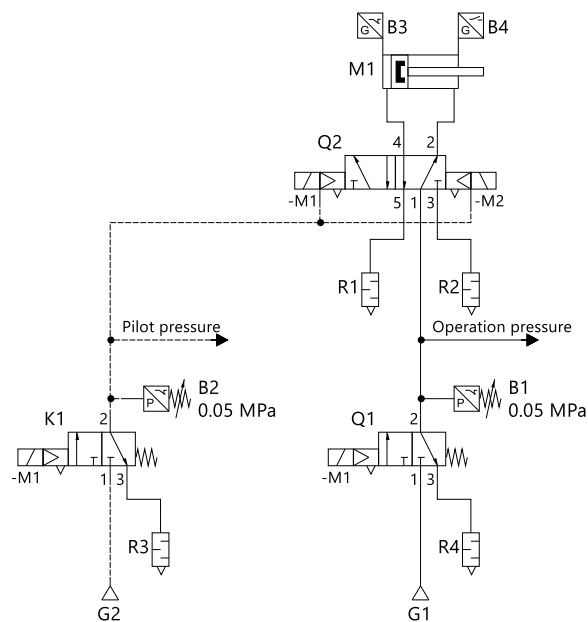


Circuit

Safety-Subfunctions Pneumatic

PUS – Prevention unexpected start-up – up to Cat. 3, up to PL e



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Title Safety Subfunctions Pneumatics - Circuit
Version 1.40
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Original German
Author Festo
Date 21.07.2026

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- Specialist in pneumatics
- Specialist in electrical engineering
- Specialist for the programming of control systems and safety switching devices

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1 General

1.1 Objectives of this Document

- This document shows a possible example circuit for the safety sub-functions PUS (Prevention of Unexpected Startup, with operation pressure supply: up to category 3, up to PL e) and PUS (with pilot pressure supply) with up to category 3, up to PL d.
- For the implementation of the safety sub-function relevant components, the most important features are listed.
- Based on these features, suitable products from Festo are recommended.

1.2 General Notes

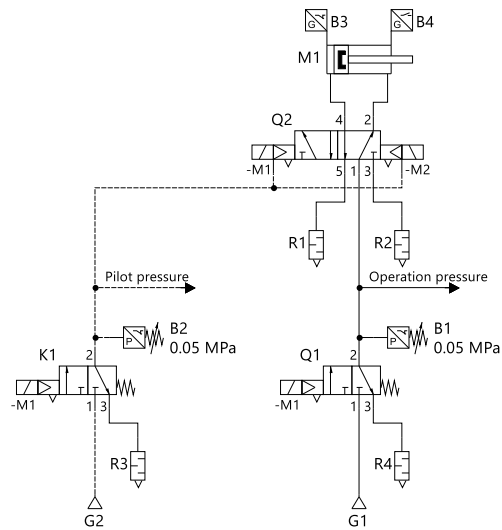
- The given circuit is a principle circuit which cannot be complete due to clarity and scope. It is a recommendation that does not exclude other possibilities.
- The abbreviations used for the safety subfunctions are based on the definitions in VDMA 24584 for pneumatics. The definitions used and important notes are given in the document [↗ 100405 Safety subfunctions pneumatics – PUS](#).
- The requirements for the valve are only considered in the context of the pneumatic circuit. Suggestions for the electrical wiring of individual valves or valve terminals have not been considered in this document.
 - For single valves, the document [↗ 100393 Safe electrical switch-off of individually controlled valves](#) should be considered.
 - For valve terminals, the document [↗ 100394 Safe electrical switch-off of valve terminals](#) should be considered.
- In the product list included here with recommendations for suitable products, we have checked the specified requirements for the pneumatic circuit. However, if further information is available to us, e.g. through our product observation, this data can be changed on a daily basis. Therefore, these data must be checked in the data sheets available online before final use to see if there has been any change.
- Whether a recommended product is suitable for a particular application must be checked by the user and confirmed in his technical documentation.
- For the Sistema project file of this circuit, the document [↗ 100395 Notes on Sistema project files](#) must be taken into account.

1.3 Notes on safety-related features of the partial circuit

- For safety sub-functions with 2-channel architecture of the safety circuit (here category 3), a fault does not lead to a single failure of the safety sub-function.
- If the pilot air is switched off alone, the valve Q2 requires the fault exclusion “spontaneous change of the initial switching position (without input signal) for the main stage”. This fault exclusion reduces the structure to one channel. Since PL e cannot be based solely on a fault exclusion (ISO 13849-1, 6.1.10.3), the maximum possible PL is limited to PL d.
- Faults can occur with valve Q2 that may require further action as failure reaction. This must be assessed depending on the application. Failures include, for example, controlling a movement by introducing compressed air via the exhausting of the pilot valve or the drive does not reach the end position.
- By switching off Q1 in the event of a failure, a safe state can be reached if any movement from the end position does not lead to any hazard.
- Other measures may also be appropriate. This must be assessed on an application-related basis.
- The consideration of measures for failures due to common cause (CCF) are to be evaluated depending on the application. Recommendations on possible measures are contained in the document [↗ 100399 Recommendations for the implementation of measures against common cause failures \(CCF\)](#).
- The calculation of the MTTF₀ characteristic value from the B₁₀ values are included in the Sistema project file. The B₁₀ value must be adjusted according to the valves used.

- A B_{10} value only for the pilot valves of Q2 is not available. The B_{10} value for the total valve is used, which in any case takes the pilot valves into account.
- In order for valve Q2 to reach a switching position, valve K1 should be switched off after valve Q2. The time delay should be the switching time of valve Q2 with safety factor.
- To ensure that the pneumatic drive M1 reaches an end position, valve Q1 should be switched off after valve Q2. The time delay should be the positioning time of the drive with safety factor.
- In order to estimate a diagnostic coverage for the valves Q1, K1 a suitable plausibility and switching time monitoring of the control signal up to the signal change of the sensors B1, B2 should be implemented.
- In order to estimate a diagnostic coverage for valve Q2, a suitable plausibility and positioning time monitoring of the control signals up to the signal change of sensors B3, B4 should be implemented.

2 Circuit



Parts list

Pos...	Identifi...	Description
1	B1	Pressure switch
2	B2	Pressure switch
3	B3	Limit switch
4	B4	Limit switch
5	G1	Operation pressure
6	G2	Pilot air
7	K1	3/2-way valve
8	M1	Double-acting drive
9	Q1	3/2-way valve
10	Q2	5/2-way valve
11	R1	Silencer
12	R2	Silencer
13	R3	Silencer
14	R4	Silencer

Q1

In the event of certain failures, the shut-off of valve Q1 is used as a failure reaction. Failures are e.g. control of a movement by entry of compressed air via the exhaust of the pilot valve or the drive does not reach the end position.

By switching off Q1 in the event of a failure, a safe state can be reached, if a possible movement out of an end position does not lead to any hazard.

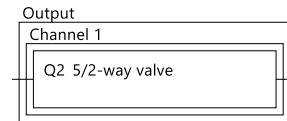
Other measures may also be suitable.

This has to be assessed in relation to the application.

Safety subfunctions and Block diagrams

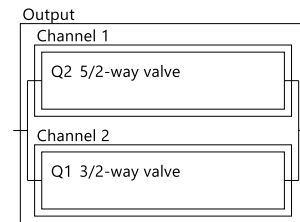
Switch-off working valve

PUS - Prevention unexpected start-up: up to category 1, up to PL c can be reached



Switch-off working pressure and working valve

PUS - Prevention unexpected start-up: up to category 3, up to PL e can be reached

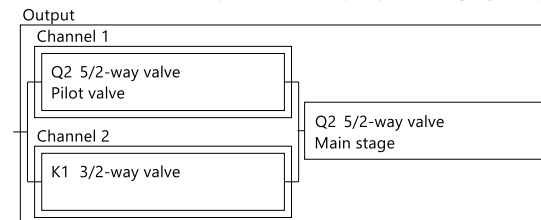


Q2, B3, B4
5/2-way valve
Diagnostic coverage DC=90%
Indirect monitoring
With positioning time monitoring by limit switches
(estimate according ISO 13849-1, table E.1)

Q1, B1
3/2-way valve
Diagnostic coverage DC=90%
Indirect monitoring
With switching time monitoring by pressure switch
(estimate according ISO 13849-1, table E.1)

Switch-off pilot pressure and working valve

PUS - Prevention unexpected start-up: up to category 3, up to PL d can be reached



Q2, B3, B4
5/2-way valve
Diagnostic coverage DC=90%
Indirect monitoring
With positioning time monitoring by limit switches
(estimate according ISO 13849-1, table E.1)
Q2
Valve needs following fault exclusion:
Spontaneous change of the initial switching position
(without an input signal) for the main stage
PL e shall not depend solely on fault exclusion
(ISO 13849-1, 6.1.10.3), so the maximum
possible PL is limited to PL d.

K1, B2
3/2-way valve
Diagnostic coverage DC=90%
Indirect monitoring
With switching time monitoring by pressure switch
(estimate according ISO 13849-1, table E.1)

3 Suitable Products for Sensor B1, B2

3.1 Pressure Switch

- Based on the following features, other suitable pressure switches from Festo can also be selected using the features in the data sheets available online.
- Depending on the application, it must be evaluated whether this list of features needs to be added.

Feature	Value
Product category	pressure switch
Measured variable	relative pressure
Switching element function	antivalent OR NC contact OR changeover OR switchable
Operating pressure	0 – 8 bar OR 1 – 10 bar OR 1 – 12 bar OR -1 – 10 bar
As an alternative to the operating pressure the start and end value for pressure measuring range can be used.	
Start value for pressure measuring range	0 bar
End value for pressure measuring range	10 bar

Other values for the features may be possible and must be considered separately.

Note: These pressure switches were selected as examples from different series and sizes.

No.	Material	Designation/Type (Sorting ↑)	Link Data Sheet
1.	10773	Pressure switch PEV-1/4-B	↗
2.	8000210	Pressure switch SPBA-P2R-G18-2P-M12-0,25X	↗

3.2 Pressure sensors

- Based on the following features, other suitable pressure sensors from Festo can also be selected using the features in the data sheets available online.
- Depending on the application, it must be evaluated whether this list of features needs to be added.

Feature	Value
Product category	pressure sensors
Measured variable	contains "Relative pressure"
Switching element function	NC/NO contact switchable OR switchable OR NC contact
Switching output	contains "PNP"
Operating pressure	0 – 8 bar OR 1 – 12 bar OR -1 – 10 bar
As an alternative to the operating pressure the start and end value for pressure measuring range can be used.	
Start value for pressure measuring range	-1 bar OR 0 bar
End value for pressure measuring range	The end value should be ≥ 6 bar.

Other values for the features may be possible and must be considered separately.

Note: These pressure sensors were selected as examples from different series and sizes.

No.	Material	★	Designation/Type (Sorting ↑)	Link Data Sheet
1.	540209		Pressure sensor SDE3-D10D-B-HQ4-2P-M8	↗
2.	542889	★	Pressure sensor SDE5-D10-C-Q4E-P-M8	↗
3.	8001448		Pressure sensor SPAE-P10R-Q4-PNLK-2.5K	↗
4.	609149	★	Pressure sensor SPAN-B11R-G18M-PNLK-PNVBA-L1	↗
5.	8001221		Pressure sensor SPAU-P10R-H-G18FD-L-PNLK-PNVBA-M8U	↗

★ Core product range

4 Suitable Products for Limit Switches B3, B4

- Based on the following features, other suitable proximity or position sensors from Festo can also be selected using the features in the data sheets available online.
- Depending on the application, it must be evaluated whether this list of features needs to be added.

Feature	Value
Product category	proximity sensor
Measured variable	position
Switching output	contact OR contactless OR PNP OR NPN/PNP switchable
Switching element function	NO OR NC/NO switchable
Operational voltage range DC	The maximum permissible operating voltage must be ≥ 30 V

Other values for the features may be possible and must be considered separately.

Note: These proximity sensors were selected as examples from different series and sizes.

No.	Material	★	Designation/Type (Sorting ↑)	Link Data Sheet
1.	8059122	★	Proximity sensor SDBT-MSX-1L-PU-E-5-N-LE	↗
2.	543863		Proximity sensor SME-8M-DS-24V-K-5,0-OE	↗
3.	543872		Proximity sensor SME-8M-ZS-24V-K-2,5-OE	↗
4.	574336	★	Proximity sensor SMT-8M-A-PS-24V-E-5,0-OE	↗
5.	8165237	★	Proximity sensor SMT-8M-A-ZS-24V-E-5,0-OE	↗

★ Core product range

5 Suitable Products for Valve Q1

5.1 Soft-Start/Quick Exhaust Valve in Service Unit

- Based on the following features, other suitable soft-start/quick exhaust valves from Festo can also be selected using the features in the data sheets available online.
- Depending on the application, it must be evaluated whether this list of features needs to be added.
- Additional information on these features can be found in the document ➤ [100396 Notes on features of directional control valves](#).

Feature	Value
Product category	Soft-Start/Quick Exhaust Valve
Valve function	3/2-way, closed, monostable, soft-start function
Type of actuation	electric
Type of piloting	pilot actuated
Type of reset	mechanical spring
Duty cycle	100 %
Service-life value B ₁₀	specified
Performance Level (PL)	PL c

Other values for the features may be possible and must be considered separately.

Note: These soft-start and quick exhaust valves were selected as examples from different series and sizes.

No.	Material	Designation/Type (Sorting ↑)	Link Data Sheet	Link Data Sheet Product Reliability
1.	8001469	Soft-start/quick exhaust valve MS6-SV-1/2-C-10V24-S	↗	↗
2.	570737	Soft-start/quick exhaust valve MS9-SV-G-C-V24-S-VS	↗	↗

Note

- Soft-start and quick exhaust valves with category 3, PL d and category 4, PL e can also be used in the service unit if this is required in the application.

5.2 On-Off Valves in Service Unit

- Based on the following features, other suitable valves from Festo can also be selected using the features in the data sheets available online.
- Depending on the application, it must be evaluated whether this list of features needs to be added.
- Additional information on these features can be found in the document [↗ 100396 Notes on features of directional control valves](#).

Feature	Value
Product category	On-off Valves
Valve function	3/2-way, closed, monostable
Type of actuation	electric
Type of piloting	pilot actuated
Type of reset	mechanical spring
Duty cycle	100 %
Service-life value B ₁₀	specified
Relevant basic safety principles	yes
Relevant well-tried safety principles	yes

Other values for the features may be possible and must be considered separately.

Note: These on-off valves were selected as examples from different series and sizes.

No.	Material	★	Designation/Type (Sorting ↑)	Link Data Sheet	Link Data Sheet Product Reliability
1.	542602	★	On-off valve MS6-EE-1/2-10V24-S	↗	↗

★ Core product range

5.3 Soft-Start Valves in Valve Terminals

- Based on the following features, other suitable soft-start valves from Festo can also be selected using the features in the data sheets available online.
- Depending on the application, it must be evaluated whether this list of features needs to be added.
- Additional information on these features can be found in the document [↗ 100396 Notes on features of directional control valves](#).

Feature	Value
Product category	Soft-start valves
Valve function	Soft-start function
Type of actuation	Electric
Type of piloting	Pilot actuated
Type of reset	Mechanical spring
Switching element function	NO contact
Switching position sensing	Switching position via sensor
Duty cycle	100 %
Service-life value B ₁₀	Specified
Relevant basic safety principles	Yes
Relevant well-tried safety principles	Yes

Other values for the features may be possible and must be considered separately.

Note: These soft-start valves were selected as examples from different series and sizes.

No.	Material	Designation/Type (Sorting ↑)	Code ¹	Link Data Sheet	Link Data Sheet Product Reliability
	<i>Valves for valve terminals</i>				
1.	557377	Soft-start valve VABF-S6-1-P5A4-G12-4-1-P	PM/PP	↗	↗
2.	8067407	Soft-start valve VABF-S6-1-P5A4S1YE-G12-1T5-PA	PM/PT	↗	↗

¹ Code of the valve for the configurator or in the order code of the valve terminal.

5.4 Single Valves

- Based on the following features, suitable valves from Festo can be selected using the features in the data sheets available online.
- Depending on the application, it must be evaluated whether this list of features needs to be extended.
- Additional information on these features can be found in the document [↗ 100396 Notes on features of directional control valves](#).

Feature	Value
Product category	Electrically actuated valves
Valve function	3/2 closed monostable
Type of actuation	Electric
Type of piloting	Pilot actuated
Pilot air supply	Internal or external
Type of reset	Mechanical spring
Duty cycle	100 % OR 100 % with holding current reduction
Service-life value B10	Specified
Relevant basic safety principles	Yes
Relevant well-tried safety principles	Yes

Other values for the features may be possible and must be considered separately.

Note: These valves were selected as examples from different series and sizes.

No.	Material		Designation/Type (Sorting ↑)	Link Data Sheet	Link Data Sheet Product Reliability
	<i>Single valves</i>				
1.	574348		Solenoid valve VUUG-L10-T32C-MT-M5-1P3	↗	↗
2.	574352		Solenoid valve VUUG-L10-T32C-MZT-M5-1P3	↗	↗
3.	575274	★	Solenoid valve VUVS-L20-M32C-MD-G18-F7-1C1	↗	↗
4.	575273	★	Solenoid valve VUVS-L20-M32C-MZD-G18-F7-1C1	↗	↗

★ Core product range

6 Suitable Products for Valve K1

6.1 Single Valves

- Based on the following features, suitable valves from Festo can be selected using the features in the data sheets available online.
- Depending on the application, it must be evaluated whether this list of features needs to be extended.
- Additional information on these features can be found in the document [↗ 100396 Notes on features of directional control valves](#).

Feature	Value
Product category	Electrically actuated valves
Valve function	3/2 closed monostable
Type of actuation	Electric
Type of piloting	Pilot actuated
Pilot air supply	Internal or external
Type of reset	Mechanical spring
Duty cycle	100 % OR 100 % with holding current reduction
Service-life value B10	Specified
Relevant basic safety principles	Yes
Relevant well-tried safety principles	Yes

Other values for the features may be possible and must be considered separately.

Note: These valves were selected as examples from different series and sizes.

No.	Material		Designation/Type (Sorting ↑)	Link Data Sheet	Link Data Sheet Product Reliability
	<i>Single valves</i>				
1.	574348		Solenoid valve VUVG-L10-T32C-MT-M5-1P3	↗	↗
2.	574352		Solenoid valve VUVG-L10-T32C-MZT-M5-1P3	↗	↗
3.	575274	★	Solenoid valve VUVS-L20-M32C-MD-G18-F7-1C1	↗	↗
4.	575273	★	Solenoid valve VUVS-L20-M32C-MZD-G18-F7-1C1	↗	↗

★ Core product range

6.2 On-Off Valves

- Based on the following features, other suitable valves from Festo can also be selected using the features in the data sheets available online.
- Depending on the application, it must be evaluated whether this list of features needs to be added.
- Additional information on these features can be found in the document [↗ 100396 Notes on features of directional control valves](#).

Feature	Value
Product category	On-off Valves
Valve function	3/2-way, closed, monostable
Type of actuation	Electric
Type of piloting	Pilot actuated
Type of reset	Mechanical spring
Duty cycle	100 %
Service-life value B ₁₀	Specified
Relevant basic safety principles	Yes
Relevant well-tried safety principles	Yes

Other values for the features may be possible and must be considered separately.

Note: These on-off valves were selected as examples from different series and sizes.

No.	Material	★	Designation/Type (Sorting ↑)	Link Data Sheet	Link Data Sheet Product Reliability
1.	542602	★	ON-OFF VALVE MS6-EE-1/2-10V24-S	↗	↗

★ Core product range

6.3 Pilot air valves with integrated pressure switch

- Based on the following features, other suitable valves from Festo can also be selected using the features in the data sheets available online.
- Depending on the application, it must be evaluated whether this list of features needs to be added.
- Additional information on these features can be found in the document [↗ 100396 Notes on features of directional control valves](#).

Feature	Value
Product category	Pilot air valve
Valve function	3/2-way, closed, monostable
Type of actuation	Electric
Type of piloting	Pilot actuated
Type of reset	Mechanical spring
Switching element function	NC contact
Switching position sensing	Via pressure switch, exhausted status
Duty cycle	100 % OR 100 % with holding current reduction
Service-life value B ₁₀	Specified
Relevant basic safety principles	Yes
Relevant well-tried safety principles	Yes

Other values for the features may be possible and must be considered separately.

Note: These valves were selected as examples from different series and sizes.

No.	Material	Designation/Type (Sorting ↑)	Code ¹	Link Data Sheet	Link Data Sheet Product Reliability
1.	8126790	Solenoid valve VMPA1-M1H-IS-PI	IS	↗	↗
2.	573202	Solenoid valve VSVA-B-M52-MZD-A2-1T1L-APP	SO	↗	↗
3.	8066569	Solenoid valve VSVA-BT-M32CS1-MYE-A2-1T5L-PA	CS	↗	↗

¹ Code of the valve for the configurator or in the order code of the valve terminal.

Note

- With the valve terminal VTUG, the pilot air can be switched off via an external 3/2-way valve. Suitable valves are specified in section “6.1 Single Valves”.

7 Suitable Products for Valve Q2

- Based on the following features, suitable valves from Festo can be selected using the features in the data sheets available online.
- Depending on the application, it must be evaluated whether this list of features needs to be extended.
- Additional information on these features can be found in the document [↗ 100396 Notes on features of directional control valves](#).

Feature	Value
Product category	electrically actuated valves
Valve function	5/2 bistable
Type of actuation	Electric
Type of piloting	Pilot actuated
Pilot air supply	External
Duty cycle	100 % OR 100 % with holding current reduction
Service-life value B ₁₀	Specified
Relevant basic safety principles	Yes
Relevant well-tried safety principles	Yes
Well-tried component	Yes
Fault exclusion	Spontaneous change of the initial switching position of the main stage without an input signal. The control signal at piloted valves consists of the electrical control signal for the valve magnet and the pneumatic signal (pilot air supply) of the pilot valve. Note If the fault exclusion is not specified in the Product Reliability Data Sheet, it can also be stated in the ↗ Technical Report TR-300004 .

Other values for the features may be possible and must be considered separately.

Note: These valves were selected as examples from different series and sizes.

No.	Material		Designation/Type (Sorting ↑)	Code ¹	Link Data Sheet	Link Data Sheet Product Reliability
<i>Single valves</i>						
1.	547074		Solenoid valve VSVA-B-B52-ZH-A1-1C1		↗	↗
2.	566467		Solenoid valve VUVG-L10-B52-ZT-M5-1P3		↗	↗
3.	575683	★	Solenoid valve VUVS-L20-B52-ZD-G18-F7-1C1		↗	↗
<i>Valve for valve terminals</i>						
4.	533343		Solenoid valve VMPA1-M1H-J-PI	J	↗	↗
5.	8033042		Solenoid valve VSVA-B-B52-ZH-A1-1T1L	J	↗	↗
6.	573418		Solenoid valve VUVG-B10-B52-ZT-F-1T1L	J	↗	↗

★ Core product range

¹ Code of the valve for the configurator or in the order code of the valve terminal.

8 Used Literature

8.1 Cited Documents from Festo

- [1] [100393 Safe electrical switch-off of individually controlled valves](#)
- [2] [100394 Safe electrical switch-off of valve terminals](#)
- [3] [100395 Notes on Sistema project files](#)
- [4] [100396 Notes on features of directional control valves](#)
- [5] [100399 Recommendations for the implementation of measures against common cause failures \(CCF\)](#)
- [6] [100405 Safety subfunctions pneumatics – PUS](#)
- [7] [TR-300004 – Festo AG & Co. KG bistable valves for safety-related applications](#)

8.2 Standards

- [8] DIN EN ISO 4414:2011-04 – Pneumatic fluid power - General rules and safety requirements for systems and their components (ISO 4414:2010); German version EN ISO 4414:2010
- [9] ISO 5598:2020-01 – Fluid power systems and components - Vocabulary
- [10] DIN EN ISO 12100:2011-03 - Safety of machinery - General principles for design - Risk assessment and risk reduction (ISO 12100:2010); German version EN ISO 12100:2010
- [11] DIN EN ISO 13849-1:2023-12 – Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design (ISO 13849-1:2023); German version EN ISO 13849-1:2023
- [12] DIN EN ISO 13849-2:2013-02 – Safety of machinery - Safety-related parts of control systems - Part 2: Validation (ISO 13849-2:2012); German version EN ISO 13849-2:2012
- [13] ISO 19973-1:2015-08 - Pneumatic fluid power - Assessment of component reliability by testing - Part 1: General procedures
- [14] VDMA 24584:2022-06 - Sicherheitsfunktionen geregelter und nicht geregelter (fluid-) mechanischer Systeme.
- [15] DIN EN 61508:2011-02 - Functional safety of electrical/electronic/programmable electronic safety-related systems (IEC 61508:2010); German version EN 61508:2010
- [16] DIN EN 61508-4:2011-02 - Functional safety of electrical/electronic/programmable electronic safety-related systems - Part 4: Definitions and abbreviations (IEC 61508-4:2010); German version EN 61508-4:2010
- [17] DIN EN 61511:2019-02 - Functional safety - Safety instrumented systems for the process industry sector - (IEC 61511:2016); German version EN 61511:2017
- [18] DIN EN IEC 62061:2023-02 - Sicherheit von Maschinen - Funktionale Sicherheit sicherheitsbezogener Steuerungssysteme (IEC 62061:2021); Deutsche Fassung EN IEC 62061:2021

8.3 Legal regulations

- [19] Machinery Directive: Directive 2006/42/EC of the European Parliament and of the Council of 17 May 2006 on machinery, and amending Directive 95/16/EC (recast)
- [20] Machinery Regulation: Regulation (EU) 2023/1230 of the European Parliament and of the Council of 14 June 2023 on machinery and repealing Directive 2006/42/EC of the European Parliament and of the Council and Council Directive 73/361/EEC

9 Information about the Document

9.1 General Information

Document number	100419	
Safety subfunction	PUS (operation pressure)	PUS (pilot pressure)
Category	up to category 3 can be reached	up to category 3 can be reached
PL	up to PL e can be reached	up to PL d can be reached

9.2 Revision History

Ver.	Date	Ed.	Chapter	Description of change/impact
1.10	2023-03-10	JKHL	All	Creation of the document
1.20	2023-11-14	JKHL	1.3	Remarks about fault exclusion, PL, measures for failure reactions and B ₁₀ value for pilot valve added
1.30	2023-09-11	JKHL	Title page, 2	Circuit changed
			3, 4, 5, 6, 7	Product lists adapted
			Last page	Addition contact possibilities
			2, 5, 6, 7, 8	Update links to support portal and of the standards
1.40	21.07.2026	JKHL	All	Update symbols Update layout document
			1, 5, 6, 7	Update links to support portal
			Title, 2	Update circuit
			3...7	Capital descriptions in normal writing changed
			8	Standards updated, Machinery Regulation added

9.3 Approval/Release of the Document

Role	Signature
Release	

9.4 Period of Validity

Document is valid until 2031-07-21 or until one of the documents used or the required relevant base are changed.



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