabling switch and safely limited speed (SLS)), a light curtain in single-ended operation (intervention leads to SS2, with automatic start).

See the technical data of the individual products for detailed information.
Please observe the legal information on page 76.
Knowledge provides greater safety

Safety is always more than simply the hardware and 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 42,000 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 optimally prepare you or your employees for the specific safety responsibilities.

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 13849-1: "Although the specifications have been implemented by the EC Machinery Directive 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, a lot of time was spent discussing the details, which resulted in very high satisfaction ratings in the seminar evaluation.

Many participants wanted follow-up events, particularly on DIN EN ISO 13849. The 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

Festo Training and Consulting can also provide you with specific assistance during implementation

... for example with the following projects:
- Risk analysis and assessment of machines
- Carrying out a conformity evaluation process
- Support in obtaining the CE marking to the Machinery Directive 2006/42/EC
- Preparing technical documentation and operating instructions

Find out online at www.festo-tac.de about the project "Support in obtaining the CE marking to the Machinery Directive 2006/42/EC" at Stanzwerk Salzwedel GmbH & Co. KG or contact us directly with your specific inquiry:

seminare@de.festo.com
Tel. 0800/3378682
Overview of training courses

"Building and operating safe machines – successful integration of all contractual partners"

Legislation requires that both the machine builder and the owner of machines must comply with the laws. Machine builders need to comply with the EC Machinery Directive and other directives applicable to a machine, and they indicate this compliance through the CE marking and the Declaration of Conformity. These directives are transposed into national law in Germany in the form of the Product Safety Act (ProdSG). In Germany, the owner needs to comply with the Operational Safety Regulation (BetrSichV).

What tasks and responsibilities lie with whom in the chain from the supplier to the machine builder, and then to the owner? How can the law be taken into account while staying within a specific budget? This is where the manufacturer and owner, as negotiating partners, play a key role. The sooner both parties appreciate, accept and promote the importance of safety, and know what must be done, the more likely it is that costs can be kept low, and the sooner construction of a safe machine can start.

Content:
- European directives
- EC Machinery Directive – Operational safety regulation
- Responsibilities of machine suppliers, manufacturers and owners
- Performance specifications and technical specifications
- Participants
- Acceptance test criteria
- Limits of the machine
- Risk assessment to EN ISO 12 100
- Risk graph to EN ISO 13849-1
- Selection of operating modes and safety measures
- Safety behaviour of pneumatic drives
- Low-cost safe design

Duration: 1 day

The European Machinery Directive 2006/42/EC has been in force since December 2009, and requires design engineers to take extensive safety provisions into account in order to obtain the CE marking for machines and systems. The risk assessment, as stipulated in EN ISO 13849-1, is an important part of this and must be taken into account and applied by design engineers. This seminar provides the opportunity for familiarisation with specific pneumatic and electro-pneumatic circuits for "safety measures in safety-related pneumatics". These typical circuits are also considered in terms of their failure properties.

The seminar focuses on circuit technology.

Content:
- Structure and function of safety-related circuits to 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
- Safety principles of pneumatics according to 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 movement; reduced force and speed; two-hand operation)
- Fault analysis and exclusion to DIN EN ISO 13849-2
- Effect of tube length, diameter and fittings on the speed of cylinders
- Information on operating instructions and maintenance

Duration: 2 days

Dates and further information can be found at: www.festo-tac.de

"Safety in pneumatics and electro-pneumatics for design engineers"
Risk reduction measures are essential when building a safe machine. The previous standard, DIN EN 954-1, only specified quantitative aspects. However, the subsequent standard, EN ISO 13849-1, required designers to consider the quality of the safety control system too - as the failure probability also needs to be taken into account.

How is this done, from assessing the risk and determining the necessary performance level to the confirmation calculation?

**Content:**
- Risk assessment to EN ISO 13849-1 Terms in EN ISO 13849-1
- Performance Level (PL) – Probability of failure per hour (PFH) – Mean time to failure (MTTF) – Characteristic service life values of components (βₙ) – Diagnostic coverage (DC) – Common cause failures (CCF)
- Safety functions and control categories
- Determining the components in the safety chain
- Structure of the SISTEMA software
- Performing calculations based on examples
- Calculation with complex structures (multiple safety doors, multiple drives)
- Calculations with safety components and fault exclusion
- Creation of own libraries
- Integration of own documentation
- Practical computer exercises using the SISTEMA software

**Duration:** 2 days

The requirements placed on pneumatics in safety engineering, and which must be met, are complex and have far-reaching consequences. Many applications require precise consideration, because the only way to achieve a complete and correct estimate is by having a complete picture, which consists of components, safety circuits, safety measures, operating modes and costs.

**Content:**
- Holding vertical loads
- Vertical load and brakes with various operating modes
- Typical circuits in control category 2
- Testing in control category 2 and with brakes
- Other typical circuits related to the topics
- Stopping – Exhausting – Reduced force – Reduced speed – Unexpected restart
- Typical continuous circuits with sample calculation in SISTEMA

**Duration:** 2 days

Dates and further information: [www.festo-tac.de](http://www.festo-tac.de)
An important task of maintenance personnel involves rapidly locating faults in safety-related circuits, and eliminating the faults reliably. For this purpose, it is therefore essential to know about the function of the components and safety components used. This also includes their interaction in circuits, their representation in circuit diagrams as well as their classification in control categories. All maintenance staff thus need to be trained in safety engineering and the corresponding standard EN ISO 13849-1.

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 for pneumatics used for safety applications
- Unexpected restart – Blocking, braking and reversing of movements – Switching off power and free movement – Reduced force and speed – Two-hand operation
- Explaining and eliminating faults 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

Electric drives and axis systems are ubiquitous in mechanical engineering. However, how can the user achieve a safe electric drive with regard to the entire safety chain from the control elements to the mechanical systems? How should toothed belts and spindle drives be considered, and how can vertical drives be kept safe?

- Contents: Control categories to EN ISO 13849-1
- Stop categories to EN 60 204-1
- Functional safety to EN 61 800-5-2
- Axis mechanism: Spindle and toothed belt drives
- Vertical loads
- Holding and service brakes
- Typical circuits

Duration: 1 day

Dates and further information: www.festo-tac.de
Machine safety services from Festo in Austria

Festo Austria offers services for machine safety engineering, such as employee training, 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 background in fluid engineering.”

“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.”

Contact at Festo Austria:
Ing. Thomas Müller
fit4safe@festo.at

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1140 Vienna
Tel.: +43(0)1/91075-300
Fax: +43(0)1/91075-302
www.festo.at
www.festo-didactic.at
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.

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 content
• 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 EC 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
Either with a CD-ROM version or with 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

These guidelines are only intended as information for everyone who uses or wants to use safety engineering. All information contained in these guidelines 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 combinations and configurations 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 suggestions for concrete customer solutions and applications. The respective customer/user must check and observe the laws, guidelines and standards relevant for the construction, manufacture and product information, independently and as part of their 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

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>German denotation</th>
<th>English denotation</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>a, b, c, d, e (PL)</td>
<td>Bezeichnung für die Performance Level</td>
<td>Denotation of performance levels</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>AB</td>
<td>Anzeige-Bediengeräte</td>
<td>Display and operating units</td>
<td>Festo</td>
</tr>
<tr>
<td>AC/DC</td>
<td>Wechsel-/Gleichstrom</td>
<td>Alternating current/direct units</td>
<td>IEC 61511</td>
</tr>
<tr>
<td>AE</td>
<td>Anfahr- und Entlüftungsventile</td>
<td>Start-up and exhaust valves</td>
<td>Festo</td>
</tr>
<tr>
<td>ALARP</td>
<td>So niedrig wie vernünftigerweise möglich</td>
<td>As low as reasonably practicable</td>
<td>IEC 61511</td>
</tr>
<tr>
<td>ANSI</td>
<td>US-amerikanische Normungsorganisation</td>
<td>American National Standards Institute</td>
<td>IEC 61511</td>
</tr>
<tr>
<td>AOPD/AOPDDR</td>
<td>Aktive optoelektronische Schutzeinrichtung</td>
<td>Active optoelectronic protection device responsive to diffuse reflection</td>
<td>ISO 12100, DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>AS-Interface</td>
<td>Aktuator Sensor Interface</td>
<td>Aktuator Sensor Interface</td>
<td></td>
</tr>
<tr>
<td>B, 1, 2, 3, 4</td>
<td>Bezeichnung für die Kategorien</td>
<td>Denotation of categories</td>
<td>DIN EN ISO 13849-1</td>
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<td>B_{10}</td>
<td>Anzahl von Zyklen, bis 10 % der Komponenten ausgefallen sind (u.a. für pneumatische und elektromechanische Komponenten)</td>
<td>Number of cycles until 10% of the components fail (for pneumatic and electromechanical components)</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>B_{10, d}</td>
<td>Anzahl von Zyklen, bis 10 % der Komponenten gefährlich ausgefallen sind (u.a. für pneumatische und elektromechanische Komponenten)</td>
<td>Number of cycles until 10% of the components fail dangerously (for pneumatic and electromechanical components)</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>BPCS</td>
<td>Betriebs- und Überwachungseinrichtungen</td>
<td>Basic process control system</td>
<td>IEC 61511</td>
</tr>
<tr>
<td>BPCS</td>
<td>Betriebs- und Überwachungseinrichtungen als ein System</td>
<td>Basic process control system</td>
<td>IEC 61511</td>
</tr>
<tr>
<td>BSL</td>
<td>Bootstraploader</td>
<td>Bootstraploader</td>
<td></td>
</tr>
<tr>
<td>BTB/RTO</td>
<td>Betriebsbereit</td>
<td>Ready-to-operate</td>
<td></td>
</tr>
<tr>
<td>BWP</td>
<td>Berührungslos wirkende Positionsschalter</td>
<td>Electro-sensitive position switch</td>
<td></td>
</tr>
<tr>
<td>BWS</td>
<td>Berührungslos wirkende Schutzeinrichtung</td>
<td>Electro-sensitive protective equipment</td>
<td>EN 61496</td>
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<tr>
<td>Cat.</td>
<td>Kategorie</td>
<td>Category</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>CC</td>
<td>Stromrichter</td>
<td>Current converter</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>ccd</td>
<td>Kommando-Code, Teil einer SDO-Nachricht</td>
<td>Command-code</td>
<td></td>
</tr>
<tr>
<td>CCF</td>
<td>Ausfall in Folge gemeinsamer Ursache</td>
<td>Common cause failure</td>
<td>IEC 61508, IEC 62061, prEN ISO 12849-1EN 61511-1:2004, DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>CEN</td>
<td>Europäisches Komitee für Normung</td>
<td>European Committee for Standardization</td>
<td></td>
</tr>
<tr>
<td>CENELEC</td>
<td>Europäisches Komitee für elektrotechnische Normung</td>
<td>European Committee for Electrotechnical Standardization</td>
<td></td>
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<tr>
<td>CMF</td>
<td>Ausfall in Folge gemeinsamer Ausfallart</td>
<td>Common mode failure</td>
<td>EN 61511-1:2004</td>
</tr>
<tr>
<td>CRC</td>
<td>Prüfsumme in einem Daten-Telegramm, Signatur durch zyklische Redundanzprüfung</td>
<td>Cyclic Redundancy Check</td>
<td>Signature by cyclical redundancy check</td>
</tr>
<tr>
<td>DCavg[%]</td>
<td>Diagnosedeckungsgrad (von Tests)</td>
<td>Diagnostic Coverage, average</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>DPV</td>
<td>Funktionsversionen von PROFIBUS</td>
<td></td>
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</tr>
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<tr>
<td>DR</td>
<td>Druckventile</td>
<td>Pressure control valves</td>
<td>Festo</td>
</tr>
<tr>
<td>DS</td>
<td>Druckschalter</td>
<td>Pressure switch</td>
<td>Festo</td>
</tr>
<tr>
<td>DV</td>
<td>Druckverstärker</td>
<td>Pressure amplifier</td>
<td>Festo</td>
</tr>
<tr>
<td>E</td>
<td>Externe Einrichtung zur Risikominderung</td>
<td>External risk reduction facilities</td>
<td>EN 61511-1:2004</td>
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<tr>
<td>E/A</td>
<td>Eingabe/Ausgabe</td>
<td>Input/Output</td>
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<tr>
<td>E/E/PE</td>
<td>Elektrisch/elektronisch/programmierbar elektronisch</td>
<td>Electrical/Electronic/programmable electronic</td>
<td>IEC 61511, IEC 61508</td>
</tr>
<tr>
<td>E/E/PES</td>
<td>Elektrisches/elektronisches/programmierbares elektronisches System</td>
<td>Electrical/Electronic/programmable electronic system</td>
<td>IEC 61511</td>
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<tr>
<td>Abbreviation</td>
<td>German denotation</td>
<td>English denotation</td>
<td>Source</td>
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<tr>
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<td>------------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------</td>
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<tr>
<td>EDM</td>
<td>Schützkontrolle, Rückführkreis</td>
<td>External Device Monitoring</td>
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<tr>
<td>EDS</td>
<td>Elektronisches Datenblatt</td>
<td>Electronic Data Sheet</td>
<td></td>
</tr>
<tr>
<td>F, F1, F2</td>
<td>Häufigkeit und/oder Dauer der Gefährdungsexposition</td>
<td>Frequency and/or time of exposure to the hazard</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>FB</td>
<td>Funktionsblock</td>
<td>Function block</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>FMEA</td>
<td>Ausfallarten und Effekt-Analyse</td>
<td>Failure modes and effects analysis</td>
<td>DIN EN ISO 13849-1, EN ISO 12100</td>
</tr>
<tr>
<td>FO</td>
<td>Funktionsorientierte Antriebe</td>
<td>Function-oriented drives</td>
<td>Festo</td>
</tr>
<tr>
<td>FR</td>
<td>Filterregler</td>
<td>Filter-regulator unit</td>
<td>Festo</td>
</tr>
<tr>
<td>FTA</td>
<td>Fehlerbaumanalyse/Fehlerzustands-baumanalyse</td>
<td>Fault Tree Analysis</td>
<td>EN ISO 12100</td>
</tr>
<tr>
<td>Gefährdung</td>
<td>Potenzielle Quellen von Verletzungen oder Gesundheitsschäden</td>
<td>Potential source of injury or damage to health</td>
<td>Machinery Directive 2006/42/EC</td>
</tr>
<tr>
<td>Gefährdungs-</td>
<td>Jeder Bereich in einer Maschine und/oder um eine Maschine herum, in dem eine Person</td>
<td>Any zone within and/or around machinery in which a person is</td>
<td>EN ISO 12100</td>
</tr>
<tr>
<td>bereich</td>
<td>einer Gefährdung ausgesetzt sein kann</td>
<td>subject to a risk to his health or safety</td>
<td></td>
</tr>
<tr>
<td>H &amp; RA</td>
<td>Gefährdungs- und Risikobeurteilung</td>
<td>Hazard and risk assessment</td>
<td>IEC 61511</td>
</tr>
<tr>
<td>H/W</td>
<td>Hardware</td>
<td>Hardware</td>
<td>IEC 61511</td>
</tr>
<tr>
<td>HFT</td>
<td>Hardware-Fehlertoleranz</td>
<td>Hardware fault tolerance</td>
<td>IEC 61511</td>
</tr>
<tr>
<td>HMI</td>
<td>Mensch-Maschine-Schnittstelle</td>
<td>Human machine interface</td>
<td>IEC 61511</td>
</tr>
<tr>
<td>HRA</td>
<td>Analyse menschlicher Zuverlässigkeit</td>
<td>Human reliability analysis</td>
<td>IEC 61511</td>
</tr>
<tr>
<td>I, I1, I2</td>
<td>Eingabegerät, z.B. Sensor</td>
<td>Input device, e.g. sensor</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>i, j</td>
<td>Index für Zählung</td>
<td>Index for counting</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>I/O</td>
<td>Eingänge/Ausgänge</td>
<td>Inputs/Outputs</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>iab, iabc</td>
<td>Verbindungsmittel</td>
<td>Interconnecting means</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>Infhärente</td>
<td>Schutzmaßnahme, die entweder Gefährdungen beseitigt oder die mit den Gefährdungen</td>
<td>Inherently safe design measure</td>
<td>EN ISO 12100</td>
</tr>
<tr>
<td>sichere</td>
<td>verbundenen Risiken vermindert, indem ohne Anwendung von trennenden oder nicht</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>trennenden Schutzeinrichtungen verhindert, dass die in den Verkehr gebrachten</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maschinen allen einschlägigen grundlegenden Sicherheits- und Gesundheitsanforderungen entspricht</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KL</td>
<td>Kolbenstangenloser Zylinder</td>
<td>Rodless cylinders</td>
<td>Festo</td>
</tr>
<tr>
<td>Konformitäts-</td>
<td>Verfahren, bei dem der Hersteller oder sein in der Gemeinschaft niedergelassener</td>
<td>Declaration of conformity</td>
<td>EC Machinery Directive 2006/42/EC</td>
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<tr>
<td>erklärung</td>
<td>Bevollmächtigter erklärt, dass die in den Verkehr gebrachten Maschinen allen ein-</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>schlägigen grundlegenden Sicherheits- und Gesundheitsanforderungen entspricht</td>
<td></td>
<td></td>
</tr>
<tr>
<td>KS</td>
<td>Kolbenstangenzylinder</td>
<td>Cylinders with position rod</td>
<td>Festo</td>
</tr>
<tr>
<td>L, L1, L2</td>
<td>Logik</td>
<td>Logic</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>Lambda</td>
<td>Ausfallrate bei ungefährlichen und Gefahr bringenden Fehlern</td>
<td>Rate to failure</td>
<td>IEC 62061</td>
</tr>
<tr>
<td>MTBF</td>
<td>Mittlere Ausfallzeit eines Gerätes</td>
<td>Mean time between failure</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>MTTF/MTTF_d</td>
<td>Zeit bis zu einem Ausfall bzw. gefährlichen Ausfall</td>
<td>Mean time to failure/ Mean time to dangerous failure</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>MTR</td>
<td>Mittlere Reparaturzeit eines Gerätes</td>
<td>Mean time to repair</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>NMT</td>
<td>Service-Dienste des CAN-Application Layers</td>
<td>Network Management</td>
<td></td>
</tr>
<tr>
<td>n niedrig</td>
<td>Anzahl von SRP/CS mit PL niedrig in einer Kombination von SRP/CS</td>
<td>Number of SRP/CS with PL in a combination of SRP/CS</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>NOT-AUS</td>
<td>Ausschalten im Notfall</td>
<td>Emergency switch-off</td>
<td>EN 418 (ISO 13850) EN 60204-1 annex D</td>
</tr>
<tr>
<td>NOT-HALT</td>
<td>Stilsetzen im Notfall</td>
<td>Emergency stop</td>
<td>ISO 13850 EN 60204-1 annex D</td>
</tr>
<tr>
<td>NP</td>
<td>Nicht programmierbares System</td>
<td>Non-programmable system</td>
<td>EN 61511-1:2004</td>
</tr>
<tr>
<td>DS</td>
<td>Druckschalter</td>
<td>Pressure switch</td>
<td>Festo</td>
</tr>
<tr>
<td>Abbreviation</td>
<td>German denotation</td>
<td>English denotation</td>
<td>Source</td>
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<td>--------------</td>
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<tr>
<td>DV</td>
<td>Druckverstärker</td>
<td>Pressure amplifier</td>
<td>Festo</td>
</tr>
<tr>
<td>O, O1, O2, OTE</td>
<td>Ausgabegerät, z.B. Antriebselement</td>
<td>Output device, e.g. actuator</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>OE</td>
<td>Öler</td>
<td>Lubricator</td>
<td>Festo</td>
</tr>
<tr>
<td>OSHA</td>
<td>Open System Interconnection</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OSI</td>
<td>Referenzmodell zur Datenkommunikation, Darstellung als Schichtenmodell mit verteilten Aufgaben für jede Schicht</td>
<td></td>
<td></td>
</tr>
<tr>
<td>OSSD</td>
<td>Ausgangsschaltelement, Sicherheits-Schaltausgang</td>
<td>Output Signal Switching Device</td>
<td>EN 61496-1</td>
</tr>
<tr>
<td>P, P1, P2</td>
<td>Möglichkeit zur Vermeidung der Gefährdung</td>
<td>Possibility of avoiding the hazard</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>Pdh</td>
<td>Wahrscheinlichkeit gefährbringender Ausfälle</td>
<td>Probability of dangerous failure</td>
<td>IEC 61508, IEC 62061</td>
</tr>
<tr>
<td>PE</td>
<td>Programmierbare Elektronik</td>
<td>Programmable electronics</td>
<td>EN 61511-1</td>
</tr>
<tr>
<td>PES</td>
<td>Programmierbares elektronisches System</td>
<td>Programmable electronic system</td>
<td>EN 61511-1, DIN EN</td>
</tr>
<tr>
<td>PFD</td>
<td>Ausfallwahrscheinlichkeit bei Auslösen/ Anfrage der Sicherheitsfunktion</td>
<td>Probability of failure on demand</td>
<td>IEC 61508, IEC 62061</td>
</tr>
<tr>
<td>PFH</td>
<td>Ausfallwahrscheinlichkeit pro Stunde</td>
<td>Probability of failure per hour</td>
<td>IEC 62061</td>
</tr>
<tr>
<td>PFH₄</td>
<td>Wahrscheinlichkeit gefährbringender Ausfälle pro Stunde</td>
<td>Probability of dangerous failure per hour</td>
<td>IEC 62061</td>
</tr>
<tr>
<td>PHA</td>
<td>Vorläufige Untersuchung von Gefährdungen</td>
<td>Preliminary hazard analysis</td>
<td>EN ISO 12100</td>
</tr>
<tr>
<td>PL/Perfor-</td>
<td>Diskreter Level, der die Möglichkeit</td>
<td>Discrete level used to specify the ability</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>mance Level</td>
<td>to vermeiden einer Steuerung</td>
<td>of safety-related parts of control systems</td>
<td></td>
</tr>
<tr>
<td>PLₜ</td>
<td>Angewandter Performance Level(PL), um die erforderliche Risikominderung für jede Sicherheitsfunktion zu erreichen</td>
<td>Performance level (PL) applied in order to achieve the required risk reduction for each safety function</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>PLC</td>
<td>Speicherprogrammierbare Steuerung (SPS)</td>
<td>Programmable logic controller</td>
<td>IEC 61511, DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>PLₙiederig</td>
<td>Niedrigster Performance Level einer SRP/CS in einer Kombination von SRP/CS</td>
<td>Lowest performance level of a SPR/CS in a combination with SPR/CS</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>PR</td>
<td>Proportionalventile</td>
<td>Proportional valves</td>
<td>Festo</td>
</tr>
<tr>
<td>RE</td>
<td>Regler</td>
<td>Regulator</td>
<td>Festo</td>
</tr>
<tr>
<td>Restrisiko</td>
<td>Risiko, das nach Ausführung der Schutzmaßnahme verbleibt</td>
<td>Risk remaining after safety measures have been taken</td>
<td>EN ISO 12100</td>
</tr>
<tr>
<td>Risiko</td>
<td>Kombination der Wahrscheinlichkeit</td>
<td>Combination of the Probability</td>
<td>EN ISO 12100</td>
</tr>
<tr>
<td>Risikoanalyse</td>
<td>Kombination aus Festlegung der Grenzen einer Maschine, Identifizierung einer Gefährdung und Risikoeinschätzung</td>
<td>Combination of the specification of the limits of the machine, hazard identification and risk estimation</td>
<td>EN ISO 12100</td>
</tr>
<tr>
<td>Risiko-</td>
<td>Gesamtheit des Verfahrens, das eine Risikoanalyse und Risikobewertung umfasst</td>
<td>Overall process comprising a risk analysis and a risk evaluation</td>
<td>EN ISO 12100</td>
</tr>
<tr>
<td>beurteilung</td>
<td>Auf der Risikoanalyse beruhende Beurteilung, ob die Ziele zur Risikominderung erreicht wurden</td>
<td>Judgement, on the basis of risk analysis, of whether the risk reduction objectives have been achieved</td>
<td>EN ISO 12100</td>
</tr>
<tr>
<td>Risiko-</td>
<td>Bestimmung des wahrscheinlichen Ausmaßes eines Schadens und der Wahrscheinlichkeit seines Eintritts</td>
<td>Defining likely severity of harm and probability of its occurrence</td>
<td>EN ISO 12100</td>
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<tr>
<td>Bewertung</td>
<td>Schwere der Verletzung</td>
<td>Severity of injury</td>
<td>DIN EN ISO 13849-1</td>
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<tr>
<td>SA</td>
<td>Schwenkantriebe</td>
<td>Semi-rotary drives</td>
<td>Festo</td>
</tr>
<tr>
<td>SAT</td>
<td>Vor-Ort-Abnahme</td>
<td>Site acceptance test</td>
<td>IEC 61511</td>
</tr>
<tr>
<td>Schaden</td>
<td>Physikalische Verletzung und/oder Schädigung von Gesundheit oder Sachen</td>
<td>Physical injury or damage to health</td>
<td>EN 61511-1</td>
</tr>
<tr>
<td>Schutz-</td>
<td>Maßnahme zur Beseitigung einer Gefährdung oder zur Minderung eines Risikos</td>
<td>Means that eliminates a hazard or reduces a risk</td>
<td>EN ISO 12100, EN 61511-1</td>
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<tr>
<td>SIF</td>
<td>Sicherheitstechnische Funktion</td>
<td>Safety instrumental function</td>
<td>EN 61511-1</td>
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<tr>
<td>Abbreviation</td>
<td>German denotation</td>
<td>English denotation</td>
<td>Source</td>
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<tr>
<td>SIL</td>
<td>Sicherheits-Integritätslevel</td>
<td>Safety integrity level</td>
<td>IEC 61511, DIN EN ISO 13849-1</td>
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<tr>
<td>SIS</td>
<td>Sicherheitstechnisches System</td>
<td>Safety instrumented system</td>
<td>EN 61511-1</td>
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<tr>
<td>SP</td>
<td>Sperrventile</td>
<td>Shut-off valves</td>
<td>Festo</td>
</tr>
<tr>
<td>SPE</td>
<td>Sensitive Schutzeinrichtung mechanisch behaftetes Betriebsmittel</td>
<td>Sensitive Protection Equipment</td>
<td>EN ISO 12100</td>
</tr>
<tr>
<td>SIS</td>
<td>Sicherheitstechnisches System</td>
<td>Safety instrumented system</td>
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<tr>
<td>SPE</td>
<td>Sensitive Schutzeinrichtung mechanisch behaftetes Betriebsmittel</td>
<td>Sensitive Protection Equipment</td>
<td>EN ISO 12100</td>
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<tr>
<td>ST</td>
<td>Stromventile</td>
<td>Flow control valves</td>
<td>Festo</td>
</tr>
<tr>
<td>SW1A, SW1B,</td>
<td>Positionsschalter</td>
<td>Position switches</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>SW2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SYNC</td>
<td>Objekt zur Synchronisierung von Teilnehmern im Netzwerk</td>
<td>Synchronisation objects</td>
<td></td>
</tr>
<tr>
<td>TE</td>
<td>Testeinrichtung</td>
<td>Test equipment</td>
<td>DIN EN ISO 13849-1</td>
</tr>
<tr>
<td>TM</td>
<td>Gebrauchsdauer</td>
<td>Mission time</td>
<td>DIN EN ISO 13849-1</td>
</tr>
</tbody>
</table>

- **SIL**: Sicherheits-Integritätslevel (Safety integrity level), source IEC 61511, DIN EN ISO 13849-1
- **SIS**: Sicherheitstechnisches System (Safety instrumented system), source EN 61511-1
- **SP**: Sperrventile (Shut-off valves), source Festo
- **SPE**: Sensitive Schutzeinrichtung mechanisch behaftetes Betriebsmittel (Sensitive Protection Equipment), source EN ISO 12100
- **ST**: Stromventile (Flow control valves), source Festo
- **SYNC**: Objekt zur Synchronisierung von Teilnehmern im Netzwerk (Synchronisation objects), source DIN EN ISO 13849-1
- **TE**: Testeinrichtung (Test equipment), source DIN EN ISO 13849-1
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