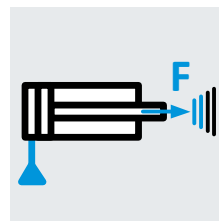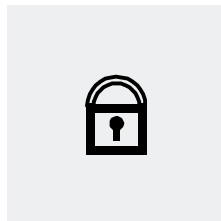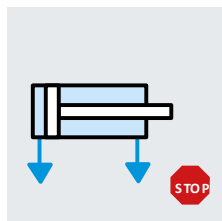# Application Note

FESTO

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

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

100223

Title .... Application Note STO, PUS, SLT, Category 1, up to PL c
Version 1.0
Document number .... (TSHQ) 100223
Original ....German
Author ....Festo
Last date of saving 13.05.2019

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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_D, category, DC, MTT_D, CCF) depend on the components used, as well as their conditions of use in the actual application.

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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

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Table of Content

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:
  - o   STO: Safe Torque Off
  - o   PUS: Prevention of unexpected start-up
  - o   SLT: Safely-limited torque
- Category and PL 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:
  - o   Valve function: 5/3 exhausted (3/2 closed)
  - o   Type of actuation: electrical
  - o   Type of reset: mechanical spring
  - o   Sealing principle: soft
  - o   Type of piloting: piloted
  - o   Pilot air supply: internal or external
  - o   Duty cycle: 100%.
  - o   Well-tried components according to EN ISO 13849-1 and the relevant basic and well-tried safety principles have been observed.
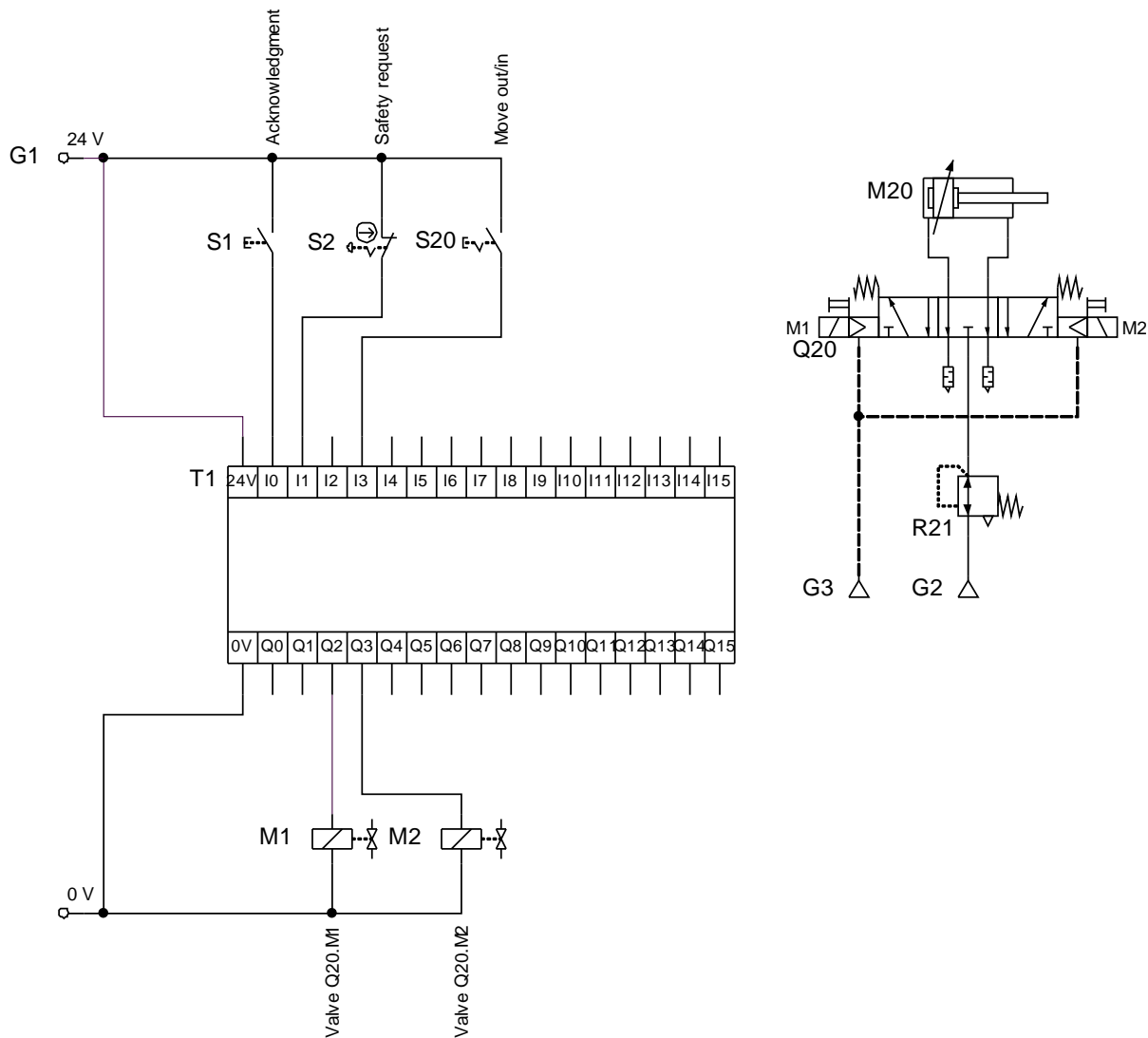 - o   B10 value required for the calculation of the $MTTF_D$ value must be available.

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

1.1 SLT permanent, Category 1, up to PL c

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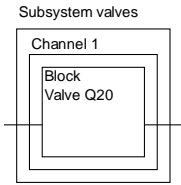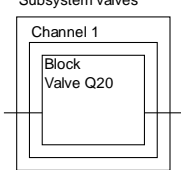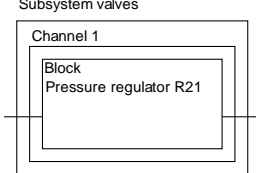
1.1.1 Circuit Diagram

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
R21	MS…-LR	Pressure regulator	1	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

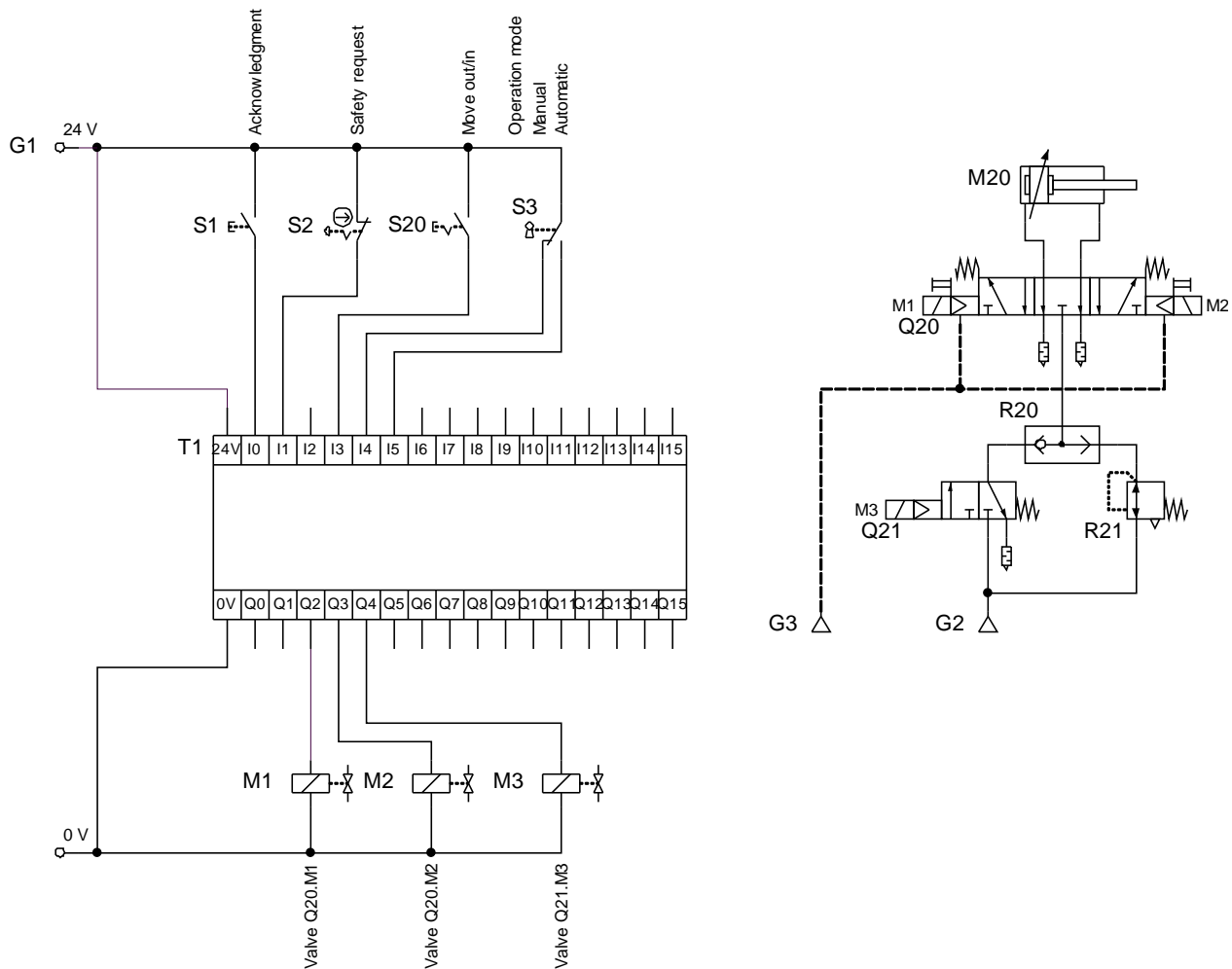|	
Application	Double acting pneumatic drive, horizontal
Triggering event	Safety request, e.g. by emergency stop switch, safety gate
Reaction (Safety Sub-function)	**Safe torque off (STO), category 1, PL c** Subsystem valves Channel 1 Block Valve Q20 **Prevention of unexpected start-up (PUS), category 1, PL c** Subsystem valves Channel 1 Block Valve Q20 **Safely-limited torque (SLT), category 1, PL c** Subsystem valves Channel 1 Block Pressure regulator R21
Safe state	After a safety request (S2) the pneumatic drive is exhausted after an application-specific time and is energy-free. It is presumed that the exhausted state of the pneumatic drive is the safe state. The pneumatic drive cannot exceed a set force by limiting the pressure. It is presumed that this limitation is the safe state of the pneumatic drive. Notes: • The precondition for the SLT safety sub-function is that no external forces are acting on the pneumatic drive (M20) that have not been taken into account. • The force of the drive can be changed with the pressure adjustment button of the pressure regulator. To prevent manipulation, sufficient measures must be taken to prevent manipulation, e.g. hidden installation.
Function	By the safety request (S2): 1. The input circuit of the safety switching device (T1) is interrupted. 2. The safe outputs of the safety switching device (T1) for the valve (Q20) are then switched off. 3. The solenoids of the valve (Q20) are no longer actuated. 4. The valve (Q20) switches to the normal position, separates the supply of the operating pressure and exhausts both chambers of the pneumatic drive (M20) via the valve (Q21). This exhausts the air from the pneumatic drive (M20). Permanent force limitation • The pressure is limited by the pressure regulator (R21) so that the pneumatic drive (M20) cannot generate a greater force.
Manual reset function	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). 2. The safety switching device (T1) can then allow the solenoids of the valve (Q20) to be controlled so that normal operation is possible.

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) and the pressure regulator (R21) 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 $MTTF_D$ must be available.

1.2 SLT switchable, Category 1, up to PL c

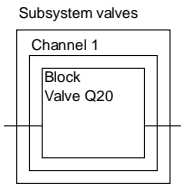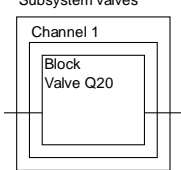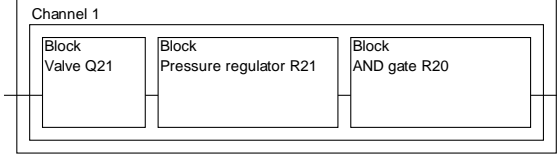STO, PUS and SLT according VDMA 24584 [1] and category 1, up to PL c according EN ISO 13849-1 [2].

1.2.1 Circuit Diagram

1.2.2 Components

Component	Type	Description / Part Number / Remarks	Qty.	Mssr.
M20		Pneumatic drive	1	Festo
Q20		5/3 directional control valve, monostable	1	Festo
Q21		3/2 directional control valve, monostable	1	Festo
		Silencer, if necessary	2	Festo
R20	OS-…-B; OS-PK-3	OR gate	1	Festo
R21	MS…-LR	Pressure regulator	1	Festo
S1		Acknowledge push button	1	
S2		Safety commanding device, e.g. emergency stop switch	1	
S20		Switch functional control	1	
S21		Operation mode switch	1	
T1		Safety switching device	1	

1.2.3 Description

Application	Double acting pneumatic drive, horizontal
Triggering event	Safety request, e.g. by emergency stop switch, safety gate
Reaction (Safety Sub-function)	**Safe torque off (STO), category 1, PL c** Subsystem valves Channel 1 Block Valve Q20 **Prevention of unexpected start-up (PUS), category 1, PL c** Subsystem valves Channel 1 Block Valve Q20 **Safely-limited torque (SLT), category 1, PL c** Subsystem valves Channel 1 Block Valve Q21 / Block Pressure regulator R21 / Block AND gate R20
Safe state	After a safety requirement (S2): • The pneumatic drive is exhausted after an application-specific time and is energy-free. It is presumed that the exhausted state of the pneumatic drive is the safe state. In "manual" operating mode additionally: • The pneumatic drive cannot exceed a set force by limiting the pressure. It is presumed that this limitation is the safe state of the pneumatic drive. Notes: • The precondition for the SLT safety sub-function is that no external forces are acting on the pneumatic drive (M20) that have not been taken into account. • The force of the drive can be changed with the pressure adjustment button of the pressure regulator. To prevent manipulation, sufficient measures must be taken to prevent manipulation, e.g. hidden installation.
Function	By the safety request (S2): 1. The input circuit of the safety switching device (T1) is interrupted. 2. The safe outputs of the safety switching device (T1) for the valve (Q20) are then switched off. 3. The solenoids of the valve (Q20) are no longer actuated. 4. The valve (Q20) switches to the normal position, separates the supply of the operating pressure and exhausts both chambers of the pneumatic drive (M20) via the valve (Q21). This exhausts the air from the pneumatic drive (M20). When switching from "automatic" mode to "manual" mode (S21) 1. The safety switching device (T1) detects the change from automatic mode to manual mode. 2. The safe outputs of the safety switching device (T1) for the valves (Q20, Q21) are then switched off. 3. The solenoids of the valves (Q20, Q21) are no longer actuated. 4. The valve (Q21) switches to the normal position and thus the OR gate (R20) switches to the flow path with the pressure regulator (R21) to limit the pressure. 5. The valve (Q20) switches to the normal position, separates the supply of the operating pressure and exhausts both chambers of the pneumatic drive (M20).
Manual reset function	For the safety request (S2):

	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).
	2. The safety switching device (T1) can then allow the solenoids of the valve (Q20) to be controlled so that normal operation is possible.
	Additionally in "automatic" operating mode:
	1. The operating mode switch (S21) is in the switching position for the operating mode "automatic".
	2. The safe output of the safety switching device (T1) for the valve (Q21) is then switched on.
	3. The solenoid of the valve (Q21) is actuated.
	4. The valve (Q21) switches to the switching position and the OR element (R20) switches to the flow path with the operating pressure. This means that the pressure is not limited and higher forces are possible.
	Additionally in the "manual" operating mode:
	1. The operating mode switch (S21) is in the switching position for the "manual" operating mode.
	2. The safe output of the safety switching device (T1) for the valve (Q21) remains switched off.
	3. The solenoid of the valve (Q21) is not actuated.
	4. The valve (Q21) remains in the normal position and the OR gate (R20) switches to the flow path with the pressure regulator (R21) to limit the pressure.

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), the pressure regulator (R21) and the OR gate (R20) 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 $MTTF_D$ 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