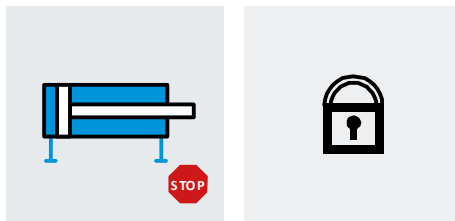


Safety Sub-functions SSC Category 1, up to PL c PUS Category 1, up to PL c



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

Title Application Note SSC, PUS, Category 1, up to PL c
Version 1.1
Document number (TSHQ) 100231
Original German
Author Festo
Last date of saving 23.04.2019

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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:
 - SSC: Safe Stopping and Closing
The safety sub-function SSC only stops the pneumatic drive before the end position if the stroke length is significantly greater than the diameter of the piston of the pneumatic drive.
 - 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_D value must be available.

Important note

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

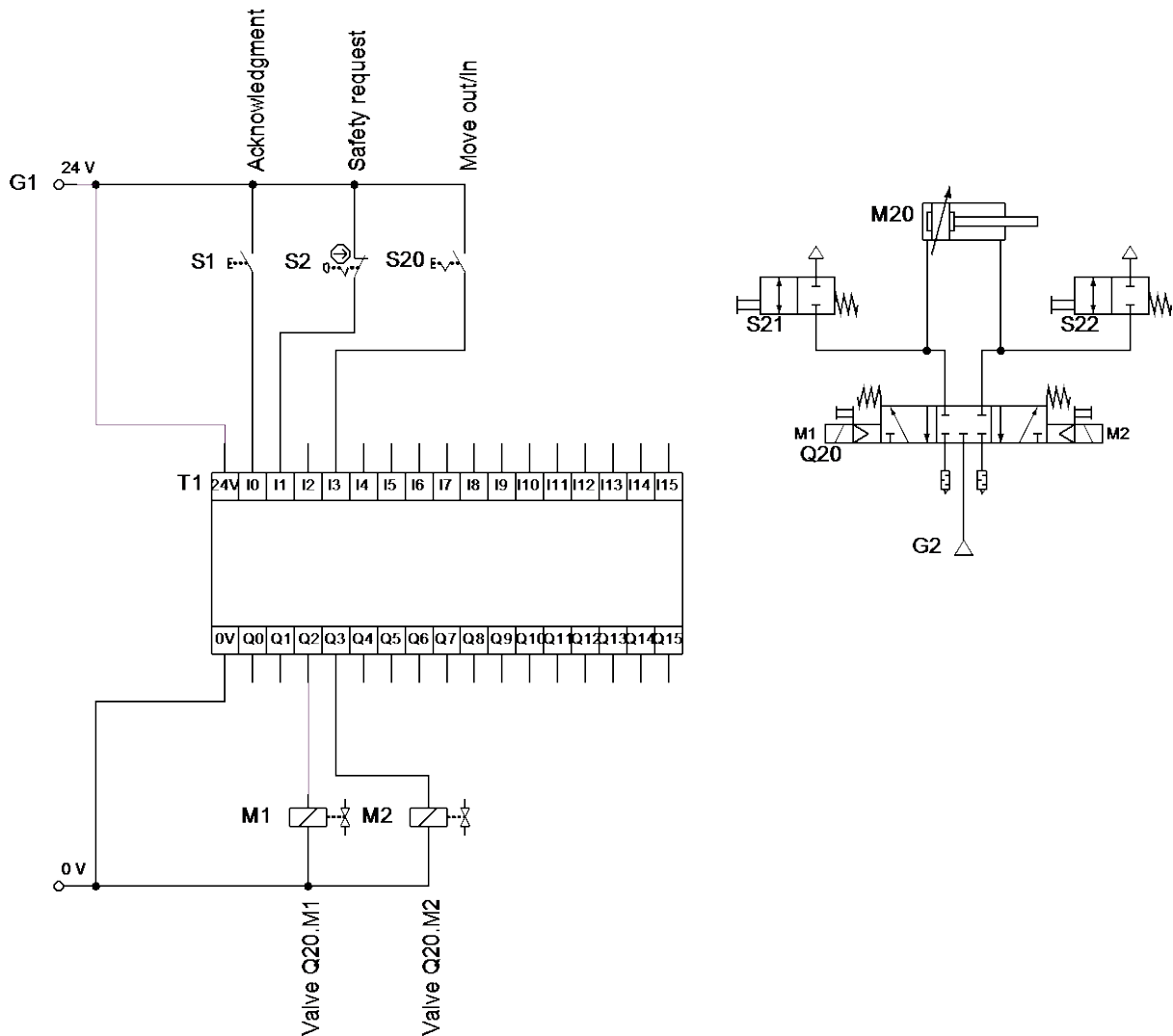
1.1 SSC and PUS with 5/3 Directional Control Valve, Category 1, up to PL c

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

1.1.1 Circuit Diagram



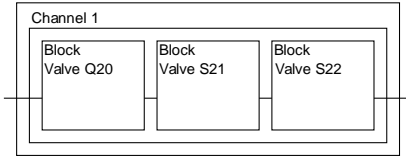
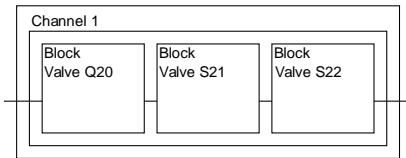
According to EN ISO 14118 enclosed pressurized air shall be marked and shall be provided with a possibility for manual pressure release. Leakage can cause movements that cannot be stopped.



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	
S21, S22	HAB-...	2/2 directional control valve, manual actuated	2	Festo
T1		Safety switching device	1	

1.1.3 Description

Application	Double acting pneumatic drive
Triggering event	Safety request (S2), e.g. by emergency stop switch, safety gate
Reaction (Safety Sub-function)	<p>Safe stopping and closing (SSC), category 1, PL c</p> <p>Subsystem valves</p>  <p>Prevention of unexpected start-up, category 1, PL c</p> <p>Subsystem valves</p> 
Safe state	<p>In the pneumatic drive compressed air is enclosed to hold the last position. Slow movements are possible by leakage that cannot be stopped. It is presumed, that this can be a possible safe state. It must be evaluated whether this may cause a hazard.</p> <p>By actuating the valves (S21, S22), the exhausted state of the pneumatic drive can be possible.</p> <p>Notes:</p> <ul style="list-style-type: none"> • According to EN 13736 [3], the movement possible due to leakage 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. • If pneumatic axes with external forces, e.g. vertical axes, are exhausted with the valves (S21, S22), a dangerous movement may result. To reduce the risk, additional protective measures may be required for this hazard.
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. Switch off the safe outputs of the safety switching device (T1). 3. The solenoids of the valve (Q20) are no longer controlled. 4. Valve (Q20) moves to its normal position, separates the compressed air supply and closes the pneumatic flow paths out of the pneumatic drive (M20). This stops the pneumatic drive (M20). <p>Note:</p> <ul style="list-style-type: none"> • The safety sub-function SSC only stops the pneumatic drive before the end position if the stroke length is significantly greater than the diameter of the piston of the pneumatic drive (M20).
Manual reset function	<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) can then allow the solenoids of the valve (Q20) to be controlled so that normal operation is possible. <p>In normal operation the manually actuated valves (S21, S22) must not be used. They are only used to release blockages in the SSC state.</p>

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, S21, S22) are a well-tried components according to EN ISO 13849-1 and the relevant basic and well-tried safety principles have been observed. B10 values required for the calculation of the $MTTF_D$ must be available.

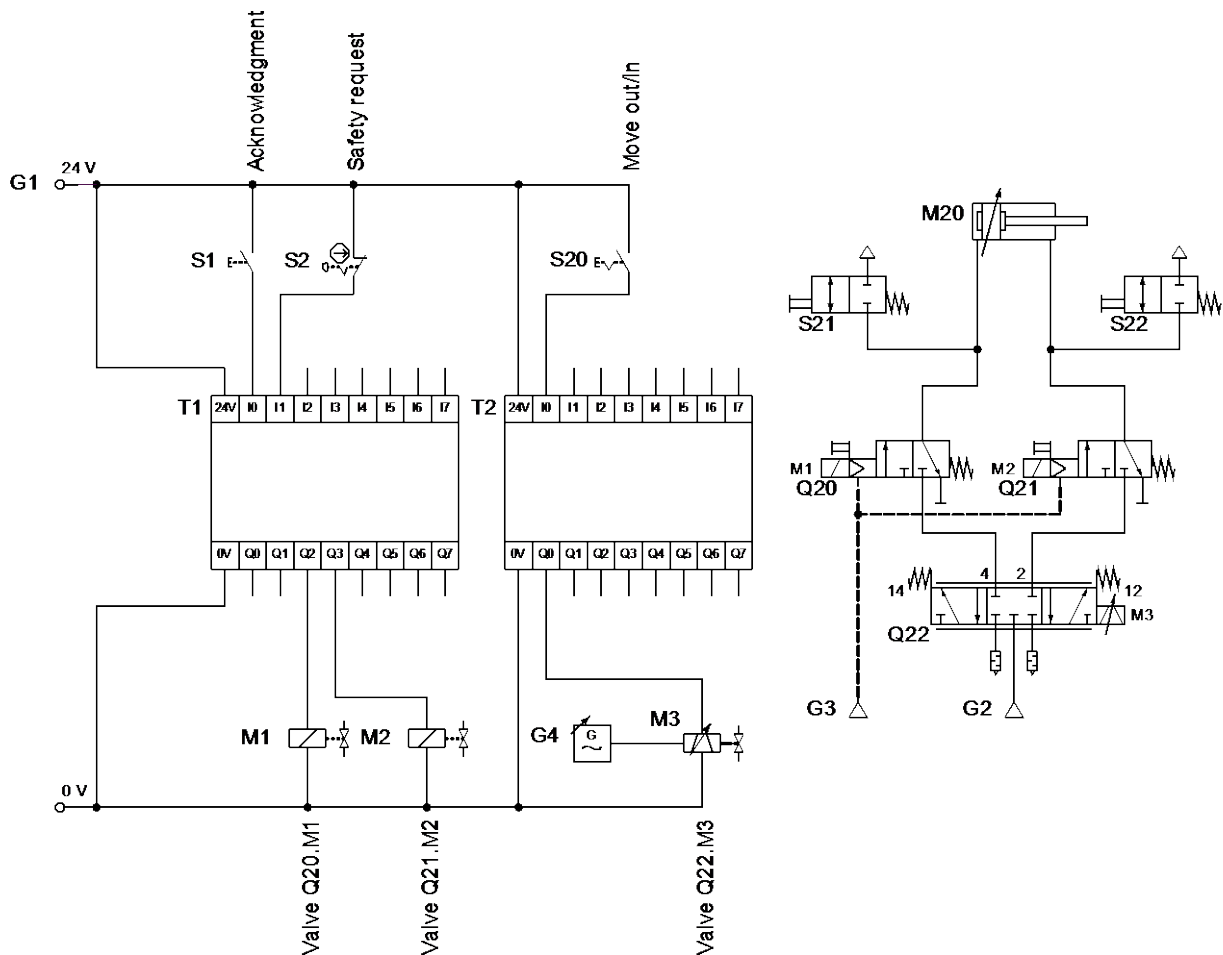
1.2 SSC and PUS with 3/2 Directional Control Valve, Category 1, up to PL c

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

1.2.1 Circuit Diagram



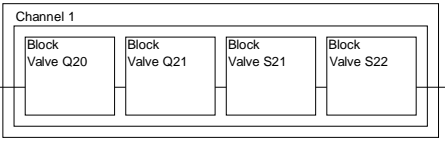
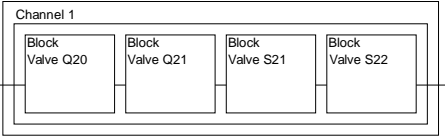
According to EN ISO 14118 enclosed pressurized air shall be marked and shall be provided with a possibility for manual pressure release. Leakage can cause movements that cannot be stopped.



1.2.2 Components

Component	Type	Description / Part Number / Remarks	Qty.	Mssr.
M20		Pneumatic drive	1	Festo
Q20, Q21		3/2 directional control valve, monostable	2	Festo
		Blanking plugs, suitable for the selected valves	2	Festo
Q22		Proportional valve	1	Festo
S1		Acknowledge push button	1	
S2		Safety commanding device, e.g. emergency stop switch	1	
S20		Switch functional control	1	
S21, S22	HAB-...	2/2 directional control valve, manually actuated	2	Festo
T1		Safety switching device	1	
T2, G4		Functional PLC	1	

1.2.3 Description

Application	Double acting drive
Triggering event	Safety request (S2), e.g. by emergency stop switch, safety gate
Reaction (Element safety function)	<p>Safe stopping and closing (SSC), category 1, PL c</p>  <p>Prevention of unexpected start-up (PUS), category 1, PL c</p> 
Safe state	<p>In the pneumatic drive compressed air is enclosed to hold the last position. Slow movements are possible by leakage that cannot be stopped. It is presumed, that this can be a possible safe state. It must be evaluated whether this may cause a hazard.</p> <p>By actuating the valves (S21, S22), the exhausted state of the pneumatic drive can be possible.</p> <p>Notes:</p> <ul style="list-style-type: none"> • According to EN 13736 [3], the movement possible due to leakage should not exceed a value of 5 mm/s. This must be checked at regular intervals, e.g. in the maintenance interval of the machine. • If pneumatic axes with external forces, e.g. vertical axes, are exhausted with the valves (S21, S22), a dangerous movement may result. To reduce the risk, additional protective measures may be required for this hazard.
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. First, the valve (Q22) should be brought functionally into the normal position. This closes ports 2 and 4 of the valve (Q22). 3. Switch off the safe outputs of the safety switching device (T1). 4. The solenoid of the valves (Q20, Q21) are no longer controlled. 5. Valves (Q20, Q21) move to their normal position, separate the compressed air supply and close the pneumatic flow paths out of the pneumatic drive (M20). This stops the pneumatic drive (M20). <p>Note:</p> <ul style="list-style-type: none"> • The valve (Q22) is not involved in the safety sub-function mentioned and cannot fail dangerously in relation to the safety sub-function mentioned. • The safety sub-function SSC only stops the pneumatic drive before the end position if the stroke length is significantly greater than the diameter of the piston of the pneumatic drive (M20).
Manual reset function	<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 solenoids of the valves (Q20, Q21) so that these can release the flow paths and the functional control with the valve (Q22) can set the desired direction of movement. <p>In normal operation the manually actuated valves (S21, S22) must not be used. They are only used to release blockages in the SSC state.</p> <p>Note:</p> <ul style="list-style-type: none"> • In the case of proportional valves with external sensors, the control loop may, under certain circumstances, exhaust ports 2 and 4 or apply maximum pressure to them. This can lead to an unexpected movement with the manual reset function.

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, S21, S22) 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.

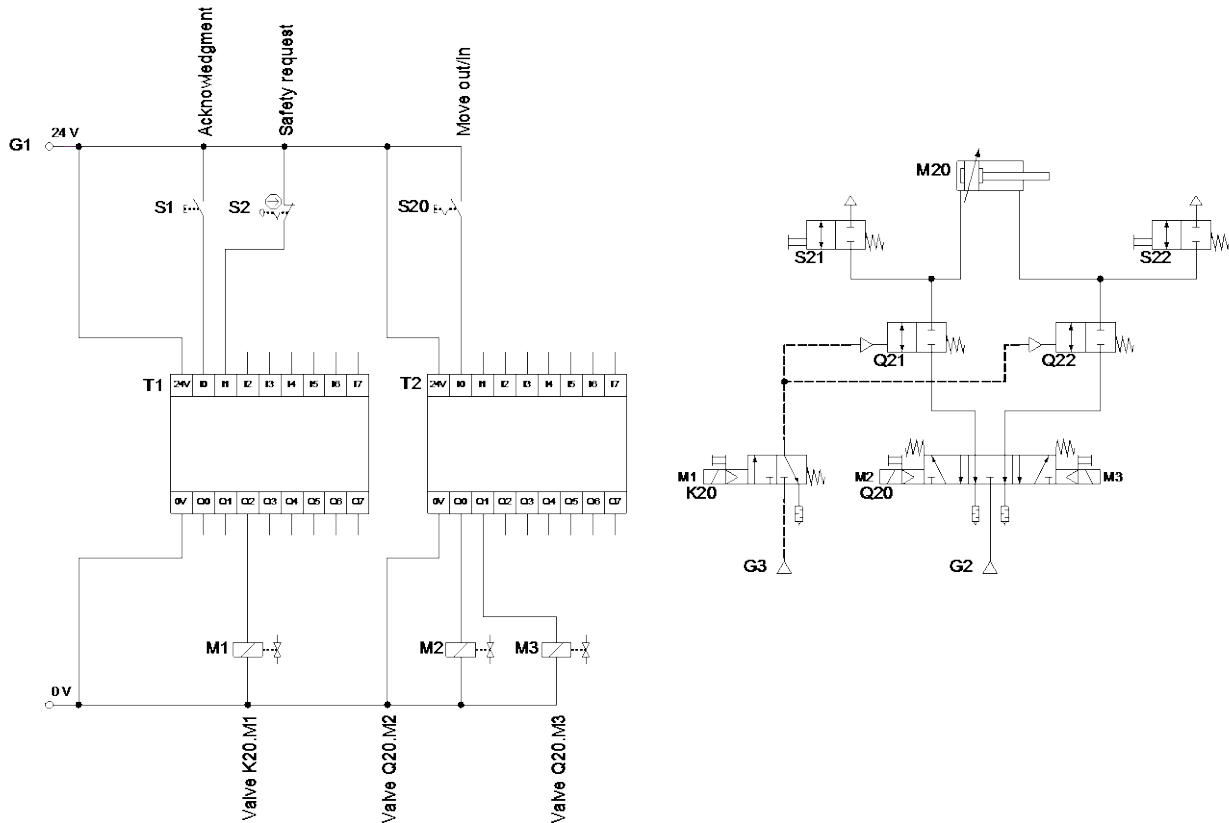
1.3 SSC and PUS with 2/2 Directional Control Valve, Category 1, up to PL c

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

1.3.1 Circuit Diagram



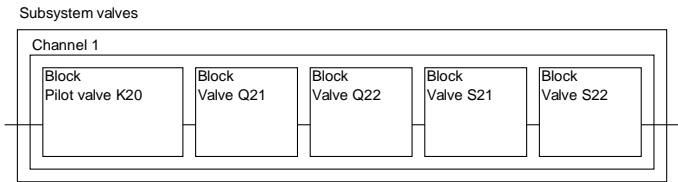
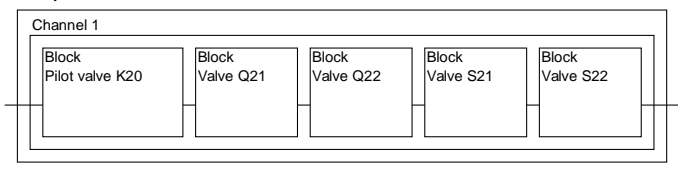
According to EN ISO 14118 enclosed pressurized air shall be marked and shall be provided with a possibility for manual pressure release. Leakage can cause movements that cannot be stopped.



1.3.2 Components

Component	Type	Description / Part Number / Remarks	Qty.	Mssr.
K20		3/2 directional control valve, monostable	1	Festo
M20		Pneumatic drive	1	Festo
Q20		5/3 directional control valve, monostable	1	Festo
Q21, Q22		2/2 directional control valve, monostable	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	
S21, S22	HAB-...	2/2 directional control valve, manually actuated	2	Festo
T1		Safety switching device	1	
T2		Functional PLC	1	

1.3.3 Description

Application	Double acting drive
Triggering event	Safety request, e.g. by emergency stop switch, safety gate
Reaction (Element safety function)	<p>Safe stopping and closing (SSC), category 1, PL c</p>  <p>Prevention of unexpected start-up (PUS), category 1, PL c</p> 
Safe state	<p>In the pneumatic drive compressed air is enclosed to hold the last position. Slow movements are possible by leakage that cannot be stopped. It is presumed, that this can be a possible safe state. It must be evaluated whether this may cause a hazard.</p> <p>By actuating the valves (S21, S22), the exhausted state of the pneumatic drive can be possible.</p> <p>Notes:</p> <ul style="list-style-type: none"> According to EN 13736 [3], the movement possible due to leakage 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. If pneumatic axes with external forces, e.g. vertical axes, are exhausted with the valves (S21, S22), a dangerous movement may result. To reduce the risk, additional protective measures may be required for this hazard.
Function	<p>The safety requirement (S2):</p> <ol style="list-style-type: none"> Interrupts the input circuit of the safety switching device (T1). Switch off the safe outputs of the safety switching device (T1). The solenoids of the valve (K20) are no longer controlled. Valve (K20) moves to its normal position, separates and exhausts the pilot air supply to the valves (Q21, Q22). Valves (Q21, Q22) moves to their normal position, separate the supply of the working pressure and close the pneumatic flow paths out of the pneumatic drive (M20). This stops the pneumatic drive (M20). <p>Note:</p> <ul style="list-style-type: none"> The safety sub-function SSC only stops the pneumatic drive before the end position if the stroke length is significantly greater than the diameter of the piston of the pneumatic drive (M20). The valve (Q20) is not involved in the mentioned safety sub-functions and cannot fail dangerously in relation to the mentioned safety sub-functions.
Manual reset function	<ol style="list-style-type: none"> 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). The safety switching device (T1) then controls the solenoid of the valve (K20) so that it switches to the switching position and allows the supply of pilot air pressure to the valves (Q21, Q22). The valves (Q21, Q22) switch to their switching position and allow the supply of the working pressure to both chambers of the pneumatic actuator (M20). This allows normal operation. <p>In normal operation the manually actuated valves (S21, S22) must not be used. They are only used to release blockages in the SSC state.</p>

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 (K20, Q21, Q21, Q22) 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.

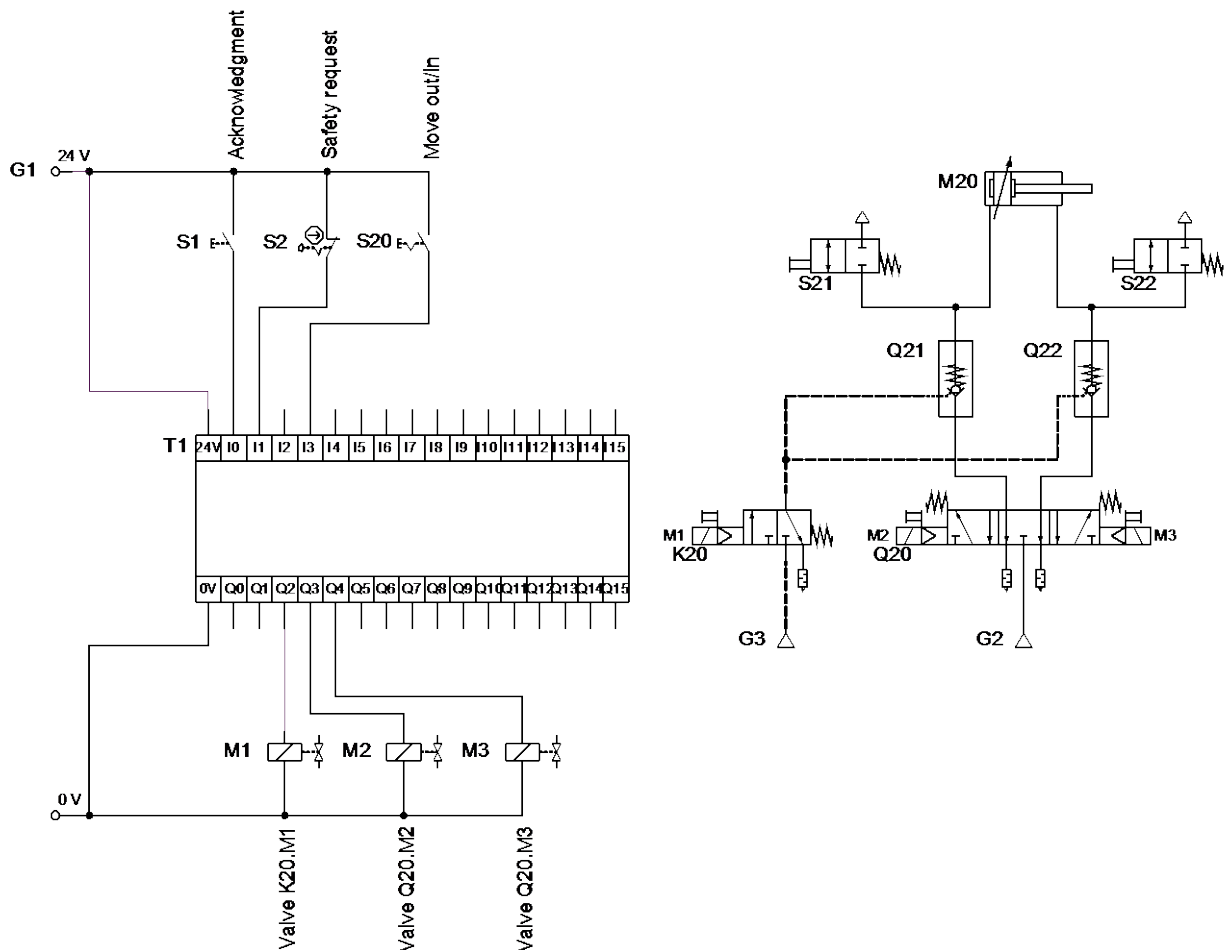
1.4 SSC and PUS with Delockable Check Valves, Category 1, up to PL c

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

1.4.1 Circuit Diagram



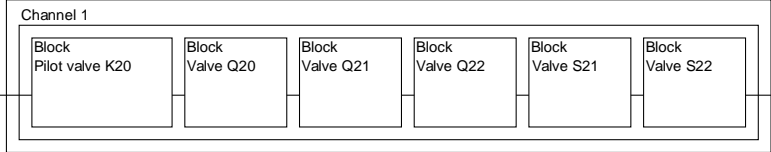
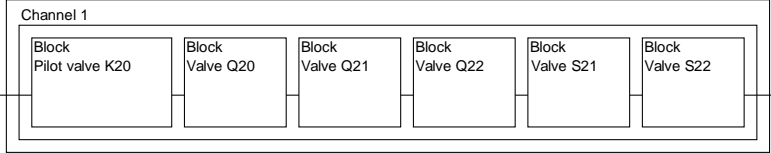
According to EN ISO 14118 enclosed pressurized air shall be marked and shall be provided with a possibility for manual pressure release. Leakage can cause movements that cannot be stopped.



1.4.2 Components

Component	Type	Description / Part Number / Remarks	Qty.	Mssr.
K20		3/2 directional control valve, monostable	1	Festo
M20		Pneumatic drive	1	Festo
Q20		5/3 directional control valve, monostable	1	Festo
Q21, Q22	HGL-...; VBNF-LBA-...; VFOF-LE-BAH-...	Delockable check valve	2	Festo
		Silencer, if necessary	3	Festo
S1		Acknowledge push button	1	
S2		Safety commanding device, e.g. emergency stop switch	1	
S20		Switch functional control	1	
S21, S22	HAB-...; VBNF-LBA-...; VFOF-LE-BAH-...	2/2 directional control valve, manually actuated	(2 only with HGL)	Festo
T1		Safety switching device	1	

1.4.3 Description

Application	Double acting drive
Triggering event	Safety request, e.g. by emergency stop switch, safety gate
Reaction (Element safety function)	<p>Safe stopping and closing (SSC), category 1, PL c</p> <p>Subsystem valves</p>  <p>Prevention of unexpected start-up (PUS), category 1, PL c</p> <p>Subsystem valves</p> 
Safe state	<p>In the pneumatic drive compressed air is enclosed to hold the last position. Slow movements are possible by leakage that cannot be stopped. It is presumed, that this can be a possible safe state. It must be evaluated whether this may cause a hazard. By actuating the valves (S21, S22), the exhausted state of the pneumatic drive can be possible.</p> <p>Notes:</p> <ul style="list-style-type: none"> According to EN 13736 [3], the movement possible due to leakage 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. If pneumatic axes with external forces, e.g. vertical axes, are exhausted with the valves (S21, S22), a dangerous movement may result. To reduce the risk, additional protective measures may be required for this hazard.
Function	<p>The safety requirement (S2):</p> <ol style="list-style-type: none"> Interrupts the input circuit of the safety switching device (T1). Switch off the safe outputs of the safety switching device (T1). The solenoids of the valve (Q20) are no longer controlled. Valve (Q20) moves to its normal position, separates and exhausts the working pressure to the delockable check valves (Q21, Q22). The solenoids of the valve (K20) are no longer controlled. Valve (K20) moves to its normal position, separates and exhausts the pilot air supply to the valves (Q21, Q22). Valves (Q21, Q22) moves to their normal position, separate the supply of the working pressure and close the pneumatic flow paths out of the pneumatic drive (M20). This stops the pneumatic drive (M20). <p>Note:</p> <ul style="list-style-type: none"> The safety sub-function SSC only stops the pneumatic drive before the end position if the stroke length is significantly greater than the diameter of the piston of the pneumatic drive (M20).
Manual reset function	<p>Important note:</p> <p>Depending on the pressure conditions, the leakage and the switching position of the valve (Q20), differences in pressure may occur during restart, triggering movement in the opposite direction before movement in the switched direction.</p> <ol style="list-style-type: none"> 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). The safety switching device (T1) allows the solenoids of the valve (Q20) to be controlled so that the functional control can set the desired direction of movement. The safety switching device (T1) then controls the solenoid of the valve (K20) so that it switches to the switching position and allows the supply of pilot air

	<p>pressure to the valves (Q21, Q22). The valves (Q21, Q22) switch to their switching position and allow the supply of the working pressure to both chambers of the pneumatic actuator (M20). This allows normal operation.</p> <p>In normal operation the manually actuated valves (S21, S22) must not be used. They are only used to release blockages in the SSC state.</p>
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1.4.4 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 (K20, Q21, Q21, S21, S22) 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
- [3] DIN EN 13736:2009-11 - Safety of machine tools - Pneumatic presses; German version EN 13736:2003+A1:2009