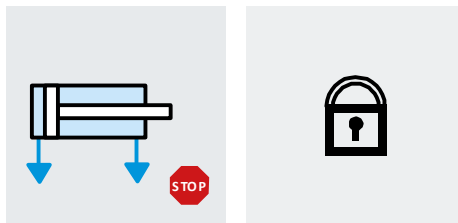


### Safety Sub-functions STO Category 1, up to PL c PUS Category 1, up to PL c



Application Note  
STO, PUS, Category  
1, up to PL c

Title .....Application Note STO, PUS, Category 1, up to PL c  
Version ..... 1.1  
Document number ..... (TSHQ) 100225  
Original ..... German  
Author ..... Festo  
Last date of saving ..... 23.04.2019

## Legal Notice

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

This Example circuit is not binding. This example circuit 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. The Example circuit is not a customised solution, it merely offers assistance with typical task assignments.

The values stated in the Example circuit are partly assumptions and assessments which do not replace a detailed examination based on EN ISO 13849 part 1 and 2.

The actual characteristic values that can be obtained (especially PL, PFH<sub>D</sub>, category, DC, MTT<sub>D</sub>, CCF) depend on the components used, as well as their conditions of use in the actual application.

The example circuit 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](http://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](http://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 EN ISO 12100 and EN ISO 13849. 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

This documentation is the intellectual property of Festo, which also holds the exclusive copyright. Any modification of the content, duplication or reprinting of this documentation, as well as distribution to third parties, is only permissible with the express consent of Festo.

Festo reserves the right to make modifications to this document in whole or in part. All brand and product names are trademarks or registered trademarks of their respective owners.

© (Festo AG & Co.KG, D - 73734 Esslingen, 2019)

Internet: [www.festo.com](http://www.festo.com)

E-Mail: [service\\_international@festo.com](mailto:service_international@festo.com)

# Table of Content

<b>1</b>	<b>Example Circuits .....</b>	<b>4</b>
1.1	STO and PUS with 5/3 Directional Control Valve, Category 1, up to PL c.....	5
1.1.1	Circuit Diagram .....	5
1.1.2	Components.....	5
1.1.3	Description.....	6
1.1.4	Safety Considerations .....	6
1.2	STO and PUS with 3/2 Directional Control Valve, Category 1, up to PL c.....	7
1.2.1	Circuit Diagram .....	7
1.2.2	Components.....	7
1.2.3	Description.....	8
1.2.4	Safety Considerations .....	8
1.3	STO and PUS with 2/2 Directional Control Valve, Category 1, up to PL c.....	9
1.3.1	Circuit Diagram .....	9
1.3.2	Components.....	10
1.3.3	Description.....	10
1.3.4	Safety Considerations .....	11
<b>2</b>	<b>Literature .....</b>	<b>11</b>

# 1 Example Circuits

- The circuits specified in this document are principle circuits which cannot be complete due to their clarity and scope.
- The abbreviations used for the safety sub-functions refer to the definitions in VDMA 24584 [1] for pneumatics:
  - STO: Safe Torque Off
  - PUS: Prevention of unexpected start-up
- Category 1, up to PL c according EN ISO 13849-1 [2]
- The circuits and the procedure described are recommendations which do not exclude other possibilities.
- Due to the wide variety of possible valves, no valve type and part numbers can be given in this document. When selecting valves, make sure that the selected valves have the following characteristics:
  - Type of actuation: electrical
  - Type of reset: mechanical spring
  - Sealing principle: soft
  - Type of piloting: piloted
  - Pilot air supply: internal or external
  - Duty cycle: 100%.
  - Well-tried components according to EN ISO 13849-1 and the relevant basic and well-tried safety principles have been observed.
  - B10 value required for the calculation of the MTTF<sub>D</sub> value must be available.

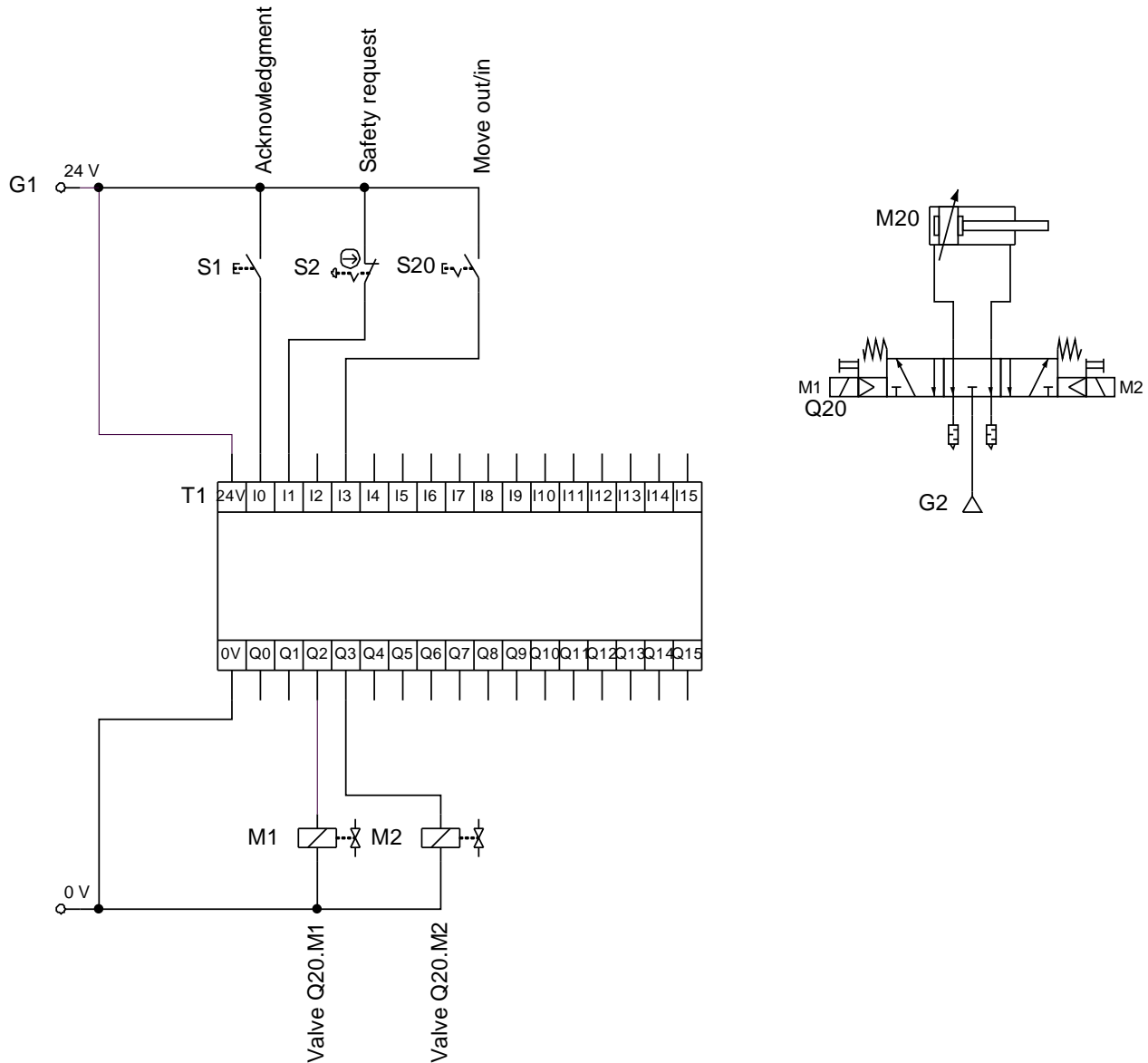
## Important note

- In addition, further design features and requirements may exist, which must be determined depending on the application.

## 1.1 STO and PUS with 5/3 Directional Control Valve, Category 1, up to PL c

STO and PUS according VDMA 24584 [1] and category 1, up to PL c according EN ISO 13849-1 [2].

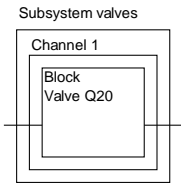
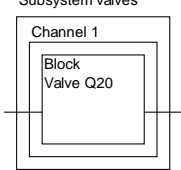
### 1.1.1 Circuit Diagram



### 1.1.2 Components

Component	Type	Description / Part Number / Remarks	Qty.	Mssr.
M20		Pneumatic drive	1	Festo
Q20		5/3 directional control valve, monostable	1	Festo
		Silencer, if necessary	2	Festo
S1		Acknowledge push button	1	
S2		Safety commanding device, e.g. emergency stop switch	1	
S20		Switch functional control	1	
T1		Safety switching device	1	

### 1.1.3 Description

Application	Double acting pneumatic drive, horizontal
Triggering event	Safety request, e.g. by emergency stop switch, safety gate
Reaction (Safety Sub-function)	<p><b>Safe torque off (STO), category 1, PL c</b></p>  <p><b>Prevention of unexpected start-up, category 1, PL c</b></p> 
Safe state	<p>The pneumatic drive is exhausted and free of energy.</p> <p>It is presumed that the exhausted state of the pneumatic drive is the safe state.</p>
Function	<p>The safety requirement (S2):</p> <ol style="list-style-type: none"> <li>1. Interrupts the input circuit of the safety switching device (T1).</li> <li>2. Switch off the safe outputs of the safety switching device (T1).</li> <li>3. The solenoids of the valve (Q20) are no longer controlled.</li> <li>4. Valve (Q20) moves to its normal position, separates the compressed air supply and exhaust both chambers of the pneumatic drive (M20). This exhausts the pneumatic drive (M20).</li> </ol>
Manual reset function	<ol style="list-style-type: none"> <li>1. After resetting the safety request (S2), e.g. by mechanically unlocking the emergency stop switch or closing the safety guard, the start or restart can be made possible by pressing the acknowledge push button (S1).</li> <li>2. The safety switching device (T1) can then allow the solenoids of the valve (Q20) to be controlled so that normal operation is possible.</li> </ol>

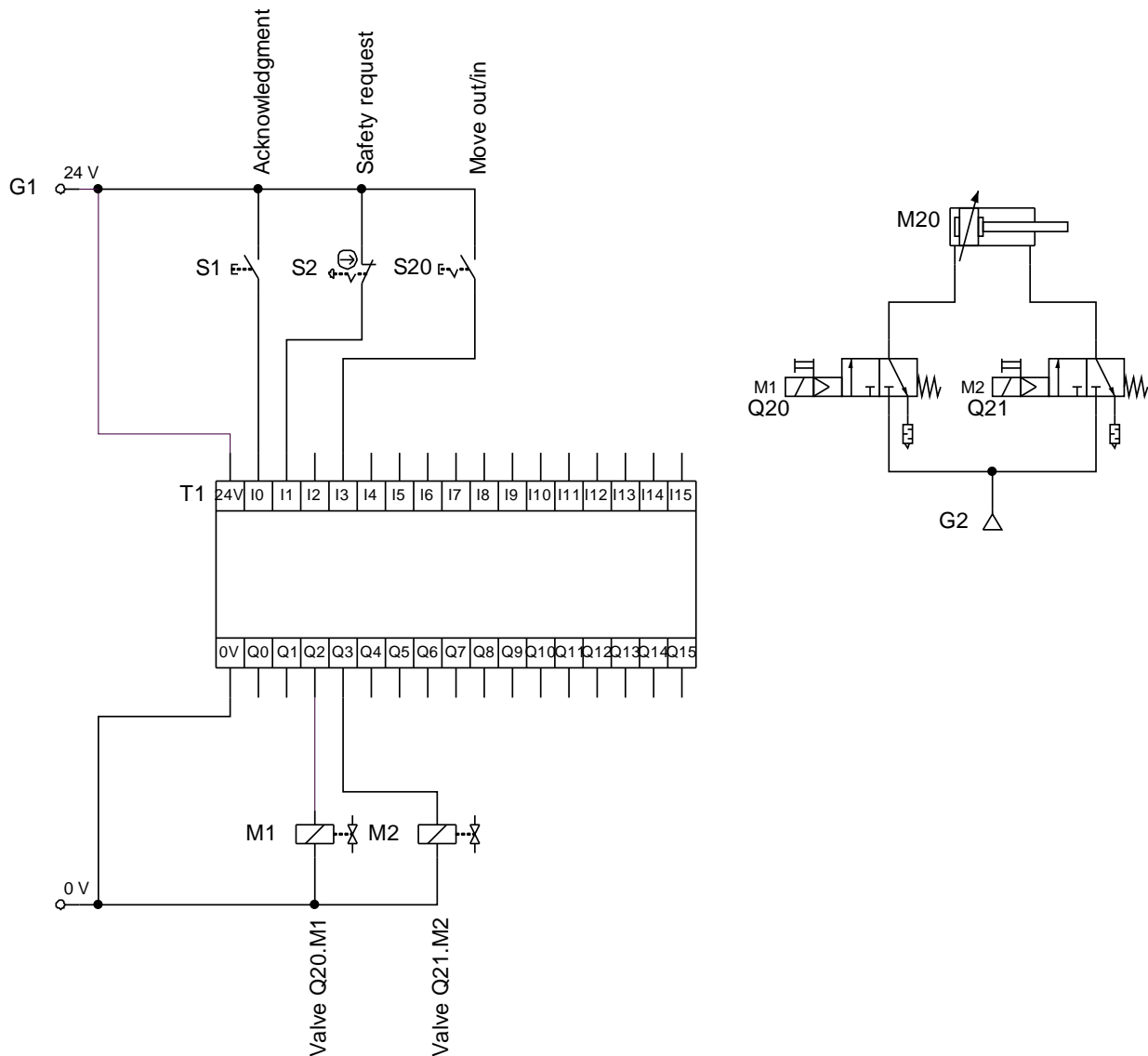
### 1.1.4 Safety Considerations

Input	Safety considerations must be carried out in accordance with the selected safety commanding device (S2).
Logic	Safety considerations must be carried out in accordance with the selected safety switching device (T1).
Output	The valve (Q20) is a well-tried component according to EN ISO 13849-1 and the relevant basic and well-tried safety principles have been observed. B10 value required for the calculation of the MTTF <sub>D</sub> must be available.

## 1.2 STO and PUS with 3/2 Directional Control Valve, Category 1, up to PL c

STO and PUS according VDMA 24584 [1] and category 1, up to PL c according EN ISO 13849-1 [2].

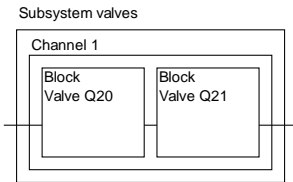
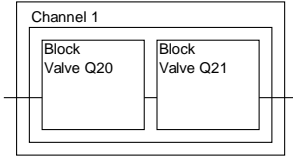
### 1.2.1 Circuit Diagram



### 1.2.2 Components

Component	Type	Description / Part Number / Remarks	Qty.	Mssr.
M20		Pneumatic drive	1	Festo
Q20, Q21		3/2 directional control valve	2	Festo
		Silencer, if necessary	2	Festo
S1		Acknowledge push button	1	
S2		Safety commanding device, e.g. emergency stop switch	1	
S20		Switch functional control	1	
T1		Safety switching device	1	

### 1.2.3 Description

Application	Double acting drive, horizontal
Triggering event	Safety request, e.g. by emergency stop switch, safety gate
Reaction (Element safety function)	<p><b>Safe torque off (STO), category 1, PL c</b></p>  <p><b>Prevention of unexpected start-up (PUS), category 1, PL c</b></p> 
Safe state	<p>The pneumatic drive is exhausted and free of energy.</p> <p>It is presumed that the exhausted state of the drive is the safe state.</p>
Function	<p>The safety requirement (S2):</p> <ol style="list-style-type: none"> <li>1. Interrupts the input circuit of the safety switching device (T1).</li> <li>2. The safe outputs of the safety switching device (T1) are then switched off.</li> <li>3. The solenoid of the valves (Q20, Q21) are no longer controlled.</li> <li>4. Valves (Q20, Q21) move to their normal position, separate the supply of the operating pressure and exhausts both chambers of the pneumatic drive (M20). This exhausts the pneumatic drive (M20).</li> </ol>
Manual reset function	<ol style="list-style-type: none"> <li>1. After resetting the safety request (S2), e.g. by mechanically unlocking the emergency stop switch or closing the safety gate, the start or restart can be made possible by actuating the acknowledgement button (S1).</li> <li>2. Then the safety switching device (T1) can allow the solenoids of the valves (Q20, Q21) to be controlled so that normal operation is possible.</li> </ol>

### 1.2.4 Safety Considerations

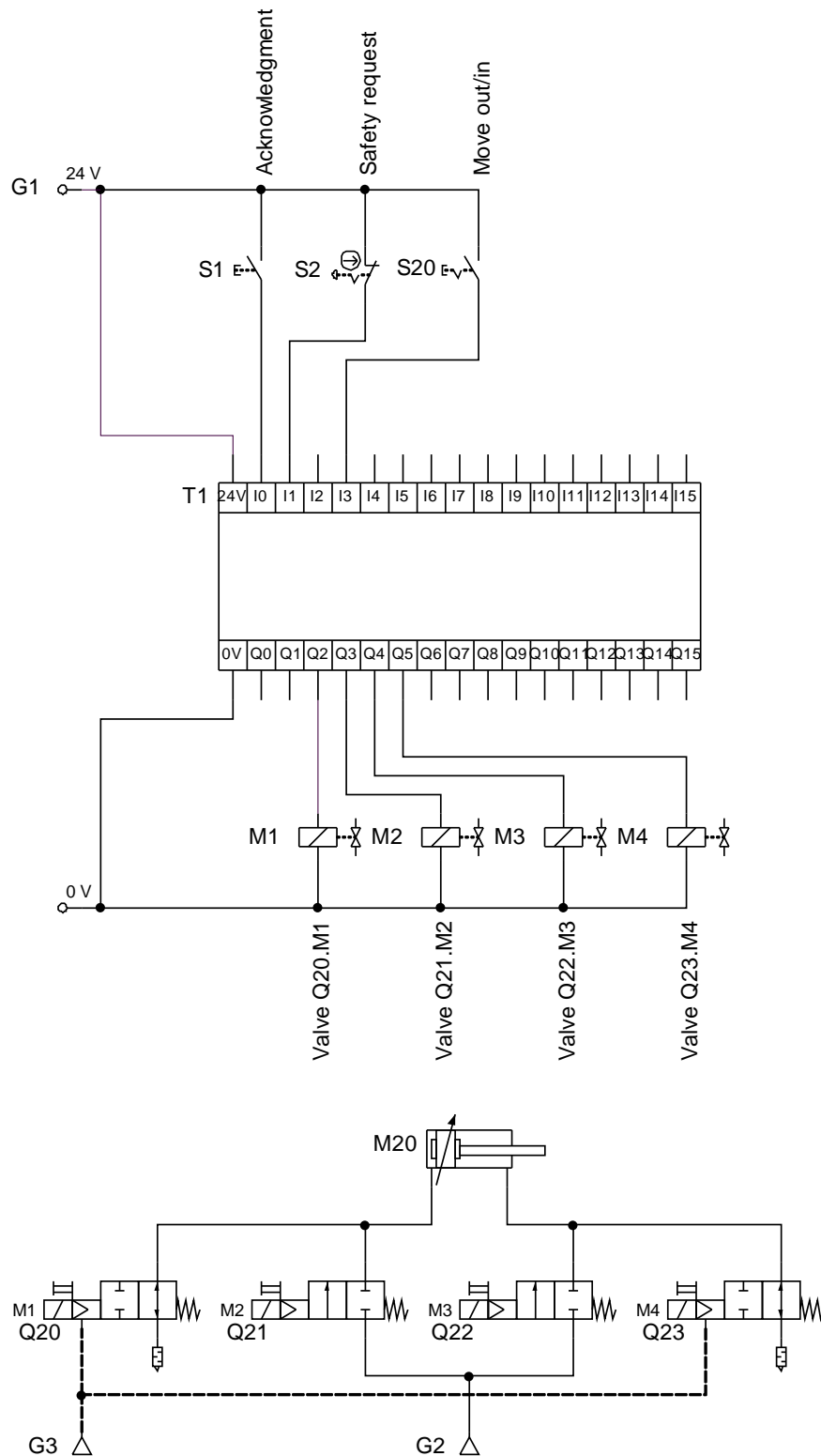
Input	Safety considerations must be carried out in accordance with the selected safety commanding device (S2).
Logic	Safety considerations must be carried out in accordance with the selected safety switching device (T1).
Output	The valves (Q20, Q21) are well-tried components according to EN ISO 13849-1 and the relevant basic and well-tried safety principles have been observed. B10 value required for the calculation of the MTTF <sub>D</sub> must be available.



### 1.3 STO and PUS with 2/2 Directional Control Valve, Category 1, up to PL c

STO and PUS according VDMA 24584 [1] and category 1, up to PL c according EN ISO 13849-1 [2].

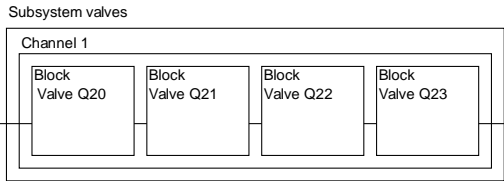
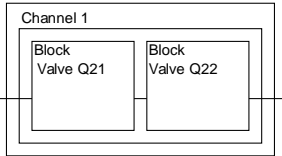
#### 1.3.1 Circuit Diagram



### 1.3.2 Components

Component	Type	Description / Part Number / Remarks	Qty.	Mssr.
M20		Pneumatic drive	1	Festo
Q20, Q23		2/2 directional control valve, open, external pilot air supply	2	Festo
Q21, Q22		2/2 directional control valve, closed	2	Festo
		Silencer, if necessary	2	Festo
S1		Acknowledge push button	1	
S2		Safety commanding device, e.g. emergency stop switch	1	
S20		Switch functional control	1	
T1		Safety switching device	1	

### 1.3.3 Description

Application	Double acting drive, horizontal
Triggering event	Safety request, e.g. by emergency stop switch, safety gate
Reaction (Element safety function)	<p><b>Safe torque off (STO), category 1, PL c</b></p>  <p><b>Prevention of unexpected start-up (PUS), category 1, PL c</b></p> 
Safe state	<p>The pneumatic drive is exhausted and free of energy.</p> <p>It is presumed that the exhausted state of the drive is the safe state.</p>
Function	<p>The safety requirement (S1):</p> <ol style="list-style-type: none"> <li>1. Interrupts the input circuit of the safety switching device (T1).</li> <li>2. The safe outputs of the safety switching device (T1) are then switched off.</li> <li>3. The solenoid of the valves (Q20, Q21, Q22, Q23) are no longer controlled.</li> <li>4. Valves (Q21, Q22) move to their normal position, separate the supply of the working pressure to the pneumatic drive (M20). Valves (Q20, Q23) move to their normal position and exhausts both chambers of the pneumatic drive (M20). This exhausts the pneumatic drive (M20).</li> </ol>
Manual reset function	<ol style="list-style-type: none"> <li>1. After resetting the safety request (S2), e.g. by mechanically unlocking the emergency stop switch or closing the safety gate, the start or restart can be made possible by actuating the acknowledgement button (S1).</li> <li>2. Then the safety switching device (T1) can allow the solenoids of the valves (Q20, Q21, Q22, Q23) to be controlled so that normal operation is possible.</li> </ol>

#### 1.3.4 Safety Considerations

Input	Safety considerations must be carried out in accordance with the selected safety commanding device (S2).
Logic	Safety considerations must be carried out in accordance with the selected safety switching device (T1).
Output	The valves (Q20, Q21, Q22, Q23) are well-tried components according to EN ISO 13849-1 and the relevant basic and well-tried safety principles have been observed. B10 value required for the calculation of the MTTF <sub>D</sub> must be available.

## 2 Literature

- [1] VDMA 24584:2016-08 - Safety functions of regulated and unregulated (fluid) mechanical systems (German edition)
- [2] DIN EN ISO 13849-1:2016-06 - Safety of machinery - Safety-related parts of control systems - Part 1: General principles for design (ISO 13849-1:2015); German version EN ISO 13849-1:2015