

Definition

Safety Subfunction Pneumatics

PUS – Prevention of Unexpected Startup for Bistable Valves



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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

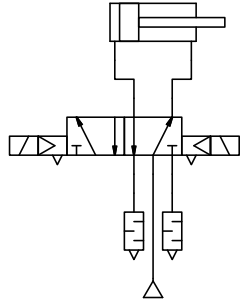
1.1 Objectives of this Document

- This document defines the safety sub-function “Prevention Unexpected Start (PUS)” for pneumatic circuits and specifies their safe state. For practical implementation, additional instructions are then given which should be observed depending on the application.
- For the possible diagnostic measures according to ISO 13849-1, Table E.1, additional information is given on how a certain diagnostic coverage can be achieved in one channel of these safety subfunctions. How these diagnostic coverage levels can be implemented in 2-channel circuits is referred to Safety Application Notes in the Support Portal in section “3 References to example circuits”.

1.2 General Notes

- The given circuits are principle circuits which cannot be complete due to clarity and scope. It is a recommendation that does not exclude other possibilities.
- The abbreviations used for safety subfunctions are based on the definitions in VDMA 24584 for pneumatics.
- The electrical circuit has not been considered in this document.

2 PUS – Prevention Unexpected Start-up for bistable valves

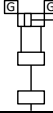
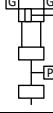
Symbol	
Principle circuit	
Reaction on demand	The safety subfunction PUS prevents the switching element of a valve from leaving its current position so that the volume flow paths through the valve are maintained. Important notes - Normally, the safety sub-function PUS is evaluated <u>after</u> a dangerous movement has been stopped by another safety sub-function or <u>after</u> a dangerous machine function has been safely switched off. - For bistable valves, it is not possible to define a stop function, as various relevant safety principles cannot be observed. Therefore, only the safety sub-function PUS can be evaluated for bistable valves.
Safe state	The switching element of the valve remains in position so that the volume flow paths through the valve are kept.
Warnings	 Attention Due to various external influences on the switching element of a valve, forces can act that can lead to a movement of the switching element. When executing the PUS safety function, the following must be taken into account: - Vibrations and shocks; - Mass moment of inertia on the switching element due to movements; - External magnetic fields; - Compressed air/vacuum at exhausting and breathing holes on pilot valves and main stages; - Pressurized air volume flow through the main stage by, for example, manual movements of the pneumatic drive. Attention - With bistable 5/2 valves, one chamber of the pneumatic drive is connected to the compressed air supply. When the compressed air supply is switched on, there may be a hazard due to an unexpected movement. Depending on the application,

	it must be assessed whether additional measures are required to the compressed air supply, e.g. by means of a pressure build-up valve. Attention • With bistable 5/2 valves, one chamber of the pneumatic drive is connected to the compressed air supply. With bistable valves, an unexpected movement can be dangerous if the compressed air supply is switched off or fails. Depending on the application, it must be assessed whether additional measures are required to the compressed air supply, e.g. by means of a non-return valve.
Notes	• In the case of valves, it must be noted that various external and internal influences can act on the switching element, which can lead to a movement of the switching element. The valve manufacturer must assess ○ Flow of compressed air through the main stage with maximum possible pressure drop on the valve; ○ Changes in the tribological system in the valve over the service life and the influence on the switching behaviour. ○ Behaviour of the switching element in the last switching position of the valve. If a valve manufacturer has evaluated these points in worst-case scenarios without any movement of the switching element, he can confirm the fault exclusion “spontaneous change of the output switching position (without input signal) for the main stage” according ISO 13849-2, table B.3. To be evaluated by the machine manufacturer ○ Vibrations and shocks ○ Mass moment of inertia on the switching element due to movements ○ External magnetic fields ○ Compressed air/vacuum at exhausting and breathing holes on pilot valves and main stages. ○ Pressurized air volume flow through the main stage by, for example, manual movements of the pneumatic drive. • The valves used to implement the safety sub-function should have one of the following design features: ○ Fault exclusion “automatic change of the output switching position (without input signal) of the main stage” by the valve manufacturer (preferred measure for bistable valves). ○ A detent on the main stage of the valve (another possible measure for bistable valves). • For the implementation of the safety subfunction PUS, the following circuit-technical measures can be possible for one channel (see ➔ “3 References to example circuits”.): ○ Electrical switch-off of the valve solenoids; ○ Switching off the operation pressure supply; ○ Switching off the pilot pressure supply • After the safety function PUS has been executed, the pneumatic drive is not freely movable when the working pressure is present. If the supply of working pressure is interrupted and exhausted, the pneumatic drive can move freely.

	- After execution of the safety subfunction PUS, a downstream pneumatic system can be pressurised. - With bistable valves: If the valve is not actuated during the request for PUS, the valve is in its last switching position, and the pneumatic drive is in the corresponding end position or the downstream pneumatic system remains in its current state. If the valve was activated during the request of PUS, the position of the valve and the pneumatic drive or the downstream pneumatic system is not determined. - This safety sub-function corresponds to PUS according to VDMA 24584.
Possible diagnoses	Diagnostic coverage DC=90% In order to achieve a diagnostic coverage of DC=90% for the safety subfunction PUS, the switching element of the directional control valve must be indirectly monitored (estimation according to ISO 13849-1, table E.1). For directional control valves, there are two possibilities for implementation: - Monitoring the pressure at the output of the directional valve Q1 by pressure switches B1, B2 At the outputs of a directional control valve, the unpressurised or pressurised state can be monitored with pressure switches B1, B2. For the output without pressure, the lowest possible switching pressure is set at the pressure switch (recommendation ≤ 0.5 bar for pneumatic drives). For the output with pressure, a sufficiently high switching pressure is set on the pressure switch (pressure required to hold the load or to maintain the safe state of the machine function, > 2 bar). The pressures should be selected so that no dangerous movement occurs in the application, or no dangerous machine function is triggered. - Monitoring of the end position of the pneumatic drive by limit switches B3, B4 The end positions of the pneumatic drive are monitored. If the drive is in an end position and moves out of the end position, it can be assumed that the valve has switched. In the event of a fault, the pneumatic drive will move out of the end position. This movement should not cause any hazard from category 2. Note - For the application of these diagnostic measures in circuits from category 2, please refer to the Application Notes in “3 References to example circuits”.

3 References to example circuits

Safety Application Notes with a possible evaluation based on ISO 13849 for basic circuits with different valve functions are available in the Support Portal.

PUS	Channel 1: Valve function diagnosis	Channel 2: Valve function diagnosis	Structure	Link
up to category 1, up to PL c	5/2-bistabil	–		➔ 100416
up to category 2, up to PL d	5/2-bistabil limit switch drive	Operation pressure: 3/2 way, closed		➔ 100588
up to category 3, up to PL e	5/2-bistabil limit switch drive	Operation pressure: 3/2 way, closed pressure switch		➔ 100418
up to category 3, up to PL e	5/2-bistabil limit switch drive	Operation pressure: 3/2 way, closed pressure switch		➔ 100419
up to category 3, up to PL d		Pilot pressure: 3/2 way, closed pressure switch		

4 Used Literature

4.1 Cited Documents from Festo

- [1] [100416 Circuit Safety Subfunction Pneumatics - PUS, cat. 1, PL c; CH 1 \(working valve\): 5/2-way, bistable](#)
- [2] [100418 PUS, up to cat. 3, up to PL e; CH 1 \(working valve\): 5/2-way, bistable, monitoring by limit switch drive; CH 2 \(operation pressure\): 3/2 closed, monitoring pressure switch](#)
- [3] [100419 Circuit Safety Subfunction Pneumatics - PUS, up to cat. 3, up to PL e; CH 1 \(working valve\): 5/2-way, bistable, monitoring by limit switch drive; CH 2 \(operation pressure\): 3/2 closed, monitoring limit switch piston spool; CH 2 \(pilot pressure\): 3/2 closed, monitoring pressure switch](#)
- [4] [100588 PUS, up to cat. 2, up to PL d; CH 1 \(working valve\): 5/2-way, bistable, monitoring by limit switch drive; CH 2 \(operation pressure\): 3/2 closed](#)

4.2 Standards

- [5] 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
- [6] ISO 5598:2020-01 – Fluid power systems and components - Vocabulary
- [7] VDMA 24584:2022-06 – Safety functions of regulated and unregulated (fluid) mechanical systems; German Version
- [8] 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
- [9] 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
- [10] 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
- [11] ISO 19973-1:2015-08 - Pneumatic fluid power - Assessment of component reliability by testing - Part 1: General procedures
- [12] DIN EN 61508:2011-02 - Functional safety of electrical/electronic/programmable electronic safety-related systems (IEC 61508:2010); German version EN 61508:2010
- [13] 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
- [14] DIN EN 61511:2019-02 - Functional safety - Safety instrumented systems for the process industry sector - (IEC 61511:2016); German version EN 61511:2017
- [15] 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

4.3 Legal Regulations

- [16] 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)
- [17] 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

5 Information about the Document

5.1 General Information

Document Number	100405
Safety Subfunction	Definition
	PUS – Prevention of Unexpected Startup

5.2 Revision History

Ver.	Date	Ed.	Chapter	Description of Change/Impact
1.10	2023-03-08	JKHL	All	Creation of the document
1.20	2023-07-24	JKHL	2	Notes for implementation modified
			Last page	Contact possibilities added
1.30	2023-09-07	JKHL	4, 5	Updating the links to the Support Portal and standards
1.40	2024-04-24	JKHL	3,4	Update symbol PUS and of links
1.50	2026-07-24	JKHL	3	Update of list with example circuits
			4.3	Machinery Regulation (EC) 2023/1230 added

5.3 Approval/Release of the Document

Role	Signature
Release	

5.4 Period of Validity

Document is valid until 2031-07-24 or until one of the documents used or the required relevant base are changed.



Do you have any questions about this Application Note?

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