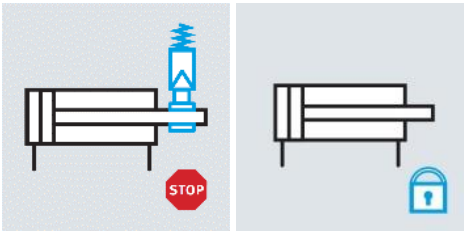
Safety Application Note ISO 13849

FESTO

Definitions
Safety-Subfunctions Pneumatic

SB-f – Safe Blocking with Friction Locking
PUS – Prevention unexpected start-up



100422

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 - Definitions
Version 1.40
Document number 100422
Original ..... German
Author ..... Festo
Last date of saving 2024-05-29

Legal Notice

In the following, the “Festo SE & Co. KG“ is designated as “Festo”.

This document is not binding. This documents outlines a possible solution for a sample application and makes no claim of completeness, especially with regard to configuration and equipment, as well as any eventualities for your actual application. This document is not a customised solution, it merely offers assistance with typical task assignments.
The values stated in this document are partly assumptions and assessments which do not replace a detailed examination based on ISO 13849 part 1 and 2, IEC 61508, IEC 62061 and/or IEC 61511.
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.
This document does not relieve you of the obligation to carry out a risk assessment and a validation of the specific application and to ensure the adherence to all specifications, especially the EC Machinery Directive 2006/42/EG. As the user, you are responsible for your specific application and for the correct operation of the described products.
Festo does not accept any liability for damages arising from the use of any incorrect or incomplete information contained in this documentation or any information missing therefrom. This equally applies to defects resulting from improper handling of devices and modules. In addition, all liability, with the exception of intent or gross negligence on the part of Festo, for damages arising due to non-adherence of the specifications of the EC Machinery Directive 2006/42/EG is also rejected.
The information in this document is in no way intended as a substitute for the operating instructions of the respective manufacturers or the design and testing of the application by the user. The operating instructions for products from Festo can be found at www.festo.com. Users of this document must themselves verify that all the functions described herein also work correctly in the application. Even after examining this document and using the specifications contained herein, users are nevertheless solely responsible for their own application.
Otherwise, all stipulations concerning liability included in the terms and conditions of delivery, payment and use of software from Festo, which can be found at www.festo.com and can be supplied on request, apply.
This document is only suitable for persons with sufficient expertise for machine safety based on ISO 12100, ISO 13849, IEC 61508, IEC 62061 and IEC 61511. In addition, the following qualifications are required in the project team:

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

Copyright Notice

Table of Contents

1 General

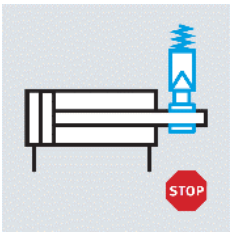
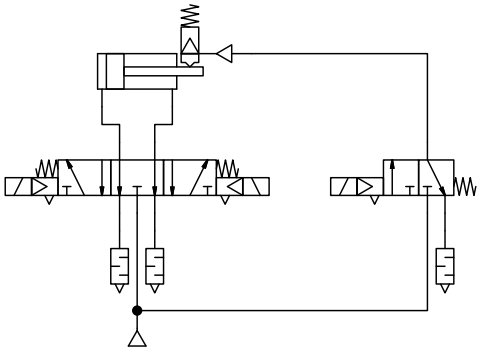
1.1 Objectives of this Document

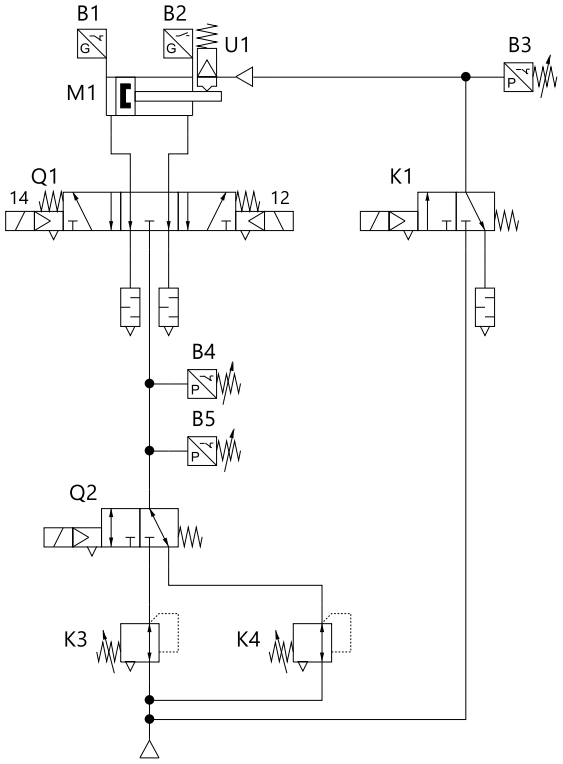
- This document defines the safety sub-functions “Safe Blocking with Friction Locking (SB-f)” and “Prevention of Unexpected Start (PUS)” for pneumatic circuits and specifies their safe state. For practical implementation, additional instructions are then given which should be observed depending on the application.
- How the safety sub-functions SB-f and PUS are interrelated is described in a separate section.
- 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 section “5 References to Example Circuits”.

1.2 General Notes

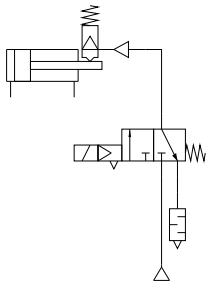
- The given circuits are principle circuits which cannot be complete due to clarity and scope. It is a recommendation that does not exclude other possibilities.
- The abbreviations used for the safety subfunctions are based on the definitions in VDMA 24584 for pneumatics. The safety sub-function “Safe Blocking with friction locking (SB-f)" is derived from the safety sub-function “Safe Stopping and Blocking (SSB)”. The background to this is that, that with factory automation clamping units, it is usually only possible to block an power transmission element.

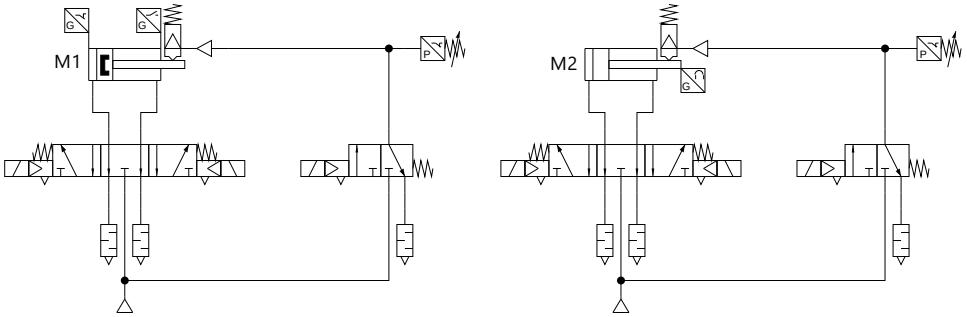
2 SB-f – Safe Blocking with Friction Locking

Symbol	
Principle circuit	
Reaction on demand	The movement of the pneumatic drive is stopped. The compressed air supply to the clamping unit is interrupted and exhausted. This causes the clamping unit to go to its normal position and blocks the free movement of the power transmission element of the pneumatic drive by frictional locking.
Safe state	The free movement of the pneumatic drive is friction-locked.
Warnings 	**Attention** • Clamping units are usually only suitable for clamping a power transmission element that has already been brought to a standstill and thus holding it in position. They are not designed for continuous active deceleration (braking). • If a clamping unit is used for active deceleration, increased wear will occur. In this case, it is necessary to carry out a function test of the clamping unit before the next start-up of the drive (see “possible diagnoses”). • With clamping units, it should be noted that there are various influences that affect the friction surfaces of the clamping unit and can lead to a movement of the power transmission element. The machine manufacturer must take these into account: ○ Only use lubricants approved by the manufacturer of the clamping unit. If the friction between the friction surfaces of the clamping unit is unacceptably reduced by a lubricant, movement is possible. ○ If a component with a friction surface for the clamping unit is provided by the machine manufacturer, the specifications of the manufacturer of the clamping unit regarding the properties of this component, especially strength, surface properties and dimensions with tolerances, must be observed. ○ If the holding forces of the locking unit are exceeded, movement will occur. In addition, there is increased wear. ○ Vibrations and shocks. ○ Mass moment of inertia due to movements.
Notes	• In the safe state, the pneumatic drive is not free to move. • When dimensioning and selecting the clamping unit, it is important to consider which external forces (moving mass and load) the clamping unit must hold in position. ○ As a rule, clamping units in factory automation are designed to hold external forces (moving mass and load). Consideration of the force of the pneumatic drive is not necessary in most applications. In the evaluation of the safety sub-function SB-f, the working valve of the pneumatic drive must then also be taken into account in the safety-related block diagram.

	○ If the clamping unit is to hold the external forces (moving mass and load) and the force of the pneumatic drive, this must be taken into account in the dimensioning. In the evaluation of the safety sub-function SB-f, the consideration of the working valve of the pneumatic drive in the safety-related block diagram is not absolutely necessary. • Whether the position of the pneumatic drive is determined after SB-f has been executed depends on the stop function used. • Clamping units with friction locking usually require a short movement to build up the full frictional force. • Depending on the functional principle of the locking unit, the position of the force transmission element may shift slightly during clamping. • According to the safety requirements, a regular function test of the locking unit is necessary (see possible diagnoses). • For the 3/2-way valve for controlling the clamping unit, the safety sub-function SDE must be evaluated additionally. See document "100381 Safety subfunctions pneumatics - SDE, PUS". • This safety sub-function does not correspond to any stop category according to IEC 60204-1. • This safety sub-function does not correspond to any safety sub-function according to IEC 61800-5-2. • Depending on the application, additional measures for freeing and rescuing trapped persons according to ISO 12100 may be required.
Possible diagnoses	**Diagnostic coverage DC=99% is not possible.** For a diagnostic coverage of 99%, direct monitoring of the effect on which the safety subfunction is based is required. This means that the friction between the friction partners of the clamping unit must be monitored. This is not possible, so that a DC=99% cannot be achieved by clamping units with frictional locking. **Diagnostic coverage DC=90%** For a diagnostic coverage of DC=90%, a static function test must be carried out regularly or directly before any access in the hazardous area. In addition, the actuation of the control valve of the clamping unit should be monitored with a pressure switch or with a limit switch in the clamping unit.  • For a description of the static brake test, see document "100423 BT-s - Static Brake Test".

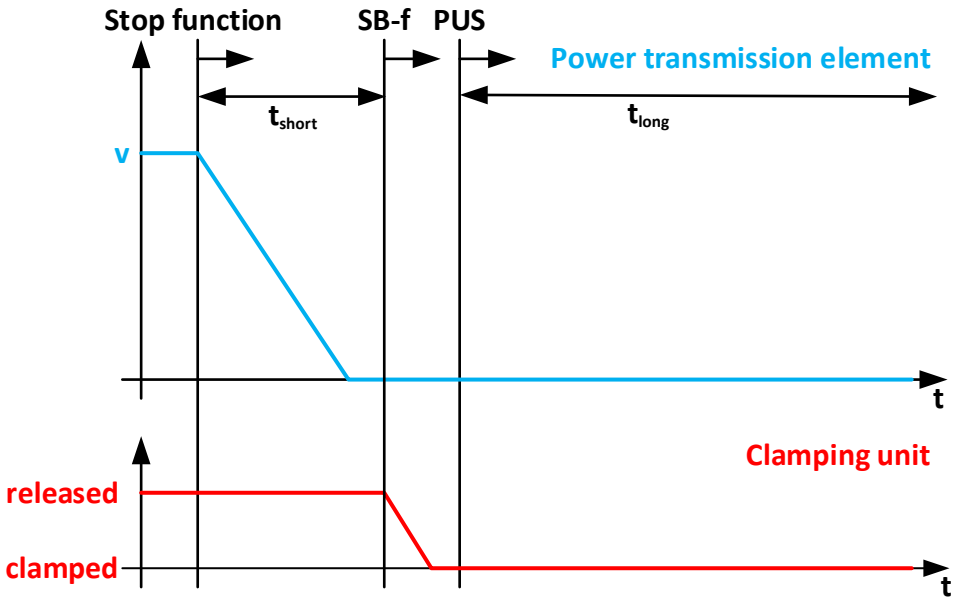
3 PUS – Prevention Unexpected Start-up

Symbol	
Principle circuit	
Reaction on demand	The safety sub-function PUS prevents the power transmission element of a drive from leaving its current position.
Safe state	The output element of the drive is frictionally clamped and remains in its position.
Warnings 	**Attention** • With clamping units, it should be noted that there are various influences that affect the friction surfaces of the clamping unit and can lead to a movement of the power transmission element. The machine manufacturer must take these into account: ○ Only use lubricants approved by the manufacturer of the clamping unit. If the friction between the friction surfaces of the clamping unit is unacceptably reduced by a lubricant, movement is possible. ○ If a component with a friction surface for the clamping unit is provided by the machine manufacturer, the specifications of the manufacturer of the clamping unit regarding the properties of this component, especially strength, surface properties and dimensions with tolerances, must be observed. ○ If the holding forces of the locking unit are exceeded, movement will occur. In addition, there is increased wear. ○ Vibrations and shocks. ○ Mass moment of inertia due to movements.
Notes	• The safety subfunction PUS is evaluated after a movement has been stopped by another safety subfunction and after the compressed air supply for the clamping unit has been interrupted and exhausted. • In the safe state, the pneumatic drive is not free to move. • When dimensioning and selecting the clamping unit, it is important to consider which external forces (moving mass, load and/or force of the drive) the clamping unit must hold in position. ○ As a rule, clamping units in factory automation are designed to hold external forces (moving mass and load). Consideration of the force of the pneumatic drive is not necessary in most applications. In the evaluation of the safety sub-function SB-f, the working valve of the pneumatic drive must then also be taken into account in the safety-related block diagram. ○ If the clamping unit is to hold the external forces (moving mass and load) and the force of the pneumatic drive, this must be taken into account in the dimensioning. In the evaluation of the safety sub-function SB-f, the consideration of the working valve of the pneumatic drive in the safety-related block diagram is not absolutely necessary.

	• For the 3/2-way valve for controlling the clamping unit, the safety sub-function PUS must be evaluated additionally. See document “100381 Safety subfunctions pneumatics - SDE, PUS”.
Possible diagnoses	**Diagnostic coverage DC=99% is not possible.** For a diagnostic coverage of 99%, direct monitoring of the effect on which the safety subfunction is based is required. This means that the friction between the friction partners of the clamping unit must be monitored. This is not possible, so that a DC=99% cannot be achieved with frictionally engaged clamping units. **Diagnostic coverage DC=90%** In order to achieve a diagnostic coverage of DC=90% for the safety subfunction PUS, the position of the power transmission element of the pneumatic drive can be monitored (estimation according to DIN EN ISO 13849-1, Table E.1). There are several possibilities for implementing this:  • Monitoring of the end position of the pneumatic drive by limit switch (M1) 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 there is a fault in the clamping unit or its control. In the event of a fault, the pneumatic drive will move. This movement must not cause any hazard. • Monitoring the position of the pneumatic drive with measuring system (M2) The position of the pneumatic drive is monitored with a measuring system. If the drive moves from its current position, it can be assumed that there is a fault in the clamping unit or its control. In the event of a fault, the pneumatic drive will move. This movement must not cause any hazard. • The pressure switch can be used to monitor the 3/2-way valve if, based on the risk assessment, the static brake test is not carried out before each access, and a different time interval has been selected.

4 Relationship between SB-f and PUS

- The safety sub-function “Safe Blocking with Frictional Locking (SB-f)” is a holding function that is used to block a power transmission element after the movement has stopped. After the power transmission element is blocked with frictional locking, the clamping unit should not be actuated. This is evaluated with the safety sub-function PUS.
- This results in the following temporal relationship between these safety sub-functions:



Procedure

1. When the stop function is requested, the power transmission element is brought to a standstill.
2. After an application-specific time (t_{short}), the compressed air supply to the clamping unit is interrupted and exhausted so that it changes from the released to the clamped state.
3. This keeps the power transmission element frictionally locked in position (t_{long}).
4. The safety sub-function PUS follows, which is intended to ensure that the clamping unit remains clamped and the control valve does not actuate the clamping unit.
   If the clamping unit is only designed to hold the load and the moving parts, the working valve should also not be controlled.
   If the locking unit is designed to hold the load, the moving parts and the force of the drive, the working valve should not be controlled.

5 References to Example Circuits

5.1 Base ISO 13849

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

Channel 1: Holding function diagnosis	Channel 2: Holding function diagnosis	SB-f	PUS	Link
Clamping unit	-	Up to category 1, up to PL c	Up to category 1, up to PL c	100427
Clamping unit, static brake test	Clamping unit, static brake test	Up to category 3, up to PL d	Up to category 3, up to PL d	100429

6 Used Literature

6.1 Cited documents from Festo

[1] 100381 Safety subfunctions pneumatics - SDE, PUS
[2] 100423 Safety Subfunction Pneumatics - BT-s - Static Brake Test
[3] 100427 Circuit Safety Subfunction Pneumatics - SB-f, up to Cat. 1, up to PL c; PUS, up to Kat. 1, up to PL c; CH 1: Clamping unit
[4] 100429 Circuit Safety Subfunction Pneumatics - SB-f, up to Cat. 3, up to PL d; PUS, up to Kat. 3, up to PL d; CH 1: Clamping unit

6.2 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] 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
[8] 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
[9] 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
[10] DIN EN ISO 14118:2018-07 - Safety of machinery - Prevention of unexpected start-up (ISO 14118:2017); German version EN ISO 14118:2018
[11] VDMA 24584:2022-06 – Safety functions of regulated and unregulated (fluid) mechanical systems; German Version
[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 61511:2019-02 - Functional safety - Safety instrumented systems for the process industry sector - (IEC 61511:2016); German version EN 61511:2017
[14] 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

6.3 Legal regulations

[15] 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)

7 Information about the Document

7.1 General Information

Project	100422
	Definitions Safety Subfunctions Pneumatics
	SB-f – Safe Blocking with Friction PUS – Prevention unexpected start-up

7.2 Revision History

Ver.	Date	Ed.	Chapter	Description of change/impact
1.10	2023-03-08	JKHL	All	Creation of the document
1.20	2023-07-13	JKHL	Last page	Contact possibilities added
1.30	2023-09-07	JKHL	2, 3, 5, 6	Updating the links to the Support Portal and standards
1.40	2024-05-29	JKHL	5, 6	Updating the links to the Support Portal and standards

7.3 Approval/Release of the Document

Role	Signature
Release	 Digital signiert von Jürgen Kühnle DN: cn=Jürgen Kühnle gn=Jürgen Kühnle c=DE Germany l=DE Germany o=Festo SE & Co. KG ou=SC-OTP e=juergen.kuehnle@festo.com Grund: Freigabe dieses Dokuments Ort: Esslingen Datum: 2024-05-29 13:43+02:00

7.4 Period of Validity

Document is valid until 2029-05-29 or until one of the documents used or the required relevant base are changed.

Do you have any questions about this Application Note?

You are welcome to send us your questions via the contact form.

Are you looking for Safety Application Notes with solution examples for the most important safety sub-functions in pneumatics?

We regularly expand our collection of documents in the Support Portal.

Do you want to get a general overview of machine and system safety?

We have compiled information on machine and functional safety in our guide.

Download the guide.

Do you need further support?

We also offer services for machine safety

- Risk assessment
- Safety concept
- Circuit design
- Verification / validation

You can request a quotation via the contact form.

Do you need training or further education?

At Festo Didactic you will find training courses on machine safety, functional safety and CE marking.

Request a quote for training or workshop.