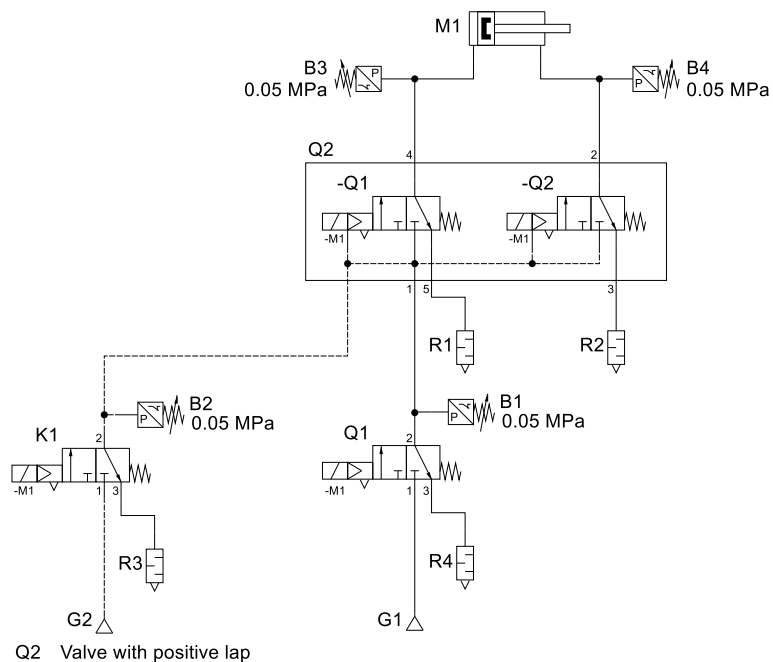
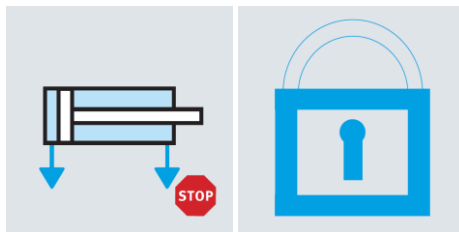


Circuit

Safety-Subfunctions Pneumatic

STO – Safe Torque Off – up to Cat. 1, up to PL c

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



Our effort – your advantage

Our effort for the preparation of these documents

and your saved time 6 h

Free of charge for you.

Title Safety Subfunctions Pneumatics - Circuit
Version 1.20
Document number 100556
Original German
Author Festo
Date 2026-07-22

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The actual characteristic values that can be obtained (especially PL, PFH_D, category, DC, MTTF_D, CCF, SIL, HFT, PFH, PFD) depend on the components used, as well as their conditions of use in the actual application.

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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 STO (up to category 1, up to PL c), PUS (with operation pressure supply: up to category 3, up to PL e) and PUS (with pilot pressure supply, up to category 3, up to PL e).
- 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.

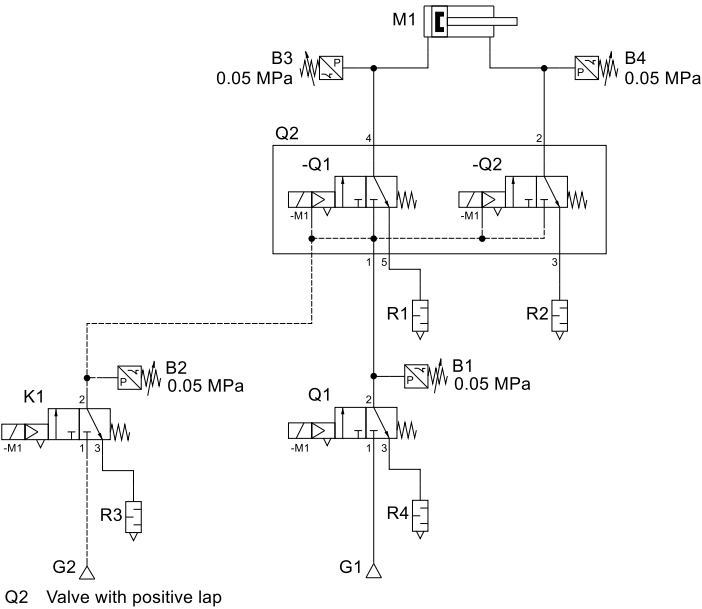
1.2 General Notes

- 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 [↗ 100380 Safety subfunctions pneumatics – STO, 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 subfunctions with 1-channel architecture of the safety circuit (here category 1), a fault leads to a single failure of the safety subfunction.
- 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.
- 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 from the B₁₀ values are included in the Sistema project file. The B₁₀ value must be adjusted according to the valves used.
- In order to estimate a diagnostic coverage for the valves K1, Q1 a suitable plausibility and switching time monitoring of the control signal up to the signal change of the sensors B2, B1 should be implemented.
- In order to estimate a diagnostic coverage for valve Q2, a suitable plausibility and switching time monitoring of the control signals up to the signal change of sensors B3, B4 should be implemented.

2 Circuit



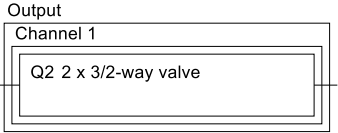
Parts list

Pos...	Identifi...	Description
1	B1	Pressure switch
2	B2	Pressure switch
3	B3	Pressure switch
4	B4	Pressure 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	2 x 3/2-way valve
11	R1	Silencer
12	R2	Silencer
13	R3	Silencer
14	R4	Silencer

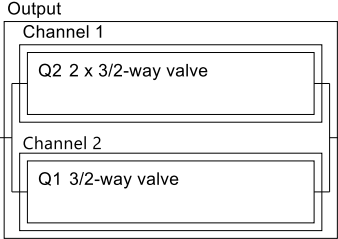
Safety subfunction and Block diagram

STO - safe torque off

up to category 1, up to PL c can be reached



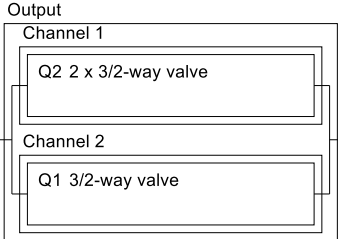
PUS - Prevention unexpected start-up (operation pressure) up to category 3, up to PL e can be reached



Q2, B3, B4
2 x 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)

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)

PUS - Prevention unexpected start-up (pilot pressure) up to category 3, up to PL e can be reached



Q2, B3, B4
2 x 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)

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)

Q2 Valve with positive lap

3 Suitable Products for Sensor B1, B2, B3, B4

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

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 Valve Q1

4.1 Soft-Start/Quick Exhaust Valve

- 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.
- 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.

4.2 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

4.3 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

5 Suitable Products for Valve K1

5.1 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

5.2 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

5.3 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 %
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 control air can be switched off via an external 3/2-way valve. Suitable valves are specified in section [➔ 5.1 Single Valves](#).

6 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	2 x 3/2 exhausted
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
Well-tried component	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
<i>Single valves</i>						
1.	574352		Solenoid valve VUVG-L10-T32C-MZT-M5-1P3		↗	↗
<i>Valve for valve terminals</i>						
2.	556838		Solenoid valve VMPA1-M1H-KS-PI	KS	↗	↗
3.	573413		Solenoid valve VUVG-B10-T32C-MZT-F-1T1L	VK	↗	↗

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

7 Used Literature

7.1 Cited Documents from Festo

- [1] [100380 Safety subfunctions pneumatics – STO, PUS](#)
- [2] [100393 Safe electrical switch-off of individually controlled valves](#)
- [3] [100394 Safe electrical switch-off of valve terminals](#)
- [4] [100395 Notes on Sistema project files](#)
- [5] [100396 Notes on features of directional control valves](#)
- [6] [100399 Recommendations for the implementation of measures against common cause failures \(CCF\)](#)

7.2 Standards

- [7] 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
- [8] ISO 5598:2020-01 – Fluid power systems and components - Vocabulary
- [9] VDMA 24584:2022-06 – Safety functions of regulated and unregulated (fluid) mechanical systems; German Version
- [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 – Safety functions of regulated and unregulated (fluid) mechanical systems; German Version
- [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 - Safety of machinery - Functional safety of safety-related control systems (IEC 62061:2021); German version EN IEC 62061:2021

7.3 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

8 Information about the Document

8.1 General Information

Document Number	100556		
Safety Subfunction	STO	PUS (operation pressure)	PUS (pilot pressure)
Category	up to category 1 can be reached	up to category 3 can be reached	up to category 3 can be reached
PL	up to PL c can be reached	up to PL e can be reached	up to PL e can be reached

8.2 Revision History

Ver.	Date	Ed.	Chapter	Description of Change/Impact
1.10	2023-12-19	JKHL	All	Creation of the document
1.20	2026-07-22	JKHL	All	Update layout
			2	Update circuit
			7	Machinery regulation added

8.3 Approval/Release of the Document

Role	Signature
Release	

8.4 Period of Validity

Document is valid until 2031-07-22 or until one of the documents used or the required relevant base are changed.



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