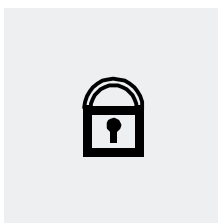
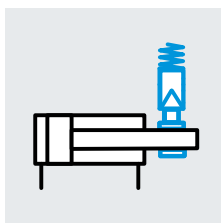


Safety Sub-functions **SB Category 1, up to PL c** **PUS Category 1, up to PL c**



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

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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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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
 - SET: Safe Equilibrium of Torque
 - SB: Safe Blocking
The output of the pneumatic drive is stopped. The free movement of the drive output is blocked by friction.
 - PUS: Prevention of unexpected start-up
- 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:
 - Type of actuation: electrical
 - Type of reset: mechanical spring
 - Sealing principle: soft
 - Type of piloting: piloted
 - Pilot air supply: 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_D value must be available.

Important note

- In addition, further design features and requirements may exist, which must be determined depending on the application.
- Due to the wide variety of possible pressure regulators, no pressure regulator type and part numbers can be given in this document. When selecting pressure regulators, make sure that the selected pressure regulators have the following characteristics:
 - Controller function: output pressure constant with secondary exhaust
 - 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 value must be available.

Important note

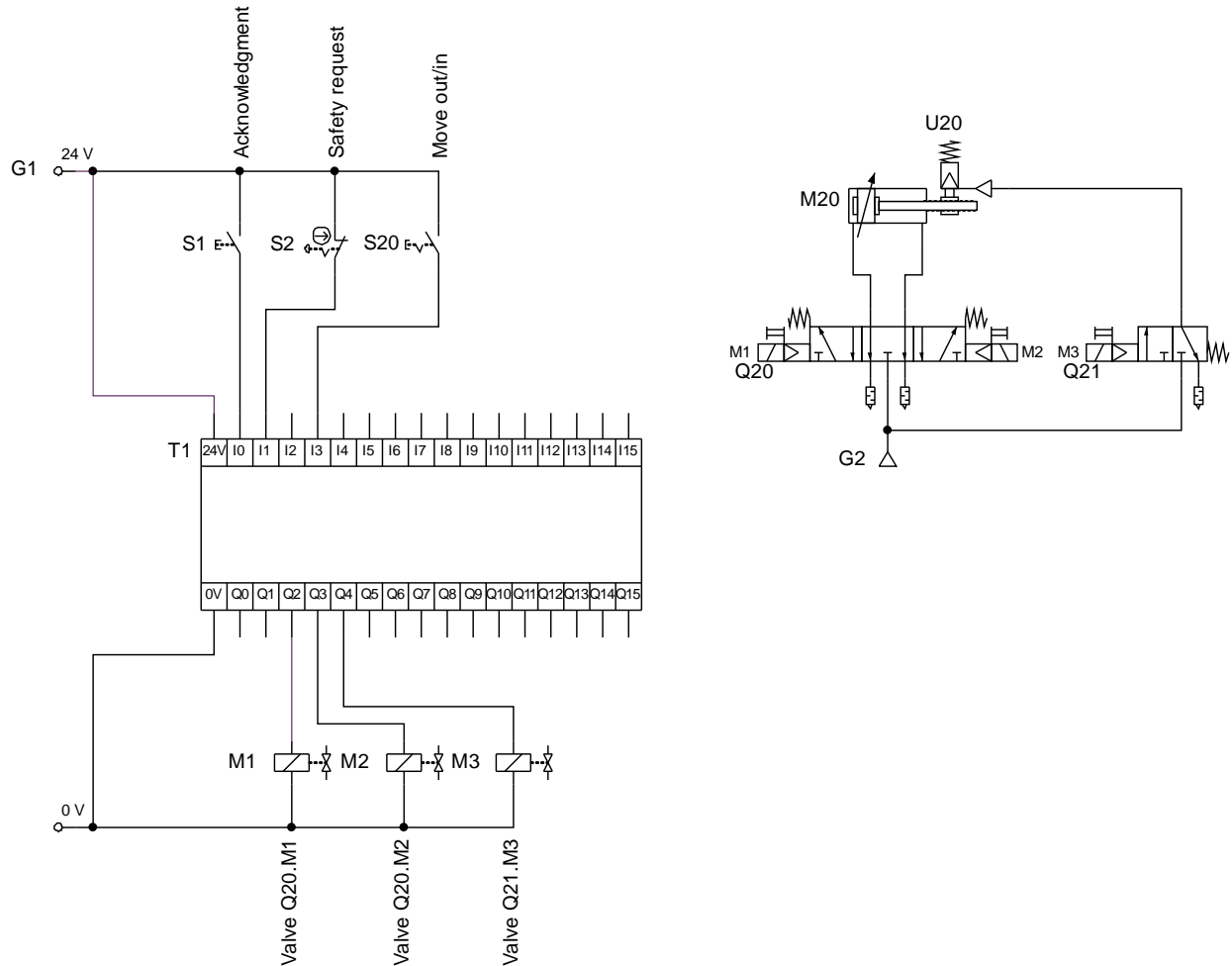
- In addition, further design features and requirements may exist, which must be determined depending on the application.
- Due to the wide variety of possible clamping units, no clamping unit type and part numbers can be given in this document. When selecting clamping units, make sure that the selected clamping unit have the following characteristics:
 - Type of clamping with direction of action: at both sides; clamping with spring, release with compressed air
 - 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 value must be available.
 - In order to be able to execute the safety sub-function Safe Blocking (SB), the holding force of the clamping unit must be dimensioned so that it can hold all simultaneously acting forces of the application.

Important note

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

1.1 STO, SB and PUS, Category 1, up to PL c

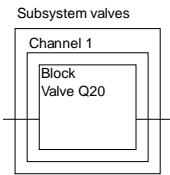
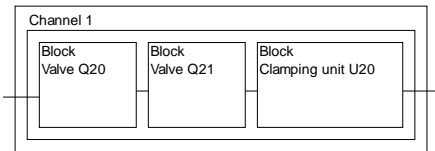
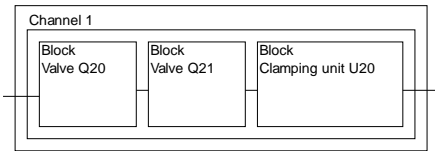
1.1.1 Circuit Diagram



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
Q21		3/2 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	
U20		Clamping unit	1	Festo

1.1.3 Description

Application	Double acting pneumatic drive
Triggering event	Safety request, e.g. by emergency stop switch, safety gate
Reaction (Safety Sub-function)	<p>Safe torque off (STO), category 1, PL c</p>  <p>Safe Blocking (SB), category 1, PL c</p>  <p>Prevention of unexpected start-up, category 1, PL c</p> 
Safe state	<p>The pneumatic drive is stopped, exhausted and free of energy and in addition, the output of the pneumatic drive is blocked by friction.</p> <p>It is presumed that the exhausted and frictionally blocked state of the pneumatic drive is the safe state.</p> <p>Notes:</p> <ul style="list-style-type: none"> • Clamping units for factory automation are normally only suitable for static clamping. Manufacturers of clamping units normally do not allow the clamping unit to decelerate the movement (braking). If a movement should nevertheless be delayed with a clamping unit, e.g. due to a power failure, a functional test of the clamping unit for the static clamping is necessary due to the increased wear. If necessary, the clamping unit must be replaced. • When implementing, make sure that the pneumatic drive is only clamped in an end position when stationary. This prevents additional forces from acting on the clamping unit when the actuator is pressurized. • The forces of the load and the moving parts of the drive must at all times be less than the holding force of the clamping unit. If the clamping unit is also to be able to hold the force of the drive, the clamping unit must be dimensioned accordingly. • Clamping units are subject to wear. Therefore a regular inspection at least during the maintenance cycle of the machine is recommended.
Function	<p>The safety requirement (S2):</p> <ol style="list-style-type: none"> 1. Interrupts the input circuit of the safety switching device (T1). 2. The safety switching device (T1) prevents the outputs for the valve (Q20) from being changed so that the valve (Q20) remains in its current switching position. 3. After a time delay in which the pneumatic drive (M20) reaches its end position in any case, the safe outputs of the safety switching device (T1) for the valve (Q21) are switched off. 4. The solenoids of the valve (Q21) are no longer controlled. 5. This means that the clamping unit (U20) is no longer controlled. This causes the clamping unit (U20) to go into normal position and clamps the output of the pneumatic drive (M20). 6. After a time delay the solenoids of the valve (Q20) are no longer controlled. 7. 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).

Manual reset function	<p>It is presumed that the pneumatic drive is in one of its end positions.</p> <ol style="list-style-type: none"> 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) controls the valve (Q20) so that the pneumatic drive is held in its current end position. 3. After a time delay, the solenoid of the valve (Q21) is actuated. This switches the valve (Q21) to its switching position so that the clamping unit (U20) is actuated. This releases the clamping of the clamping unit (U20). 4. The safety switching device (T1) can then allow the solenoids of the valve (Q20) to be controlled so that normal operation is possible.
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1.1.4 Safety Considerations

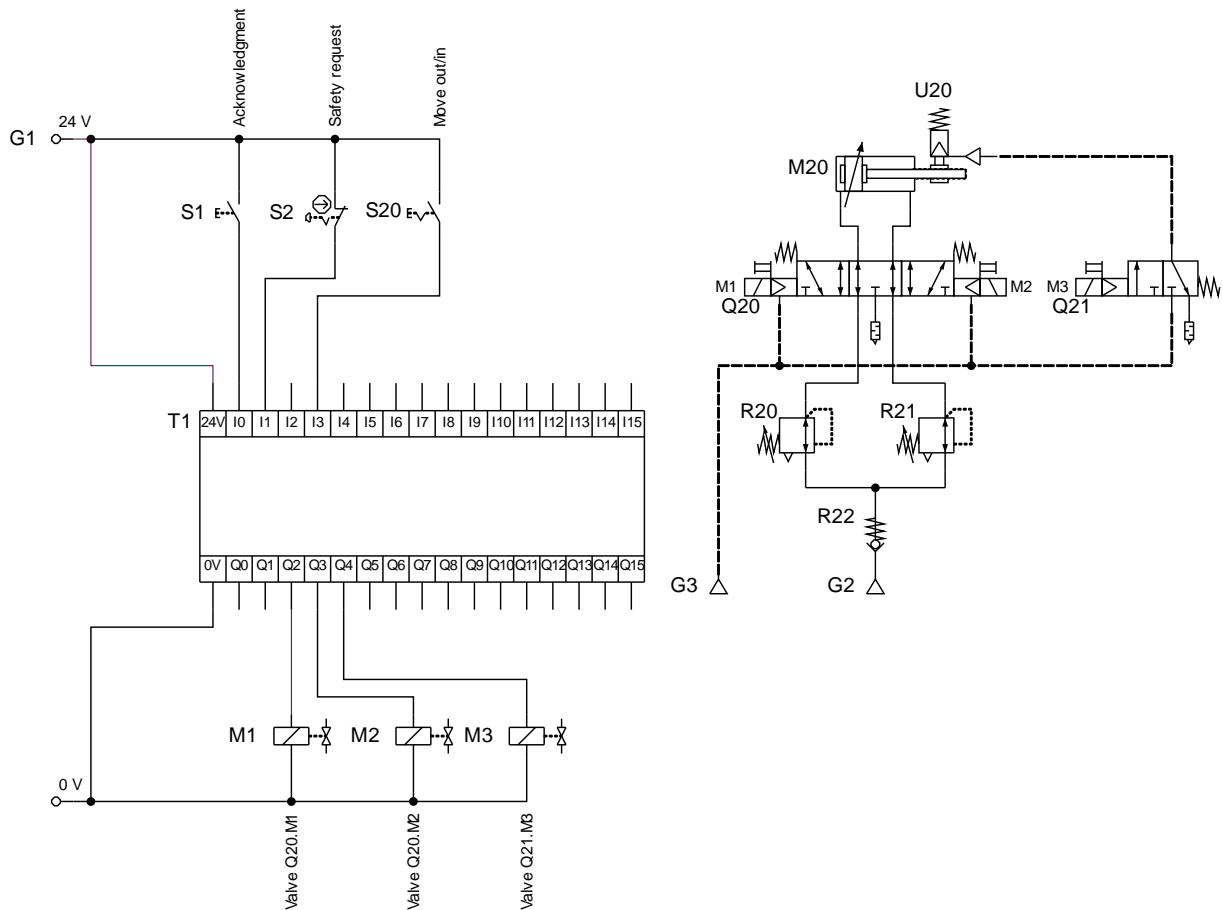
Input	Safety considerations must be carried out in accordance with the selected safety commanding device (S2).
Logic	Safety considerations must be carried out in accordance with the selected safety switching device (T1).
Output	The valves (Q20, Q21) are well-tried components according to EN ISO 13849-1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

1.2 SET, SB and PUS, Category 1, up to PL c

1.2.1 Circuit Diagram



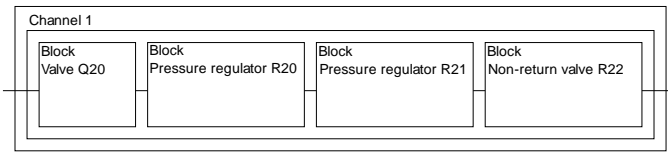
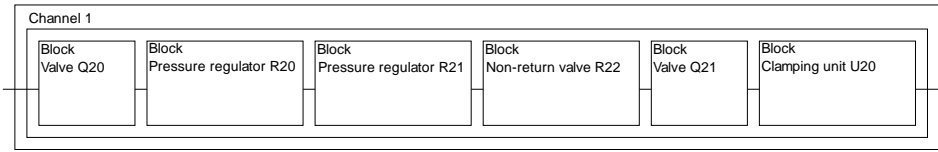
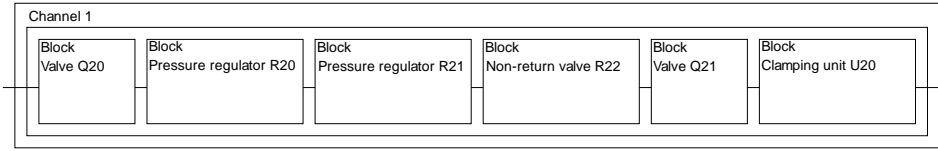
According to EN ISO 14118 enclosed pressurized air shall be marked and shall be provided with a possibility for manual pressure release.



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	1	Festo
R20, R21		Pressure regulator	2	Festo
R22		Non-return valve	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	
U20		Clamping unit	1	Festo

1.2.3 Description

Application	Double acting pneumatic drive
Triggering event	Safety request, e.g. by emergency stop switch, safety gate
Reaction (Safety Sub-function)	<p>Safe equilibrium of torque (SET), category 1, PL c</p> <p>Subsystem valves</p>  <p>SB: Safe Blocking, category 1, PL c</p> <p>Subsystem Output</p>  <p>Prevention of unexpected start-up, category 1, PL c</p> <p>Subsystem Output</p> 
Safe state	<p>The chambers of the pneumatic drive are supplied with compressed air. The pressures in the chambers are adjusted with pressure regulators so that all forces on the pneumatic drive are balanced, i.e. the external forces are compensated by the force of the pneumatic drive and the pneumatic drive can thus maintain its current position. In addition, the output of the pneumatic drive is blocked by friction.</p> <p>It is presumed that this condition of the pneumatic drive can be a safe condition.</p> <p>Notes:</p> <ul style="list-style-type: none"> • The safe state presumes that the external forces and the force generated by the drive remain constant. If there are different load conditions in the application, it is recommended to adjust the moment equilibrium for the largest load so that for smaller loads there is movement in the direction where the risk is lower. Depending on the risk, it may be necessary to evaluate the safety sub-function SLT for smaller loads or to use the clamping unit (U20). The movement of the smaller loads can be blocked in the end position by the clamping unit (U20). • Clamping units for factory automation are normally only suitable for static clamping. Manufacturers of clamping units normally do not allow the clamping unit to decelerate the movement (braking). If a movement should nevertheless be delayed with a clamping unit, e.g. due to a power failure, a functional test of the clamping unit for the static clamping is necessary due to the increased wear. If necessary, the clamping unit must be replaced. • Depending on the settings of the pressure regulators (R20, R21) and the application, the SET safety sub-function can perform a stop function. If there are different load conditions in the application, the stop function can only be executed for one load condition. With the other load conditions, the pneumatic drive will normally come to a standstill in its end position. In the end position, the movement can then be blocked by friction with the clamping unit (U20). • The movement can be stopped by the clamping unit (U20). It should be noted, however, that deceleration of the movement (braking) is permitted for the selected clamping unit according to the manufacturer's specifications. • If the operating pressure supply (G2) is exhausted, the exhausted state of the pneumatic drive (M20) can be brought about by actuating the valve (Q20) in both switching states. • The non-return valve (R22) is used to maintain the operating pressure when the compressed air supply is switched off or fails. After switching off or after failure of the

	<p>operating pressure, a movement may occur due to the leakage which cannot be stopped.</p> <ul style="list-style-type: none"> • The settings of the pressure regulators (R20, R21) must be protected against manipulation, e.g. by lockable pressure regulators. • The forces of the load and the moving parts of the drive must at all times be less than the holding force of the clamping unit. If the clamping unit is also to be able to hold the force of the drive, the clamping unit must be dimensioned accordingly. • Clamping units are subject to wear. Therefore a regular inspection at least during the maintenance cycle of the machine is recommended. • According to EN ISO 13736 [3], the movement possible due to leakage or changes in the tribological system must not exceed a value of 5 mm/s. This must be checked at regular intervals, e.g. in the maintenance interval of the machine.
Function	<p>The safety requirement (S2):</p> <ol style="list-style-type: none"> 8. Interrupts the input circuit of the safety switching device (T1). 9. Switch off the safe outputs of the safety switching device (T1) for the valve (Q20). 10. The solenoids of the valve (Q20) are no longer controlled. 11. The valve (Q20) switches to its normal position and connects the chambers of the pneumatic drive (M20) with the pressure regulators (R20, R21). The pressure regulators are set so that the known load is held in position at standstill. 12. After a time delay in which the pneumatic drive (M20) is always stopped, the safe outputs of the safety switching device (T1) for the valve (Q21) are switched off. 13. The solenoid of the valve (Q21) is no longer controlled. 14. Therefore the locking unit (U20) is no longer actuated. This causes the clamping unit (U20) to go into the normal position and clamps the output of the pneumatic drive (M20).
Manual reset function	<ol style="list-style-type: none"> 5. 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). 6. The safety switching device (T1) controls the valve (Q21). This switches the valve (Q21) to its switching position so that the clamping unit (U20) is actuated. This releases the clamping of the clamping unit (U20). The current position can be held by the active SET safety sub-function. 7. After a time delay, the safety switching device (T1) allows the solenoids of the valve (Q20) to be controlled. The safety switching device switches the valve (Q20) to the switching position of the desired direction of movement. The pneumatic drive (M20) moves to the controlled end position. Normal operation is then possible.

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 valve (Q20, Q21), pressure regulators (R20, R21), non-return valve (R22) and clamping unit (U20) are well-ried components according to EN ISO 13849-1 and the relevant basic and well-ried 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
- [3] DIN EN 13736:2009-11 - Safety of machine tools - Pneumatic presses; German version EN 13736:2003+A1:2009