Multi-turn actuators

SA 07.2 – SA 16.2/SAR 07.2 – SAR 16.2

SAEx 07.2 – SAEx 16.2/SAREx 07.2 – SAREx 16.2

with actuator controls

AC 01.2-SIL/ACExC 01.2-SIL

SIL version

NOTICE for use!

This document is only valid in combination with the current operation instructions enclosed with the device.

Purpose of the document:

The present documents informs about the actions required for using the device in safety-related systems in accordance with IEC 61508 or IEC 61511.

Reference documents:

- Operation instructions (Assembly, operation, commissioning) for actuator
- Manual (Operation and setting) AUMATIC AC 01.2
- Manual (Device integration Fieldbus) AUMATIC AC 01.2/ACExC 01.2
- Technical data on multi-turn actuator and on actuator controls

Reference documents can be downloaded from the Internet (www.auma.com) or ordered directly from AUMA (refer to <Addresses>).

Table of contents

1. Terminology

Information sources

- IEC 61508-4, Functional safety of electrical/electronic/programmable electronic safety-related systems – Part 4: Definitions and abbreviations
- IEC 61511-1, Functional safety - Safety instrumented systems for the process industry sector – Part 1: Framework, definitions, system, hardware and software requirements

1.1. Abbreviations and concepts

To evaluate safety functions, the lambda values or the PFD value (Probability of Dangerous Failure on Demand) and the SFF value (Safe Failure Fraction) are the main requirements. Further figures are required to assess the individual components. These figures are explained in the table below.

Table 1: Abbreviations of safety parameters

Figure	English	Description
λ_S	Lambda **S**afe	Number of safe failures
λ_D	Lambda **D**angerous	Number of dangerous failures
λ_{DU}	Lambda **D**angerous **U**ndedected	Number of undetected dangerous failures
λ_{DD}	Lambda **D**angerous **D**edected	Number of detected hazardous failures
DC	**D**iagnostic **C**overage	Diagnostic Coverage - ratio between the failure rate of dangerous failures detected by diagnostic tests and total rate of dangerous failures of the component or subsystem. The diagnostic coverage does not include any failures detected during proof tests.
MTBF	**M**ean **T**ime **B**etween **F**ailure	Mean time between two failures following one after the other
SFF	**S**afe **F**ailure **F**raction	Fraction of safe failures
PFD_{avg}	Average **P**robability of dangerous **F**ailure on **D**emand	Average probability of dangerous failures on demand of a safety function.
HFT	**H**ardware **F**ailure **T**olerance	Ability of a functional unit to execute a required function while faults or deviations are present. HFT = n means that the function can still be safely executed for up to n faults occurring at the same time.
T_{proof}	Proof test interval	Interval for proof test

SIL

Safety **I**ntegrity **L**evel

The international standard IEC 61508 defines 4 levels (SIL 1 through SIL 4).

Safety function

Function to be implemented by a safety-related system for risk reduction with the objective to achieve or maintain a safe state for the plant/equipment with respect to a specific hazardous event.

Safety instrumented function (SIF)

Function with defined safety integrity level (SIL) to achieve functional safety.

Safety instrumented system (SIS)

Safety instrumented system for executing a single or several safety instrumented functions. A SIS consists of sensor(s), logic system and actuator(s).

Safety-related system

A safety-related system includes all factors (hardware, software, human factors) necessary to implement one or several safety functions. Consequently failures of safety function would result in a significant increase in safety risks for people and/or the environment.

A safety-related system can comprise stand-alone systems dedicated to perform a particular safety function or can be integrated into a plant.

Proof test

Periodic test performed to detect dangerous hidden failures in a safety-related system so that, if necessary, a repair can restore the system to an "as new" condition or as close as practical to this condition.

MTTR (Mean Time To Restoration)

Mean time to restoration once a failure has occurred. Indicates the expected mean time to achieve restoration of the system. It is therefore an important parameter for system availability. The time for detecting the failure, planning tasks as well as operating resources is also included. It should be reduced to a minimum.

MRT (Mean Repair Time)

Mean repair time indicates the mean time required to repair a system. The MRT is crucial when defining the reliability and availability of a system. The MRT should preferably be small.

Device type (type A and type B)

Actuator controls can be regarded as **type A** devices if all of the following conditions are met for all components required to achieve the safety instrumented function:

- The failure modes for all constituent components involved are well defined
- The behaviour under fault conditions can be completely determined.
- There is sufficient dependable failure data from the field to show that the claimed rates of failure are met (confidence level min. 70 %).

Actuator controls shall be regarded as **type B** devices if one or several of the following conditions are met:

- The failure of at least one constituent component is not well defined.
- The fault behaviour is not completely known.
- There is insufficient dependable failure data to support claims for rates of failure for detected and undetected dangerous failures.

PTC (Proof Test Coverage)

Proof test coverage describes the fraction of failures which can be detected by means of a proof test.

2. Application and validity

2.1. Range of application

AUMA actuators and actuator controls in SIL version are intended for operation of industrial valves and are suitable for use in safety instrumented systems in accordance with IEC 61508 or IEC 61511.

2.2. Standards

Both actuators and actuator controls meet the following requirements:

- IEC 61508 ED.2: Functional safety of electrical/electronic/programmable electronic safety-related systems

2.3. Valid device types

The data on functional safety contained in this manual applies to the device types indicated hereafter.

Table 2: Overview on suitable device types

Type		**Power supply**
Actuator	**Controls**	**Motor**
SA 07.2 – SA 16.2	AC 01.2 in SIL version	3-phase AC current
SAR 07.2 – SAR 16.2	AC 01.2 in SIL version	3-phase AC current
SAEx 07.2 – SAEx 16.2	ACExC 01.2 in SIL version	3-phase AC current
SAREx 07.2 – SAREx 16.2	ACExC 01.2 in SIL version	3-phase AC current

3. Architecture, configuration and applications

3.1. Architecture (actuator sizing)

For actuator architecture (actuator sizing) the maximum torques, running torques and operating times are taken into consideration.

NOTICE

Incorrect actuator architecture can lead to device damage within the safety-related system!

Possible consequences can be valve damage, motor overheating, contactor jamming, defective thyristors, heating up or damage to cables.

→ The actuator technical data must imperatively be observed when selecting the actuator.

→ Sufficient reserves have to be provided to ensure that actuators are capable of reliably opening or closing the valve even in the event of an accident or under-voltage.

Architecture when using the Safe STOP function

Information For the Safe STOP function, the motor is switched off, overrun may possibly occur!

NOTICE

Valve damage due to overrun!

→ For the Safe Stop function (SS), the overrun of the arrangement (actuator, gearbox, valve) and the reaction time have to be observed.

→ If the application requires self-locking of the actuator, please consult AUMA.

Architecture when using the Safe ESD function

Actuators with electromechanical control unit:

End position signalling (limit switching) and torque signalling via the electromechanical control unit are safe signals which may be integrated into a safety-related system.

For "SIL seating" = "no seating" (without end position protection), we recommend:

- To prevent valve damage during safety operation, we recommend, depending on the stiffness, sizing the valve to 3 – 5 times the maximum actuator torque.
- To avoid thermal damage due to excessive currents, we recommend monitoring (assessing) the motor protection.

Actuator with electronic control unit MWG:

Information End position signalling (limit switching) and torque signalling via the electronic control unit MWG are not considered as safe signals.

- In case safe signals are required, they have to be implemented differently, e.g. using switches on the valve.
- To prevent valve damage during safety operation, we recommend, depending on the stiffness, sizing the valve to 3 – 5 times the maximum actuator torque.
- To avoid thermal damage due to excessive currents, we recommend monitoring (assessing) the motor protection.

Actuators with electronic control unit MWG including limit switches:

Information In this version, safe signalling can exclusively be ensured via limit switches.

For "SIL seating" = "no seating" (without end position protection), we recommend:

- To prevent valve damage during safety operation, we recommend, depending on the stiffness, sizing the valve to 3 – 5 times the maximum actuator torque.
- To avoid thermal damage due to excessive currents, we recommend monitoring (assessing) the motor protection.

Information For "SIL seating" = "forced limit seating in end position", the seating is performed via limit switches in the end position. Since each switch has a hysteresis, the actuator leaves the end position prior to limit switch release. Consequently, there is a marginal range of actuator positions to the safety position, for which the limit switch is still operated when leaving the safety position while the Safe ESD function is NOT available. In this case, safety function triggering leads to actuator standstill. If the range in question is approached from the opposite direction, this limitation does not apply. In general this range is relatively low. However, for unfavourable configurations (low number of turns per stroke), this range can amount to more than 10 % of the total stroke.
Should within the framework of unfavourable conditions the effect described above represent an unacceptable limitation for the safety function, we recommend applying the configuration "forced torque seating in end position" or "no seating" for safety operation.

Power supply

Information The plant operator is responsible for power supply.

3.2. Configuration (setting)/version

Configuration (setting) of safety-related functions is adjusted in the factory during controls assembly and validated during final inspection. Subsequent modification of the configuration by the plant operator is not permissible.

General functions are set as described in the Operation instructions or the Manual (Operation and setting) AUMATIC AC 01.2.

For configuration of safety-related functions refer to the order-related wiring diagram.

Configuration options for safety function

Table 3: Configuration options for safety function

Configuration SIL function	Short description
Safe ESD CLOSE/CLOSE	Safe CLOSING
Safe ESD OPEN/OPEN	Safe OPENING
Safe STOP CLOSE/OPEN	Safe STOP in direction CLOSE and direction OPEN
Safe ESD CLOSE/CLOSE + Safe STOP CLOSE/OPEN	Safe CLOSING and Safe STOP in direction CLOSE and direction OPEN
Safe ESD OPEN/OPEN + Safe STOP CLOSE/OPEN	Safe OPENING and Safe STOP in direction CLOSE and direction OPEN

Seating configuration options

Information Seating of standard actuator controls should be configured as set forth in the tables below.

Table 4: For actuators with electromechanical control unit:

Configuration SIL seating type	Short description	Configuration Type of seating Standard controls
1: No seating	No seating by limit or torque switches during safety operation	Freely selectable
2: Forced torque seating in end position	Safety operation is stopped if both limit and torque switches trip simultaneously	Torque seating
3: Forced limit seating in end position	Safety operation is stopped by limit switch tripping	Limit seating
4: Limit seating with overload protection	Safety operation is stopped by tripping the limit switches and/or the torque switches (overload protection).	Limit seating

Table 5: For actuators with electronic control unit MWG

Configuration SIL seating type	Short description	Configuration Type of seating Standard controls
1: No seating	No seating by limit or torque switches during safety operation	Freely selectable

Table 6: For actuators with electronic control unit MWG including limit switches

Configuration SIL seating type	Short description	Configuration Type of seating Standard controls
3: Forced limit seating in end position	Safety operation is stopped by limit switch tripping	Limit seating

Configuration options for motor protection assessment

Table 7: Configuration options for motor protection assessment

Configuration SIL motor protection	Short description
Active	Tripping of the motor protection (thermal fault) stops or prevents safety operation
Inactive	Motor protection has no impact on the safety operation

Information "SIL motor protection" = "inactive" configuration is only set if explicitly required. The version does not meet the Ex approval requirements.

3.3. Applications (environmental conditions)

When specifying and using the actuators within safety instrumented systems, particular attention has to be paid that the permissible service conditions and the EMC requirements by the peripheral devices are met. Service conditions are indicated in the technical data sheets:

- Enclosure protection
- Corrosion protection
- Ambient temperature
- Vibration resistance

If the actual ambient temperatures exceed an average of +40 °C, the lambda values have to be incremented by a safety factor. For an average temperature of +60 °C, this factor is defined at 2.5.

For environmental test, actuator and actuator controls were subjected to the following standards:

- Dry heat: EN 60068-2-2
- Damp heat: EN 60068-2-30
- Cold: EN 60068-2-1

- Vibration test: IEC 60068-2-6
- Induced seismic vibration (earthquake): IEC 68-3-3[1)]
- Enclosure protection test IP68: EN 60529
- Salt spray test: EN ISO 12944-6
- Immunity requirements: EN 61326-3-1
- Emission: EN 61000-6-4

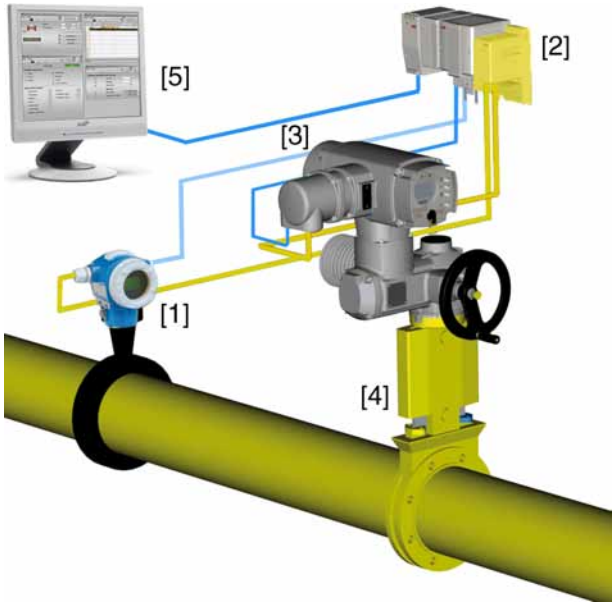
1) Thyristor version only

4. Safety instrumented systems and safety functions

4.1. Safety instrumented system including an actuator

Typically, a safety instrumented system including an actuator is composed of the components as shown in the figure.

Figure 1: Typical safety instrumented system



[1] Sensor
[2] Controls (standard and safety PLC)
[3] Actuator with actuator controls
[4] Valve
[5] Process control system

The safety integrity level is always assigned to an overall safety instrumented system and not to an individual component.

For an individual component (e.g. an actuator), safety instrumented parameters are determined. These parameters are used to assign the devices to a potential safety integrity level (SIL). The final classification of the safety instrumented system can only be made after assessing and calculating all subsystems.

4.2. Safety functions

In calculating the safety instrumented actuator system parameters, the following safety functions are taken into account:

- Safe ESD function (**E**mergency **S**hut **D**own): Safe OPENING/CLOSING
  - Redundant Safe ESDa and Safe ESDb signals (standard: low active) make the actuator travel to the configured direction (OPEN/CLOSE).
- Safe STOP function: Safe STOP
  - An operation command of standard controls (in directions OPEN or CLOSE) will only be executed if an additional enable signal for the operation command is applied.
  - If this is not the case, operation in directions OPEN or CLOSE is stopped or even suspended (motor is switched off).
- Safe ESD function combined with Safe STOP function
  - Safe ESD function has a higher priority i.e. if both functions are activated, the actuator is operated into the configured direction (OPEN/CLOSE).

The different configuration options of the safety functions are described in the <Configuration (setting)/version> chapter.

4.3. Safe inputs and outputs

Safe inputs for Safe OPENING/CLOSING (Safe ESD function):

- `Safe ESDa`
- `Safe ESDb`

Safe inputs for safe stop (Safe STOP function):

- `Safe STOP OPEN`
- `Safe STOP CLOSE`

Safe outputs (indication that it might not be possible to perform the safety function:

- `SIL failure`
- `SIL ready`

For detailed information on safe inputs and outputs, refer to <Configuration (setting)/version> chapter and <Installation> chapter.

4.4. Redundant system architecture

Besides the already described typical safety instrumented system including an actuator, safety can be increased by integrating a second, redundant valve and actuator with actuator controls in SIL version into the safety instrumented system. The decision on the correct version depends on the entire system. With the redundant system architecture shown below, actuator and actuator controls achieve SIL 3 in accordance with IEC 61508.

Figure 2: Redundant system with Safe ESD for Safe CLOSING

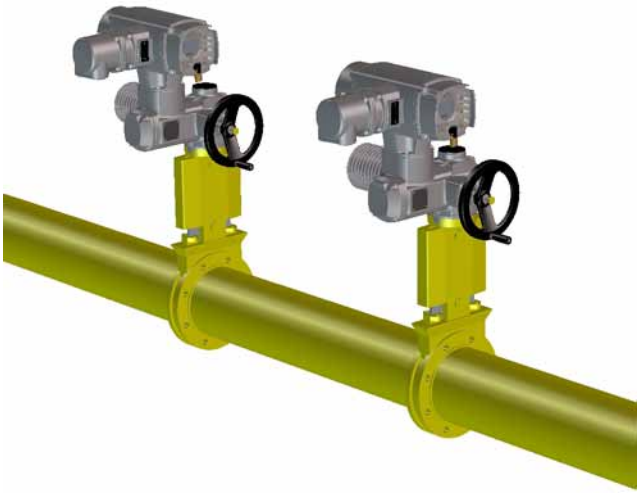


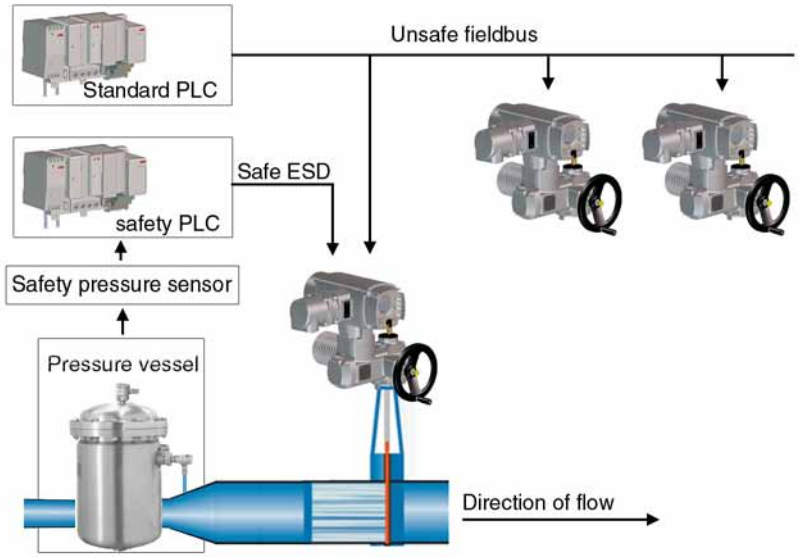
Figure 3: Redundant system with Safe ESD for Safe OPENING

4.5. Examples of applications

Safe OPENING of a pressure vessel using the Safe ESD function

The standard PLC controls the entire system. A system fault occurs if excessive pressure is generated within the system. In this case, the safety PLC immediately opens the valve for safe pressure relief.

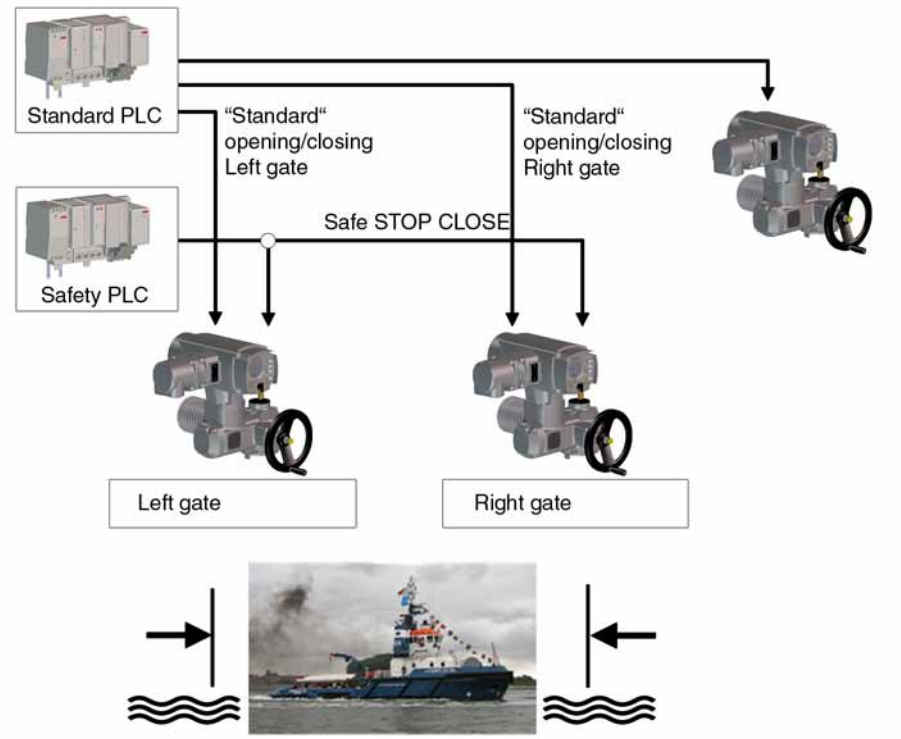
Figure 4: Application example: Pressure vessel



Safe stop of locks to prevent destruction using the Safe STOP function.

Operation safety (preventing hazards to persons and systems) is of utmost importance for locks. Once the lock closes, no boats must be between the gates. Otherwise, the Safe STOP function (e.g. via EMERGENCY Stop button) is executed.

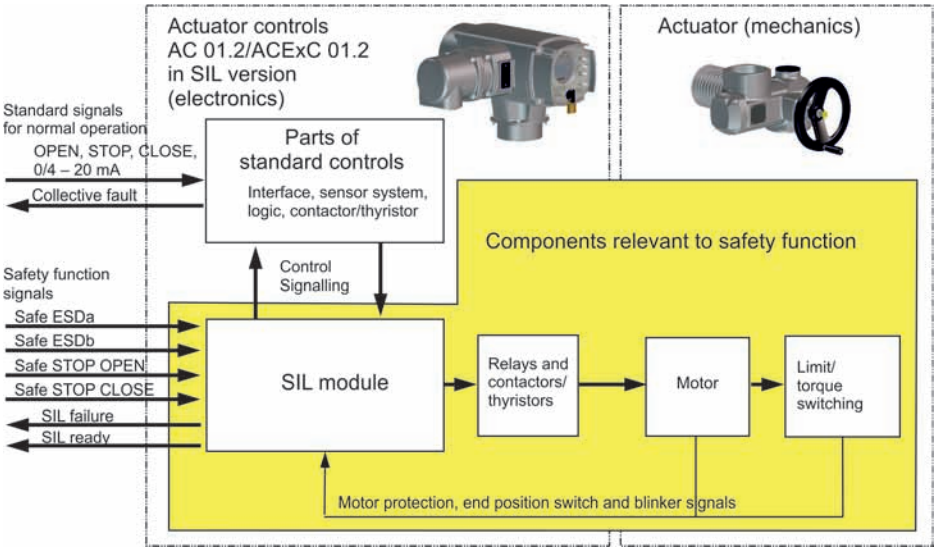
Figure 5: Application example: Lock



4.6. System representation

The representation below shows the simplified design of an AC 01.2/ACExC 01.2 in SIL version.

Figure 6: Simplified system representation



5. Installation, commissioning and operation

Information Installation and commissioning have to be documented by means of an assembly report and an inspection certificate. Installation must be carried out exclusively by suitably qualified personnel.

The plant operator is responsible for ensuring power supply protection against overvoltage and undervoltage during execution of a safety function.

5.1. Installation

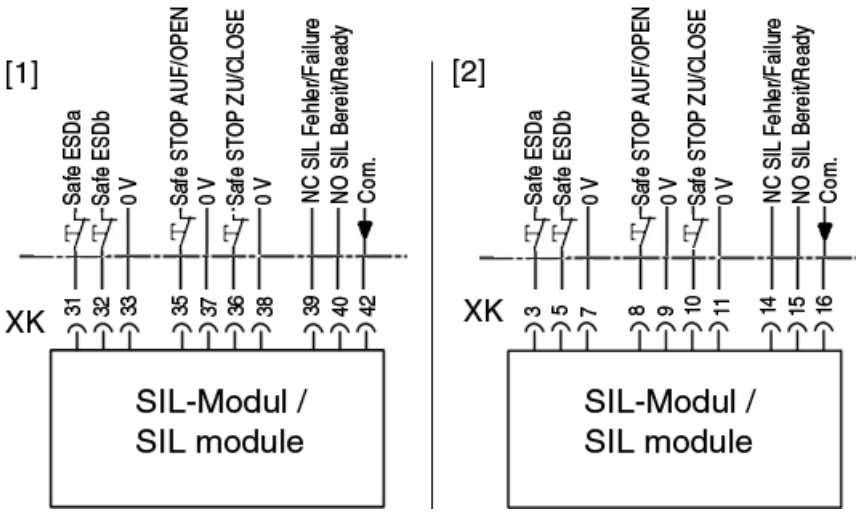
General installation tasks (assembly, electrical connection) have to be performed according to the operation instructions pertaining to the device and the enclosed order-specific wiring diagram.

When operating and storing the devices in ambient temperatures below –25 °C, ensure power supply of integral heating system.

Safety functions are connected via the SIL module integrated in the AC 01.2/ACExC 01.2 actuator controls.

SIL fault must be connected to a SIL 2 compatible input of a safety PLC and subsequently analysed.

Figure 7: Connections for safety functions via SIL module



[1] Connections for parallel control

[2] Connections for fieldbus control

Input switching behaviour of `Safe ESDa/ESDb` and `Safe STOP OPEN/CLOSE`:

- Input level = **high level** (standard: +24 V DC)
  = **No** safety operation for Safe ESD function or
  = **No** safe stop for Safe STOP function
- Input signal = **low level** (0 V DC or input open)
  = Failure operation for Safe ESD function or
  = Safe stop for Safe STOP function

Permissible input voltage range:

- High level: 15 – 30 V DC
- Low level: max. 5 V DC

Signal behaviour of `SIL ready` and `SIL failure` outputs:

- SIL ready (signal inactive), i.e.:
  NO (NO contact) output = **closed**
  NC (NC contact) output = **open**

- SIL failure (signal active), i.e.:
  NO (NO contact) output = **open**
  NC (NC contact) output = **closed**

Designation Wiring diagram	Signal	Customer connections for control	
		[1] Parallel	[2] Fieldbus
Safe ESDa	Digital input for Safe ESD function	XK 31	XK 3
Safe ESDb	Redundant input for Safe ESD function	XK 32	XK 5
0 V	Reference potential for Safe ESDa and Safe ESDb	XK 33	XK 7
Safe STOP CLOSE	Digital input for Safe STOP function in direction CLOSE	XK 35	XK 8
0 V	Reference potential for Safe STOP CLOSE	XK 37	XK 9
Safe STOP OPEN	Digital input for Safe STOP function in direction OPEN	XK 36	XK 10
0 V	Reference potential for Safe STOP OPEN	XK 38	XK 11
SIL ready	NO contact of SIL fault signal	XK 40	XK 15
SIL failure	NC contact of SIL fault signal	XK 39	XK 14
Com.	Reference potential for SIL fault signal	XK 42	XK 16

SIL fault displayed via `SIL failure` output

Fault causes SIL	Description
Thermal fault	Motor protection tripped
Torque fault	Torque fault in directions OPEN and/or CLOSE
Fault position feedback	Current position feedback is outside permissible range.
Phase failure	One phase of power supply is missing. Controls are not supplied with mains voltage
Phase sequence fault	The phase conductors L1, L2 and L3 are connected in the wrong sequence.
Power supply failure	The safety-related part of controls is without power supply.
Temperature fault	Temperature within controls housing too high Failure of heating system for ambient temperatures below –25 °C
Failure of actuator monitoring	Actuator of valve locked
Fault in redundant wiring Safe ESD	Both signals Safe ESDa and Safe ESDb are not simultaneously on the same level.
Internal error	Internal error of the SIL module

For further information on SIL faults and in particular to assist in troubleshooting, refer to chapter <Indications>.

Information The basic function "automatic correction of direction of rotation" is not available for this version. When connecting the power supply ensure that phases L1, L2 and L3 are correctly connected. For checking the direction of rotation, refer to operation instructions pertaining to the actuator.

The "external supply of electronics" option of the actuator controls refers to standard actuator controls. In case of mains failure, the SIL module would no longer be operable despite external supply of the electronics.

5.2. Commissioning

The operation instructions pertaining to the device must be observed for general commissioning.

Information For the Safe ESD function, operation into the safe position can be performed irrespective of the selector switch position (LOCAL - OFF - REMOTE) or the operating status. Even in positions LOCAL and OFF or at system start, can the actuator start by triggering the safety function.

CAUTION

Risk of immediate actuator operation when switching on!

Risk of personal injuries or damage to the valve

→ Ensure that **high level** is present at the Safe ESDa/ESDb inputs when switching on (standard: +24 V DC).

After commissioning, the safe actuator function must be verified. Refer to <Proof test> chapter.

5.3. Operation

Regular maintenance and device checks in determined T_{proof} intervals are the basis for safe operation. The parameters indicated in the <Safety parameters> chapter are valid for T_{proof} = 1 year.

For operation, both the pertaining operation instructions and the Manual (Operation and setting) AUMATIC AC 01.2 have to be observed.

In case of possible failures or defects of the safety system, safe function must be guaranteed by introducing alternative actions. Furthermore, a detected fault including fault description has to be sent to AUMA Riester GmbH & Co. KG. Autonomous repair work by the plant operator is not permitted.

5.4. Lifetime

Lifetime of actuators is described in the technical data sheets or the operation instructions.

Safety-related parameters are valid for the cycles or modulating steps specified in the technical data for typical periods of up to 10 years (the criterion achieved first is valid). After this period, the probability of failure increases.

5.5. Decommissioning

When decommissioning an actuator with safety functions, the following must be observed:

- Impact of decommissioning on relevant devices, equipment or other work must be evaluated.
- Safety and warning instructions contained in the actuator operation instructions must be met.
- Decommissioning must be carried out exclusively by suitably qualified personnel.
- Decommissioning must be recorded in compliance with regular requirements.

6. Indications on display

This section contains indications of standard controls only available in SIL version .

General indications as well as settings and operation are described in the pertaining operation instructions and in the Manual (Operation and setting) AUMATIC AC 01.2.

Information Indications on the display are not part of a safety function! They must not be integrated in a safety-related system!

The indications support the user on site at the device, making the safety function status easily discernible.

6.1. Status indications on SIL functions

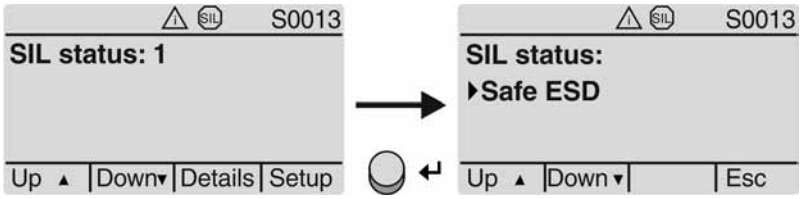
Actuator controls may indicate status information on safety-related functions on the display.

SIL status (S0013)

Indication S0013 signals the safety function and the SIL fault indication status.

If the SIL symbol is shown in the header of the display, one of the following three indications is active: Safe ESD, Safe STOP or SIL fault.

Figure 8: Safety function and SIL fault indication status



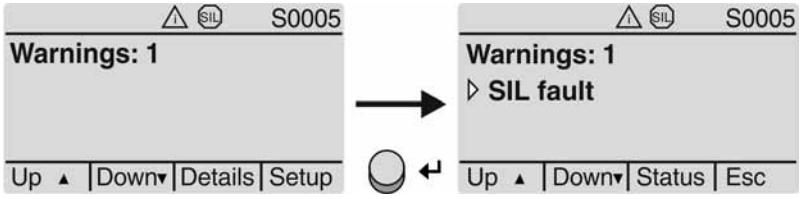
Status indications on display	Status
Safe ESD	Safe ESD function (Safe OPENING/CLOSING) is active: Actuator is operated in the configured direction (CLOSE/OPEN) (inputs Safe ESDa/Safe ESDb = 0 V or open)
Safe STOP	Safe STOP function is active, actuator stops (Safe STOP OPEN or Safe STOP CLOSE = 0 V or open inputs)
SIL fault	SIL fault signal active, i.e. possible problems when executing a safety function (Safe ESD or Safe STOP).

Warnings (S0005)

Indication S0005 shows the numbers of warnings having occurred.

In case a SIL fault occurs, the SIL fault message is listed in indication S0005. Refer to Details > Status for further details.

Figure 9: Warning: SIL fault

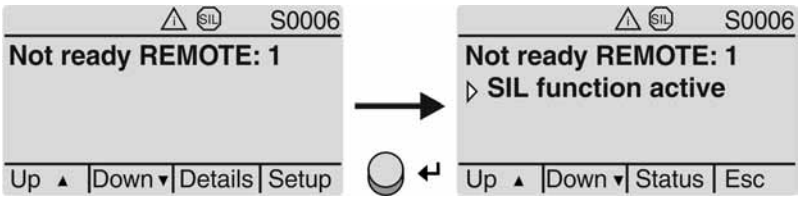


Not ready REMOTE (S0006)

Indication S0006 shows the number of occurring messages which are part of the Not ready REMOTE group.

If a safety function is active (Safe ESD or Safe STOP), the indication is listed in the SIL function active Not ready REMOTE group. Refer to Details > Status for further details.

Figure 10: Signal: Safety function active



Information As soon as a safety function is active (SIL function active indication), the actuator is controlled via the safety PLC and the SIL module. For “normal control” (standard PLC), controls are therefore “Not ready REMOTE”.

6.2. SIL configuration warning

In combination with the safety functions, the following configurations or settings of standard controls may have an impact on the standard functions:

- Self-retaining Local M0076 = OPEN/CLOSE
- Self-retaining Remote M0100 = OPEN/CLOSE

If one of these configurations is selected in the standard controls, the device generates the SIL config. warning.

6.3. Backlight

In standard operation, display backlight of actuator controls is white. In the event of a fault, the display backlight is red. The red backlight does NOT refer to the safety function status but to the faults referred to as "faults" in the Manual (Operation and setting) AUMATIC AC 01.2.

7. Signals

7.1. Signals via SIL module

The integrated SIL module signals a SIL fault via an output contact (`SIL ready` or `SIL failure` outputs). Only these signals may be used in a safety-related system.

For the signal behaviour of the `SIL ready/SIL failure` outputs, refer to <Installation> chapter.

Once a SIL fault occurs, the system has to be checked immediately and the installation has to be put in a safe state, if required.

7.2. SIL fault signal via standard controls display (for troubleshooting support)

If the SIL module output contact (`SIL ready` or `SIL failure` outputs) signals a SIL fault, the exact fault can be determined via the indication in the standard controls display. For details on all fault indications and warning indications on the standard controls display, refer to Manual (Operation and setting) AUMATIC AC 01.2.

The SIL module output contact serves as collective signal for the faults listed in the table below.

Table 8: Individual signals of SIL fault collective signal

Indication on display Standard controls	**Description/ cause of fault**	**Impact on safety function → Remedy**
Thermal fault	Motor protection tripped.	For version **“SIL motor protection” = active**: • The Safe ESD safe function cannot be executed. • If the fault is triggered during safety operation, operation is stopped. **Remedy** → Cool down, wait.
Torque fault CLOSE Torque fault OPEN	Torque fault in directions CLOSE or OPEN Torque fault in directions CLOSE and OPEN (simultaneously).	For **“SIL seating” = “"Limit seating with overload protection”** configuration: • The Safe ESD safe function cannot be executed. • If the fault is triggered during safety operation, operation is stopped. **Remedy** → Execute operation command in opposite direction. → Verify torque switching setting. → Check whether foreign object prevents the valve from closing. → Possibly problems with the valve.
Wrn range act.pos.	Current position feedback signal range is outside the permissible range. Both limit switches (OPEN and CLOSED) are operated simultaneously. Possibly defect at actuator mechanics.	For configurations **“SIL seating” = “Limit seating with overload protection”**, **“SIL seating” = “Forced limit seating in end position”**, or **“SIL seating” = “Forced torque seating in end position”**: • The Safe ESD safe function cannot be executed. • If the fault is triggered during safety operation, operation is stopped. **Remedy** → Verify reduction gearing settings within the actuator. → In case of possible defect at the actuator: Contact AUMA service
Phase fault	One phase of power supply is missing. Controls are not supplied with mains voltage	• The Safe ESD safe function cannot be executed. • The Safe STOP safe function is indirectly executed as the motor is no longer supplied with power. **Remedy** → Test/connect phases.
Incorrect phase seq	The phase conductors L1, L2 and L3 are connected in the wrong sequence.	In case of wrong phase sequence, the actuator is operated into the wrong direction during safety operation. **Remedy** → Correct the sequence of the phase conductors L1, L2 and L3 by exchanging two phases.

Indication on display Standard controls	Description/ cause of fault	Impact on safety function → Remedy
IE 24 V AC	Fault of internal 24 V DC power supply. The safety-relevant part of the controls is without power supply.	• The Safe ESD safe function cannot be executed. • If the fault is triggered during safety operation, operation is stopped. • The Safe STOP safe function is indirectly executed as the SIL module is no longer supplied with power. **Remedy** → Check power supply.
Wrn controls temp.	Temperature within controls housing too high (outside the specified temperature range).	It might not be possible to execute the Safe ESD and Safe STOP safety functions. **Remedy** → Controls must cool down (for current temperature display, check controls under: Diagnostic M0022>Device temperatures M0524>Temp. controls). → Check service conditions.
No signal in display	Internal error SIL module electronics sub-assembly.	It might not be possible to execute the Safe ESD and Safe STOP safety functions. **Remedy** → Possible defect at SIL module: Contact AUMA service
No signal in display	Actuator monitoring Actuator locked during manual operation. Possible defect at actuator:	The Safe ESD safe function can possibly not be executed. **Remedy** → In case of possible defect at the actuator: Contact AUMA service
No signal in display	Fault of redundant Safe ESD wiring. Both signals Safe ESDa and Safe ESDb are not simultaneously at the same level.	It is possible to execute the Safe ESD safety function. A SIL fault would occur. **Remedy** → Check redundant control of Safe ESD signals.

7.3. Status signals via output contacts (digital outputs) of standard controls

Actuator controls offer the possibility of signalling status information on safety-related functions via output contacts (DOUT outputs).

Information Status signals via DOUT outputs are not part of a safety function! They may not be integrated in a safety-related system! They can be used as additional information on the standard PLC, for example.

Available signals:

Safe ESD
Safe STOP
SIL fault
SIL function active

Assignment via menu in the display:

Required user level: Specialist (4) or higher.

M ▷ Device configuration M0053
I/O interface M0139
Digital outputs M0110

Default values:

Signal DOUT 5 = SIL function active

Signal DOUT 6 = SIL fault

7.4. Signal via fieldbus of standard controls

For actuator controls in fieldbus version, status information on the safety-related functions is provided in the process representation.

Information Status signals via fieldbus are not part of a safety function! They may not be integrated in a safety-related system. They can be used as additional information on the standard PLC, for example.

Signals available in process representation:

Bit: Safe ESD
Bit: Safe STOP
Bit: SIL fault
Bit: SIL function active

For further information on parameter configuration via fieldbus interface refer to Manual (Device integration fieldbus).

8. Tests and maintenance

Test and maintenance tasks may only be performed by authorised personnel who have been trained on functional safety.

Test and maintenance equipment has to be calibrated.

Information Any test/maintenance must be recorded in a test/maintenance report.

8.1. Safety equipment: check

All safety functions within a safety equipment must be checked for perfect functionality and safety at appropriate intervals. The intervals for safety equipment checks are to be defined by the plant operator.

The plant operator has to establish a safety planning for the entire safety lifecycle of the SIS. Policies and strategies for achieving safety as well as different activities during the safety life cycle should be defined.

8.2. Internal actuator monitoring with control via standard controls

The device, consisting of actuator with actuator controls and integral SIL module has an internal actuator monitoring. By controlling standard controls/actuator via standard operation commands, internal actuator monitoring is automatically performed. Internal actuator monitoring identifies most of the safety-related actuator components. If a fault occurs, the fault would be signalled via the output contact of the SIL module (`SIL failure`).

To ensure the safety parameters of the Safe ESD safety function, the device has to be controlled at least once per month via the standard controls, including output contact assessment of the SIL module (`SIL failure`). If it cannot be ensured that the device is controlled by the standard controls at least once per month, a <Partial Valve Stroke Test (PVST)> has to be performed instead.

The control signal and the pertaining operation of the actuator have to be present for at least 4 seconds. If control signal and pertaining operation of the actuator are present for at least 4 seconds without signalling a fault via the SIL output contact (SIL module: `SIL failure`), the test was successful. Otherwise, the device has to be checked in accordance with the steps in the <Proof test: execute> chapter.

8.3. Partial Valve Stroke Test (PVST): execute

— Option —

When executing the PVST, control has to be performed via the `Safe ESDa` and `Safe ESDb` inputs and not via internal actuator monitoring. Desired diagnostics is performed by evaluating the SIL output contact (SIL module: `SIL failure`). Both control signals and actuator operation have to be present for a least 4 seconds.

The test is successfully passed if both control signals and the pertaining actuator operation are present for at least 4 seconds without fault signal from the SIL output contact (SIL module: `SIL failure`). Otherwise, the device has to be checked in accordance with the steps indicated in the <Proof test: execute> chapter.

Performing a PVST includes complete diagnosis of the safety-related components. This ensures improved safety parameters compared to applications without or with minor diagnostics.

8.4. Proof test (verification of safe actuator function)

The proof test serves the purpose to verify the safety-related functions of the actuator and actuator controls.

Proof tests shall reveal dangerous faults which might be undetected until a safety function is started and consequently result in a potential danger.

Information During execution of the proof test, the safety function is unavailable for a short time.

Depending on both version and configuration, the proof test includes the following tests:

1. Check Safe ESD safety operation (Safe OPENING/CLOSING).

2. Check SIL fault signal "Actuator monitoring".
3. Check Safe ESD reaction to "Motor protection (thermal fault)" signals.
4. Check Safe ESD reaction to "Limit seating with overload protection" (limit and/or torque evaluation).
5. Check Safe ESD reaction to "Forced limit seating in end position" (limit evaluation) – for actuators with electromechanical control unit.
6. Check Safe ESD reaction to "Forced limit seating in end position" (limit evaluation) – for actuators with electronic control unit and limit switches.
7. Check Safe ESD reaction to "Forced torque seating in end position" (first torque then limit evaluation).
8. Check Safe ESD reaction for "No seating" (no evaluation of limit and torque)
9. Check Safe STOP function.
10. Check combination of Safe ESD and Safe STOP function.

The safety-related signal input is appropriately assigned to check the safety-related function. As a consequence, the actuator has to perform the safety function. For a detailed description of the proof test steps refer to the following sections.

Intervals:

A proof test interval describes the time between two proof tests. Functionality must be checked in appropriate intervals. The intervals are to be defined by the plant operator. Safety parameters depend on the selected proof test interval; in our example, they are valid for T_{proof} = 1 year (refer to <Safety parameters> chapter).

In any case, the safety-related functions must be checked after commissioning and following any maintenance work or repair as well as during the T_{proof} intervals defined in safety assessment.

If a fault occurs during proof test, safe function has to be ensured introducing alternative actions. Please contact AUMA Riester GmbH & Co. KG.

The type of proof test to be performed depends on version and configuration of the product. Only the tests applicable have to be performed.

Information Before starting the test we recommend reading the respective test procedure at least once.

8.4.1. Safe ESD safety operation (Safe OPENING/CLOSING)

Configuration The test is valid for all versions with Safe ESD function (irrespective of the "SIL seating" configuration). The Safe ESD reaction to the different seating types is verified in separate tests.

Test procedure When switching the `Safe ESDa/Safe ESDb` inputs accordingly, safety operation into the configured direction must be triggered.

NOTICE

If "SIL seating = no seating" (without end position protection) is configured, faulty operation during the test may result in damage to the elements within the safety-related system.

Possible consequences: Valve damage, motor overheating, contactor jamming, defective thyristors, heating up or damage to cables.

→ Check "SIL seating" before proof test configuration. The configured type of seating is indicated in the wiring diagram (page 2).

→ For actuators with "SIL seating" = "No seating": **Interrupt safety operation before reaching the end position** (Set `Safe ESDa/Safe ESDb` input signals to +24 V DC).

→ For the test, the valve should either be in mid-position or at sufficient distance from the end positions.

→ In case of damage, the actuator system has to be checked and repaired, if necessary.

Test procedure

1. Operate actuator in mid-position or at sufficient distance from the end positions.

2. Execute operation command in opposite direction of the configured ESD safety function:
   → For "Safe CLOSING" (Safe ESD in direction CLOSE) configuration: Start operation command in direction OPEN.
   → For "Safe OPENING" (Safe ESD in direction OPEN) configuration: Start operation command in direction CLOSE.

   Information: For the test, operation commands (in directions OPEN or CLOSE) can be executed both from remote (via DCS) and from Local at the controls (via the push buttons of the local controls).
3. Start safety operation during operation:
   → Set `Safe ESDa` and `Safe ESDb` input signals to 0 V (low).

➥ Safety function is correct, if the actuator stops and performs a safety operation into the configured direction.

➥ **No** SIL fault signal may be issued.

4. Set `Safe ESDa` and `Safe ESDb` input signals to +24 V DC (high) after the test.

8.4.2. SIL fault signal "Actuator monitoring": check

Configuration This test is required for the following versions or configurations:

- Safe ESD function: “Safe CLOSING" (Safe ESD in direction CLOSE)
- Safe ESD function “Safe OPENING" (Safe ESD in direction OPEN)

Test procedure If the motor does rotate within a defined time once safety operation was triggered, a SIL fault must be signalled.

Test procedure

1. Operate actuator in mid-position or at sufficient distance from the end positions.
2. Lock handwheel with the "Handwheel lockable" option padlock, so that the manual drive remains engaged.
3. Start Safe ESD safety operation:
   → Set `Safe ESDa` and `Safe ESDb` input signals to 0 V (low).

➥ The SIL fault signal is correct, if a SIL fault signal is sent within four seconds via the `SIL failure` output.

4. Once the test is complete set `Safe ESDa` and `Safe ESDb` input signals to +24 V DC (high) and disable motor lock.

8.4.3. Safe ESD reaction for "Motor protection (thermal fault)" signals: check

Configuration This test is required for the following versions or configurations:

- Safe ESD function: “Safe CLOSING" (Safe ESD in direction CLOSE)
- Safe ESD function “Safe OPENING" (Safe ESD in direction OPEN)

Test procedure In order to protect against overheating and impermissibly high surface temperatures at the actuator, PTC thermistors or thermoswitches are embedded in the motor winding. Motor protection trips as soon as the max. permissible winding temperature has been reached.

For a safety operation via Safe ESD function, the actuator reaction for motor protection tripping depends on the "SIL motor protection" configuration:

- For **“SIL motor protection” = active** configuration
  = safety operation is stopped.
- For **“SIL motor protection” = inactive** configuration
  = safety operation is not stopped.

The test is performed by simulating the motor protection signal via AC 01.2 local controls:

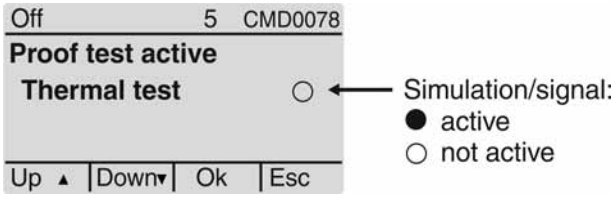
Required user level: Specialist (4) or higher.

M ▷ Diagnostic M0022

Proof test (motor prot.) M1021

Simulation value: Thermal test

Figure 11: Display indication on local controls



The simulation (active/inactive) is activated and deactivated by push button Ok.

A dot on the display indicates that the simulation is active.

Black dot (●): Motor protection simulation active (thermal fault)

White dot (○): Signal not active

Test procedure

1. Operate actuator in mid-position or at sufficient distance from the end positions.
2. Set selector switch to position **0** (OFF).
3. Change to main menu and select the Thermal test simulation value via the Proof test (motor prot.) M1021 parameter (Do not yet activate simulation: white dot).
4. Set `Safe ESDa` and `Safe ESDb` input signals to 0 V (low).

➥ Safety operation is initiated.

5. Activate motor protection simulation: Press push button Ok (black dot)

➥ Safety function is correct, if:

- For **"SIL motor protection" = active** configuration:
  - Safety operation is stopped.
  - A SIL fault signal is issued via the `SIL failure` output.
- For **"SIL motor protection" = inactive** configuration:
  - Safety operation is **not** stopped.
  - Nevertheless, a SIL fault signal is issued via the `SIL failure` output.

6. Set `Safe ESDa` and `Safe ESDb` input signals to +24 V DC (high) after the test.
7. Reset simulation or exit the simulation menu and reset selector switch to initial position.

8.4.4. Safe ESD reaction to "Limit seating with overload protection" (limit and/or torque evaluation): check

Configuration

This test is required for the following versions or configurations:

- Actuator with electromechanical control unit
- One of the following safety functions:
  - Safe ESD function: "Safe CLOSING" (Safe ESD in direction CLOSE)
  - Safe ESD function "Safe OPENING" (Safe ESD in direction OPEN)
- "SIL seating" configuration
  = **"Limit seating with overload protection"**
  (Safety operation is stopped by limit switch tripping **and/or** torque switch tripping (overload protection).

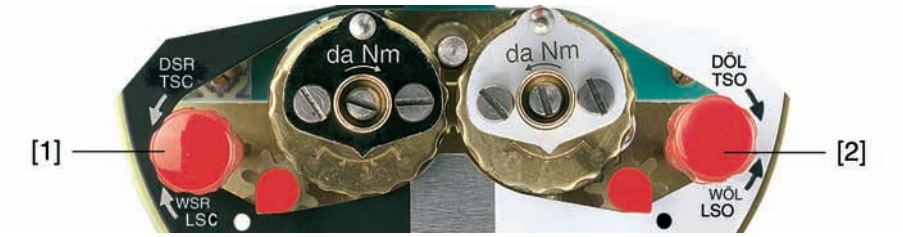
Test procedure

During the test, the reaction of the Safe ESD function to limit switch tripping and/or torque switch tripping during safety operation is checked.

During Safe ESD operation, the actuator has to stop when reaching the position set via limit switching. Safe ESD operation must also be stopped if the tripping torque set via the torque switching is exceeded.

The red test buttons [1] and [2] of the control unit are used for the test. These can be used to operate the switches manually.

Figure 12: Electromechanical control unit



- Turn test button [1] in direction of the LSC arrow: Limit switch CLOSED trips.
- Turn test button [1] in direction of the TSC arrow: Torque switch CLOSED trips.
- Turn test button [2] in direction of the LSO arrow: Limit switch OPEN trips.
- Turn test button [2] in direction of the TSO arrow: Torque switch OPEN trips.

Information If one of the test buttons (TSC/TSO) is turned without performing a safety operation, a SIL fault signal is issued!

Test procedure

1. Operate actuator in mid-position or at sufficient distance from the end positions.
2. Open the switch compartment
3. Initiate safety operation:
   → Set `Safe ESDa` and `Safe ESDb` input signals to 0 V (low).

Check seating via limit switches:

4. Operate limit switches until test is complete:
   → For "Safe CLOSING" (Safe ESD in direction CLOSE) configuration: Turn test button [1] in direction of the LSC arrow.
   → For "Safe OPENING" (Safe ESD in direction OPEN) configuration: Turn test button [2] in direction of the LSO arrow.

➥ The safety function reaction to the limit switch signals is correct if safety operation is stopped.

5. After limit switching evaluation:
   5.1 Set `Safe ESDa` and `Safe ESDb` input signals to +24 V DC (high).
   5.2 Operate actuator via local controls or from REMOTE to end position OPEN and then to end position CLOSED. (Positions will be recorded anew).
   5.3 Operate actuator to mid-position or at sufficient distance from the end positions.

Check seating via torque switches:

6. Initiate safety operation:
   → Set `Safe ESDa` and `Safe ESDb` input signals to 0 V (low).
7. Operate torque switches until test is complete:
   → For "Safe CLOSING" (Safe ESD in direction CLOSE) configuration: Turn test button [1] in direction of the TSC arrow:
   → For "Safe OPENING" (Safe ESD in direction OPEN) configuration: Turn test button [2] in direction of the TSO arrow:

➥ The safety function reaction to the torque switch signals is correct if:

- Safety operation is stopped.
- A SIL fault signal is issued via the `SIL failure` output.
- Display is illuminated in red.

8. Set `Safe ESDa` and `Safe ESDb` input signals to +24 V DC (high) after the test.
9. Acknowledge torque fault of standard controls.
10. Close switch compartment.

8.4.5. Safe ESD reaction to "Forced limit seating in end position" (limit evaluation) – for actuators with electromechanical control unit: check

Configuration

This test is required for the following versions or configurations:

- Actuator with electromechanical control unit
- One of the following safety functions:
  - Safe ESD function: “Safe CLOSING" (Safe ESD in direction CLOSE)
  - Safe ESD function “Safe OPENING" (Safe ESD in direction OPEN)
- "SIL seating" configuration
  = **“Forced limit seating in end position”**
  (safety operation is stopped by limit switch tripping)

Test procedure

During the test, the reaction of the Safe ESD function to limit switch tripping during safety operation is checked.

During Safe ESD operation, the actuator has to stop when reaching the position set via limit switching.

The red test buttons [1] and [2] of the control unit are used for the test. These can be used to operate the switches manually.

Figure 13: Electromechanical control unit

- Turn test button [1] in direction of the LSC arrow: Limit switch CLOSED trips.
- Turn test button [2] in direction of the LSO arrow: Limit switch OPEN trips.

Test procedure

1. Operate actuator in mid-position or at sufficient distance from the end positions.
2. Open the switch compartment
3. Initiate safety operation:
   → Set `Safe ESDa` and `Safe ESDb` input signals to 0 V (low).

Check seating via limit switches:

4. Operate limit switches until test is complete:
   → For "Safe CLOSING" (Safe ESD in direction CLOSE) configuration: Turn test button [1] in direction of the LSC arrow.
   → For "Safe OPENING" (Safe ESD in direction OPEN) configuration: Turn test button [2] in direction of the LSO arrow.

➥ The safety function reaction to the limit switch signals is correct if safety operation is stopped.

5. Set `Safe ESDa` and `Safe ESDb` input signals to +24 V DC (high) after the test.
6. Close switch compartment.

8.4.6. Safe ESD reaction for "Forced limit seating in end position" (limit evaluation) – for actuators with electronic control unit and limit switches: check

Configuration

This test is required for the following versions or configurations:

- Actuator with electronic control unit and limit switches
- One of the following safety functions:
  - Safe ESD function: “Safe CLOSING” (Safe ESD in direction CLOSE)
  - Safe ESD function “Safe OPENING" (Safe ESD in direction OPEN)

- "SIL seating" configuration
  = **“Forced limit seating in end position”**
  (safety operation is stopped by limit switch tripping)

Test procedure During the test, the reaction of the Safe ESD function to limit switch tripping during safety operation is checked.

During Safe ESD operation, the actuator has to stop when reaching the position set via limit switching.

Test procedure

1. Operate actuator in mid-position or at sufficient distance from the end positions.
2. Initiate safety operation:
   → Set `Safe ESDa` and `Safe ESDb` input signals to 0 V (low).

Check seating via limit switches:

3. Wait until actuator has reached the limit end position and has activated the pertaining limit switch.

➥ The safety function reaction to the limit switch signals is correct if safety operation is stopped.

4. Set `Safe ESDa` and `Safe ESDb` input signals to +24 V DC (high) after the test.

8.4.7. Safe ESD reaction to "Forced torque seating in end position" (torque after limit evaluation): check

Configuration This test is required for the following versions or configurations:

- Actuator with electromechanical control unit
- One of the following safety functions:
  - Safe ESD function: “Safe CLOSING" (Safe ESD in direction CLOSE)
  - Safe ESD function “Safe OPENING" (Safe ESD in direction OPEN)
- "SIL seating" configuration
  = **“Forced torque seating in end position”**
  (Safety operation is stopped by tripping the torque switches (overload protection). Provided that the respective limit switch tripped before).

Test procedure During the test, the reaction of the Safe ESD function to torque switch tripping (after limit switch tripping) during safety operation is checked.

The red test buttons [1] and [2] of the control unit are used for the test. These can be used to operate the switches manually.

Figure 14: Electromechanical control unit

- Turn test button [1] in direction of the TSC arrow: Torque switch CLOSED trips.
- Turn test button [2] in direction of the TSO arrow: Torque switch OPEN trips.

Test procedure

1. Use **standard controls** to operate actuator into the end position of the configured Safe ESD function (until limit switch in end position trips).
2. Open the switch compartment

Check seating via torque and limit switches:

3. Operate torque switches and hold activated.
   → For "Safe CLOSING" (Safe ESD in direction CLOSE) configuration: Turn test button [1] in direction of the TSC arrow:
   → For "Safe OPENING" (Safe ESD in direction OPEN) configuration: Turn test button [2] in direction of the TSO arrow:
4. Start safety operation while torque switch is operated:
   → Set `Safe ESDa` and `Safe ESDb` input signals to 0 V (low).

➥ The safety function reaction to the torque switch and limit switch signals is correct if:

- Safety operation is not started.
- **No** SIL fault signal is issued via `SIL failure` output.

5. Set `Safe ESDa` and `Safe ESDb` input signals to +24 V DC (high) after the test.
6. Close switch compartment.

8.4.8. Safe ESD reaction for "No seating" (no evaluation of limit and torque): check

Configuration

This test is required for the following versions or configurations:

- Actuator with electromechanical control unit
- One of the following safety functions:
  - Safe ESD function: “Safe CLOSING" (Safe ESD in direction CLOSE)
  - Safe ESD function “Safe OPENING" (Safe ESD in direction OPEN)
- "SIL seating" configuration
  = **“No seating”**
  (Safe OPENING or CLOSING without responding to any protective equipment)

Test procedure

For Safe ESD operation, the actuator has to perform the safety operation without interruption. Limit switching and/or torque switching must not stop the safety operation

NOTICE

Since "SIL seating = no seating" (without end position protection) is configured, faulty operation during the test may result in damage to the elements within the safety-related system.

Possible consequences: Valve damage, motor overheating, contactor jamming, defective thyristors, heating up or damage to cables.

→ **Interrupt safety operation before reaching the end position** (Set `Safe ESDa` and `Safe ESDb` input signals to +24 V DC).

→ For the test, the valve should either be in mid-position or at sufficient distance from the end positions.

→ In case of damage, the actuator system has to be checked and repaired, if necessary.

Test procedure

1. Operate actuator in mid-position or at sufficient distance from the end positions.
2. Open the switch compartment
3. Initiate safety operation:
   → Set `Safe ESDa` and `Safe ESDb` input signals to 0 V (low).

Limit switching evaluation

4. Operate limit switches:
   → For "Safe CLOSING" (Safe ESD in direction CLOSE) configuration: Turn test button [1] in direction of the LSC arrow.
   → For "Safe OPENING" (Safe ESD in direction OPEN) configuration: Turn test button [2] in direction of the LSO arrow.

➥ The safety function reaction to the limit switch signals is correct if safety operation is **not** stopped.

5. After limit evaluation:
   5.1 Set `Safe ESDa` and `Safe ESDb` input signals to +24 V DC (high) **before** reaching the end position.
   5.2 Operate actuator via local controls or from REMOTE to end position OPEN and then to end position CLOSED. (Positions will be recorded anew).
   5.3 Operate actuator to mid-position or at sufficient distance from the end positions.

Torque switching evaluation

6. Initiate safety operation:
   → Set `Safe ESDa` and `Safe ESDb` input signals to 0 V (low).
7. Operate torque switches:
   → For "Safe CLOSING" (Safe ESD in direction CLOSE) configuration: Turn test button [1] in direction of the TSC arrow:
   → For "Safe OPENING" (Safe ESD in direction OPEN) configuration: Turn test button [2] in direction of the TSO arrow:

➥ The safety function reaction to the torque switch signals is correct if:

- Safety operation is **not** stopped.
- A SIL fault signal is issued via the `SIL failure` output.
- Display is illuminated in red.

8. Once the test is complete, set `Safe ESDa` and `Safe ESDb` input signals to +24 V DC (high) **before** reaching the end position.
9. Acknowledge torque fault of standard controls.
10. Close switch compartment.

8.4.9. Safe STOP function: check

Configuration The test applies to the “SIL function” = **”Safe STOP CLOSE/OPEN”** (safe stop). The seating configuration is not relevant to the test as it has no impact on the safe stop function.

Test procedure If the `Safe STOP CLOSE` or `Safe STOP OPEN` signals are switched accordingly, the actuator must stop.

Test procedure

1. Operate actuator in mid-position or at sufficient distance from the end positions.
2. Start operation command in direction OPEN.

   Information: For the test, operation commands (in directions OPEN or CLOSE) can be executed both from remote (via DCS) and from Local at the controls (via the push buttons of the local controls).

3. Cancel release signals for directions CLOSE and OPEN one after the other:
   3.1 First set Safe STOP CLOSE input signal to 0 V (low).
   ➥ Actuator must continue its operation
   ➥ **No** SIL fault signal may be issued.
   3.2 Then set Safe STOP OPEN input signal to 0 V (low).
   ➥ The safety function is correct if the actuator stops.
   ➥ **No** SIL fault signal may be issued.
4. Set Safe STOP CLOSE and Safe STOP OPEN to +24 V DC (high) again.
   Information: If operation command OPEN from REMOTE issued via the control room is still present, the actuator may start its operation!
5. Start operation command in direction CLOSE
6. Cancel release signals for directions OPEN and CLOSE one after the other:
   6.1 First set Safe STOP OPEN input signal to 0 V (low).
   ➥ Actuator must continue its operation
   ➥ **No** SIL fault signal may be issued.
   6.2 Then set Safe STOP CLOSE input signal to 0 V (low).
   ➥ The safety function is correct if the actuator stops.
   ➥ **No** SIL fault signal may be issued.
7. Set Safe STOP CLOSE and Safe STOP OPEN to +24 V DC (high) again.
   Information: If operation command OPEN from REMOTE issued via the control room is still present, the actuator may start its operation!

8.4.10. Combination of Safe ESD and Safe STOP function: check

Configuration

This test is required for the following versions or configurations:

- One of the following Safe ESD safety functions with any seating configuration:
  - Safe ESD function: “Safe CLOSING" (Safe ESD in direction CLOSE)
  - Safe ESD function: "Safe OPENING" (Safe ESD in direction OPEN)
- Safe STOP function

NOTICE

If "SIL seating = no seating" (without end position protection) is configured, faulty operation during the test may result in damage to the elements within the safety-related system.

Possible consequences: Valve damage, motor overheating, contactor jamming, defective thyristors, heating up or damage to cables.

→ Check "SIL seating" before proof test configuration.

→ For actuators with "SIL seating" = "No seating": **Interrupt safety operation before reaching the end position** (Set Safe ESDa and Safe ESDb input signals to +24 V DC).

→ For the test, the valve should either be in mid-position or at sufficient distance from the end positions.

→ In case of damage, the actuator system has to be checked and repaired, if necessary.

Test procedure

This test is intended to confirm the correct function of the combination of Safe ESD safety operation and the Safe STOP function.

Test procedure

1. Operate actuator in mid-position or at sufficient distance from the end positions.

2. Execute Safe STOP command in direction of the configured Safe ESD safety function:
   → For "Safe CLOSING" (Safe ESD in direction CLOSE) configuration: Set Safe STOP CLOSE input signal to 0 V (low).
   → For "Safe OPENING" (Safe ESD in direction OPEN) configuration: Set Safe STOP OPEN input signal to 0 V (low).
3. Initiate safety operation:
   Set Safe ESDa and Safe ESDb input signals to 0 V (low).

➥ Safety function is correct, if the actuator performs a safety operation into the configured direction.

➥ **No** SIL fault signal may be issued.

4. Set Safe ESDa, Safe ESDb, Safe STOP OPEN and Safe STOP CLOSE input signals to +24 V DC (high) once the test is complete.

Information In addition to this test, all other proof tests described in this manual have to be performed for the combination of Safe ESD and Safe STOP.

8.5. Maintenance

Maintenance and service tasks may only be performed by authorised personnel who have been trained on functional safety (refer to chapter 5).

Once maintenance and service tasks have been finished, the functional test must be completed by a validating process of the safety function including at least the tests described in the <Safety equipment: check> and <Proof test (verification of safe actuator function)> chapters.

In case a fault is detected during maintenance, this must be reported to AUMA Riester GmbH & Co. KG.

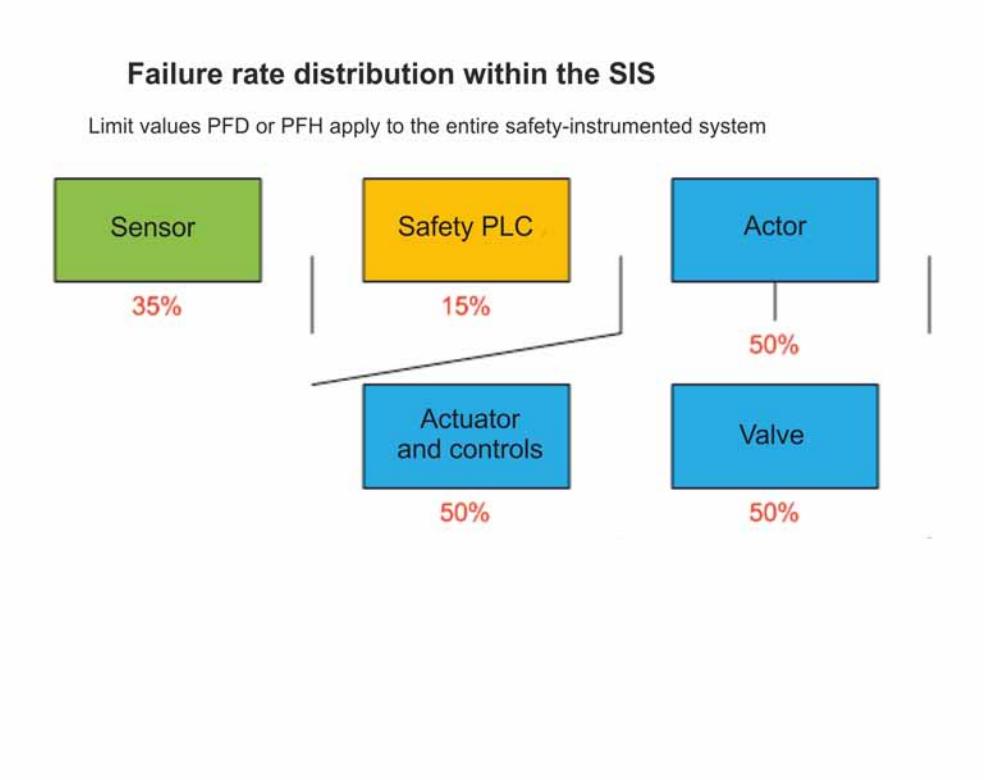
9. Safety-related parameters

9.1. Determination of the parameters

- The calculation of the safety-related parameters is based on the indicated safety functions. Hardware assessments are based on Failure Modes, Effects and Diagnostic Analysis (FMEDA). FMEDA is a step to assess functional device safety in compliance with IEC 61508. On the basis of FMEDA, the failure rates and the fraction of safe failures of a device are determined.
- Experience data and data taken from the exida database for mechanical components is used to deduce failure rates. The electronic failure rates as base failure rates are taken from the SIEMENS Standard SN 29500.
- In compliance with table 2 of IEC 61508-1, the average target PFD values for systems with low demand mode are:
  - SIL 2 safety functions: $\geq 10^{-3}$ to $< 10^{-2}$
  - SIL 3 safety functions: $\geq 10^{-4}$ to $< 10^{-3}$

  Since actuators only represent a part of the overall safety function, the actuator PFD should not account for more than approx. 25 % of the permissible total value (PFD_{avg}) of a safety function. This results in the following values:
  - Actuator PFD for SIL 2 applications: $\lesssim$ 2.5E-03
- Electric actuators with actuator controls are classified as type A components with a hardware fault tolerance of 0. The SFF for the type A subsystem should be between 60 % and <90 % according to table 2 of IEC 61508-2 for SIL 2 (subsystems with a hardware fault tolerance of 0).

Figure 15: Non-normative failure distribution assumed by AUMA



Information System power supply has not been considered for calculating the figures for actuator and actuator controls.

As previously mentioned in the architecture section, safeguarding power supply and resulting calculations are the responsibility of the plant operator.

The plant operator is responsible for complying with assumed MTTR. Otherwise the data of the quantitative results is no longer valid.

9.2. Specific parameters for AC 01.2 controls in SIL version with actuators of SA.2 series

The following parameter tables provide an example of safety-related parameters for the different versions. Complete data records of safety- related parameters of all variants are available within the exida test report.

When determining the PFD values, please note that the stipulated proof test cannot fully restore the system. For this reason, the following data is used for calculation:

- PTC = 90 % (proof test coverage rate [%])
- T_1 = 1 year (proof test interval [h])
- T_2 = 10 years (requirement interval = lifetime [h])
- MRT = 72 hours (mean repair time [h])
- Td_ESD = 730 hours
  (diagnostic test interval of actuator monitoring (for safety function Safe ESD [h])
- Td_ESD_AVG = 365 hours (mean duration for failure detection)
- Td_STOP = 0 hours (diagnostic test interval [h])
- MTTR_ESD = 437 hours
- MTTR_STOP = 72 hours

The following formula can be used for the calculation of the PFD_{avg} values:

$$PDF_{avg}(1001) = \left(\lambda_{DU} + \lambda_{DD}\right) t_{CE}$$

$$t_{CE} = \frac{\lambda_{DU}(PTC)}{\lambda_D}\left(\frac{T_1}{2} + MRT\right) + \frac{\lambda_{DU}(1 - PTC)}{\lambda_D}\left(\frac{T_2}{2} + MRT\right) + \frac{\lambda_{DD}}{\lambda_D} MTTR$$

$$MTTR = Td\_AVG + MRT$$

Table 9: SA.2 series with AC 01.2 controls in SIL version

SA 07.2 – SA 16.2 / SAEx 07.2 – SAEx 16.2 Switchgear version: Contactors		
Safety function	**Safe ESD**	**Safe STOP**
λ_S	185 FIT	570 FIT
λ_{DD} 1)	735 FIT	89 FIT
λ_{DU}	163 FIT	204 FIT
SFF	84 %	76 %
DC	81 %	30 %
PFD_{avg} T_{Proof} = 1 year (1001)	1.69×10^{-3}	1.72×10^{-3}
PFD_{avg} T_{Proof} = 1 year (1002)	1.57×10^{-4}	1.75×10^{-4}
SIL capability	SIL 2 (HFT = 0) SIL 3 (HFT = 1)	SIL 2 (HFT = 0) SIL 3 (HFT = 1)

1) including detected "annunciation" failures (λ_{AD}) (failures in diagnostic function)

Table 10: SA. 2 series with AC 01.2 controls in SIL version

SA 07.2 – SA 16.2 / SAR 07.2 – SAR 16.2 Switchgear version: Thyristors		
Safety function	**Safe ESD**	**Safe STOP**
λ_S	138 FIT	560 FIT
λ_{DD} 1)	763 FIT	89 FIT
λ_{DU}	172 FIT	152 FIT
SFF	83 %	81 %
DC	81 %	37 %

SA 07.2 – SA 16.2 / SAR 07.2 – SAR 16.2 Switchgear version: Thyristors		
Safety function	**Safe ESD**	**Safe STOP**
PFD_{avg} T_{Proof} = 1 year (1001)	1.78×10^{-3}	1.28×10^{-3}
PFD_{avg} T_{Proof} = 1 year (1002)	1.65×10^{-4}	1.30×10^{-4}
SIL capability	SIL 2 (HFT = 0) SIL 3 (HFT = 1)	SIL 2 (HFT = 0) SIL 3 (HFT = 1)

1) including detected "annunciation" failures (λ_{AD}) (failures in diagnostic function)

Table 11: SAEx. 2 series with ACExC 01.2 controls in SIL version

SAEx 07.2 – SAEx 16.2 / SAREx 07.2 – SAREx 16.2 Switchgear version: Thyristors with tripping contactor		
Safety function	**Safe ESD**	**Safe STOP**
λ_S	176 FIT	599 FIT
λ_{DD} 1)	798 FIT	89 FIT
λ_{DU}	176 FIT	152 FIT
SFF	84 %	81 %
DC	81 %	37 %
PFD_{avg} T_{Proof} = 1 year (1001)	1.82×10^{-3}	1.28×10^{-3}
PFD_{avg} T_{Proof} = 1 year (1002)	1.69×10^{-4}	1.30×10^{-4}
SIL capability	SIL 2 (HFT = 0) SIL 3 (HFT = 1)	SIL 2 (HFT = 0) SIL 3 (HFT = 1)

1) including detected "annunciation" failures (λ_{AD}) (failures in diagnostic function)

Table 12: SA. 2 series with AC 01.2 controls in SIL version, with heating system

SA 07.2 – SA 16.2 / SAEx 07.2 – SAEx 16.2 Switchgear version: Contactors		
Safety function	**Safe ESD**	**Safe STOP**
λ_S	185 FIT	575 FIT
λ_{DD} 1)	822 FIT	176 FIT
λ_{DU}	164 FIT	205 FIT
SFF	85 %	78 %
DC	83 %	46 %
PFD_{avg} T_{Proof} = 1 year (1001)	1.74×10^{-3}	1.73×10^{-3}
PFD_{avg} T_{Proof} = 1 year (1002)	1.60×10^{-4}	$1{,}76 \times 10^{-4}$
SIL capability	SIL 2 (HFT = 0) SIL 3 (HFT = 1)	SIL 2 (HFT = 0) SIL 3 (HFT = 1)

1) including detected "annunciation" failures (λ_{AD}) (failures in diagnostic function)

Table 13: SA. 2 series with AC 01.2 controls in SIL version, with heating system

SA 07.2 – SA 16.2 / SAR 07.2 – SAR 16.2 Switchgear version: Thyristor		
Safety function	**Safe ESD**	**Safe STOP**
λ_S	138 FIT	565 FIT
λ_{DD} 1)	850 FIT	176 FIT
λ_{DU}	173 FIT	153 FIT
SFF	85 %	82 %
DC	83 %	53 %
PFD_{avg} T_{Proof} = 1 year (1001)	1.82×10^{-3}	1.29×10^{-3}
PFD_{avg} T_{Proof} = 1 year (1002)	1.68×10^{-4}	1.31×10^{-4}
SIL capability	SIL 2 (HFT = 0) SIL 3 (HFT = 1)	SIL 2 (HFT = 0) SIL 3 (HFT = 1)

1) including detected "annunciation" failures (λ_{AD}) (failures in diagnostic function)

Table 14: SAEx. 2 series with ACExC 01.2 controls in SIL version, with heating system

SAEx07.2 – SAEx 16.2 / SAREx 07.2 – SAREx 16.2 Switchgear version: Thyristor with tripping contactor		
Safety function	**Safe ESD**	**Safe STOP**
λ_S	176 FIT	604 FIT
λ_{DD} 1)	885 FIT	176 FIT
λ_{DU}	177 FIT	153 FIT
SFF	85 %	83 %
DC	83 %	53 %
PFD_{avg} T_{Proof} = 1 year (1001)	1.87×10^{-3}	1.29×10^{-3}
PFD_{avg} T_{Proof} = 1 year (1002)	1.72×10^{-4}	1.31×10^{-4}
SIL capability	SIL 2 (HFT = 0) SIL 3 (HFT = 1)	SIL 2 (HFT = 0) SIL 3 (HFT = 1)

1) including detected "annunciation" failures (λ_{AD}) (failures in diagnostic function)

10. SIL Certificate

DAkkS
Deutsche
Akkreditierungsstelle
D-ZE-11074-01-01

TÜV NORD

Certificate

No. SEBS-A.120728/13, V1.0

TÜV NORD Systems GmbH & Co. KG hereby certifies

AUMA Riester GmbH & Co. KG
Aumastraße 1
79379 Müllheim, Germany

that the

electric actuator system with the actuators SA(R)07.1 – SA(R)16.1/ SA(R)ExC07.1 – SA(R)ExC16.1 and SA(R)07.2 – SA(R)16.2/ SA(R)Ex07.2 – SA(R)Ex16.2 with the actuator controls AC01.2/ACExC01.2 in SIL version

with the safety functions „Safe Emergency Shut Down (ESD)“ and „Safe Stop“ is capable for safety related applications up to SIL 3 and meets the requirements listed in the following standard.

- **DIN EN 61508: 2011 part 1 and part 2**

SIL 2 can be reached in a 1oo1 architecture and SIL 3 in a 1oo2 architecture.

Base of certification is the report SEBS-A.20130627.120728TB-1 in the valid version.

This certificate entitles the holder to use the pictured safety approved mark.

Valid until: 2019-04-15
File reference: 8110430406

Hamburg, 2014-04-15

B. Pfuff

Bianca Pfuff

Voluntary Certification
TÜV NORD
TÜV NORD Systems GmbH & Co. KG
Safety Approved
Electric Actuator System
DIN EN 61508-1/-2: 2011 capable up to SIL 3
SEBS-A.120728/13

SEECERT Software & Electronics Certification Body
TÜV NORD Systems GmbH & Co. KG
Große Bahnstraße 31, 22525 Hamburg, Germany

Please note our Test and Certification-Regulation on the back

11. Checklists

11.1. Commissioning checklist

Table 15: Commissioning checklist

1. Actuator and controls correctly wired?	☐ ✓
2. Limit and torque switching set?	☐ ✓
3. Safe function (depending on the configuration) checked in accordance with the proof test checklists?	☐ ✓
4. Commissioning of basic settings (standard control) performed in accordance with the operation instructions?	☐ Yes ☐ No
☒ ✓ = Done	

11.2. Proof test checklists

If the proof test is performed according to proof test checklists, the pertaining NOTICES contained in the <Tests and maintenance> chapter have to be observed.

11.2.1. Safe ESD safety operation (Safe OPENING/CLOSING)

Proof test checklist for version or configuration:

- Safe ESD function: “Safe CLOSING" (Safe ESD in direction CLOSE)
- Safe ESD function “Safe OPENING" (Safe ESD in direction OPEN)
- Irrespective of type of seating

Also valid for combination of SafeESD with Safe STOP.

Table 16: Proof test checklist

Configuration **Safe CLOSING (Safe ESD in direction CLOSE)**	✎	**Configuration** **Safe OPENING (Safe ESD in direction OPEN)**	✎
1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓	1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓
2. Operation command in direction OPEN executed?	☐ ✓	2. Operation command in direction CLOSE executed?	☐ ✓
3. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓	3. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓
↪ Check actuator reaction: Does actuator stop and run in direction CLOSE?	☐ Yes ☐ No	↪ Check actuator reaction: Does actuator stop and run in direction OPEN?	☐ Yes ☐ No
↪ Check SIL module signal behaviour: **No** SIL fault signal? `SIL failure` output (NC contact) = open)	☐ Yes ☐ No	↪ Check SIL module signal behaviour: **No** SIL fault signal? `SIL failure` output (NC contact) = open)	☐ Yes ☐ No
4. `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓	4. `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓
☒ ✓ = Executed ☒ Yes = Condition met ☒ No = Condition not met If the answer to one of the questions is no, the safety instrumented system must be checked.			

11.2.2. SIL fault signal "Actuator monitoring"

Proof test checklist for version or configuration:

- Safe ESD function: “Safe CLOSING" (Safe ESD in direction CLOSE)
- Safe ESD function “Safe OPENING" (Safe ESD in direction OPEN)
- Irrespective of type of seating

Also valid for combination of SafeESD with Safe STOP.

Table 17: Proof test checklist

Configuration **Safe CLOSING (Safe ESD in direction CLOSE)**	✎	**Configuration** **Safe OPENING (Safe ESD in direction OPEN)**	✎
1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓	1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓
2. Motor operation locked?	☐ ✓	2. Motor operation locked?	☐ ✓
3. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓	3. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓
↪ Check SIL module signal behaviour: SIL fault signal within 4 seconds? `SIL failure` output (NC contact) = closed)	☐ Yes ☐ No	↪ Check SIL module signal behaviour: SIL fault signal within 4 seconds? `SIL failure` output (NC contact) = closed)	☐ Yes ☐ No
4. `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓	4. `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓
5. Motor operation lock removed?	☐ ✓	5. Motor operation lock removed?	☐ ✓
☒ ✓ = Executed ☒ Yes = Condition met ☒ No = Condition not met If the answer to one of the questions is no, the safety instrumented system must be checked.			

11.2.3. Safe ESD reaction to "Motor protection (thermal fault)" signals

Proof test checklist for version or configuration:

- Safe ESD function: “Safe CLOSING" (Safe ESD in direction CLOSE)
- Safe ESD function “Safe OPENING" (Safe ESD in direction OPEN)
- Irrespective of type of seating

Also valid for combination of SafeESD with Safe STOP.

Table 18: Proof test checklist

Configuration **SIL motor protection active**	✎	**Configuration** **SIL motor protection inactive**	✎
1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓	1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓
2. Selector switch in position **0** (OFF)?	☐ ✓	2. Selector switch in position **0** (OFF)?	☐ ✓
3. Simulation value Thermal test selected under Proof test (motor prot.) parameter M1021 (required user level: Specialist (4))? Display indicates: CMD0078 Thermal test ○ (white dot)	☐ ✓	3.Simulation value Thermal test selected under Proof test (motor prot.) parameter M1021 (required user level: Specialist (4))? Display indicates: CMD0078 Thermal test ○ (white dot)	☐ ✓
4. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓	4. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓
↪ Check actuator reaction: Safety operation initiated?	☐ Yes ☐ No	↪ Check actuator reaction: Safety operation initiated?	☐ Yes ☐ No
5. Motor simulation activated via push button Ok? Display indicates: CMD0079 Thermal test ● (black dot)	☐ ✓	5. Motor simulation activated via push button Ok? Display indicates: CMD0078 Thermal test ● (black dot)	☐ ✓
↪ Check actuator reaction: Safety operation stopped?	☐ Yes ☐ No	↪ Check actuator reaction: Safety operation **not** stopped?	☐ Yes ☐ No
↪ Check SIL module signal behaviour: SIL fault signal? `SIL failure` output (NC contact) = closed)	☐ Yes ☐ No	↪ Check SIL module signal behaviour: **No** SIL fault signal? `SIL failure` output (NC contact) = open)	☐ Yes ☐ No
6. `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓	6. `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓
7. Simulation reset or simulation menu exit and select-or switch reset to initial position?	☐ ✓	7. Simulation reset or simulation menu exit and select-or switch reset to initial position?	☐ ✓
☒ ✓ = Executed ☒ Yes = Condition met ☒ No = Condition not met If the answer to one of the questions is no, the safety instrumented system must be checked.			

11.2.4. Safe ESD reaction to "Limit seating with overload protection" (limit and/or torque evaluation)

Proof test checklist for version or configuration:

- Actuator with electromechanical control unit
- One of the following safety functions:
  - Safe ESD function: “Safe CLOSING" (Safe ESD in direction CLOSE)
  - Safe ESD function “Safe OPENING" (Safe ESD in direction OPEN)
- "SIL seating" configuration
  = **“Limit seating with overload protection”**

Also valid for combination of SafeESD with Safe STOP.

Table 19: Proof test checklist

Configuration Safe CLOSING (Safe ESD in direction CLOSE)	✎	**Configuration Safe OPENING (Safe ESD in direction OPEN)**	✎
1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓	1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓
2. Switch compartment opened?	☐ ✓	2. Switch compartment opened?	☐ ✓
3. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓	3. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓
↪ Check actuator reaction: Safety operation initiated?	☐ Yes ☐ No	↪ Check actuator reaction: Safety operation initiated?	☐ Yes ☐ No
4. Limit switch CLOSE operated until step 5.1 was executed? (Test button [1] turned in direction of the LSC arrow?)	☐ ✓	4. Limit switch OPEN operated until step 5.1 was executed? (Test button [2] turned in direction of the LSO arrow?)	☐ ✓
↪ Check actuator reaction: Safety operation stopped?	☐ Yes ☐ No	↪ Check actuator reaction: Safety operation stopped?	☐ Yes ☐ No
5.1 `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓	5.1 `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓
5.2 Actuator operated via local controls or from REMOTE to end position OPEN and then to end position CLOSED?	☐ ✓	5.2 Actuator operated via local controls or from REMOTE to end position OPEN and then to end position CLOSED?	☐ ✓
5.3 Actuator operated to mid-position or at sufficient distance from the end positions?	☐ ✓	5.3 Actuator operated to mid-position or at sufficient distance from the end positions?	☐ ✓
6. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓	6. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓
↪ Check actuator reaction: Safety operation initiated?	☐ Yes ☐ No	↪ Check actuator reaction: Safety operation initiated?	☐ Yes ☐ No
7. Torque switch CLOSE operated until step 8 was executed? (Test button [1] turned in direction of the TSC arrow?)	☐ ✓	7. Torque switch OPEN operated until step 8 was executed? (Test button [2] turned in direction of the TSO arrow?)	☐ ✓
↪ Check actuator reaction: Safety operation stopped? Display illuminated in red?	☐ Yes ☐ No	↪ Check actuator reaction: Safety operation stopped? Display illuminated in red?	☐ Yes ☐ No
↪ Check SIL module signal behaviour: SIL fault signal? `SIL failure` output (NC contact) = closed)	☐ Yes ☐ No	↪ Check SIL module signal behaviour: SIL fault signal? `SIL failure` output (NC contact) = closed)	☐ Yes ☐ No
8. `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓	8. `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓
9. Torque fault of standard controls acknowledged?	☐ ✓	9. Torque fault of standard controls acknowledged?	☐ ✓
10. Switch compartment closed?	☐ ✓	10. Switch compartment closed?	☐ ✓
☒ ✓ = Executed ☒ Yes = Condition met ☒ No = Condition not met If the answer to one of the questions is no, the safety instrumented system must be checked.			

11.2.5. Safe ESD reaction to "Forced limit seating in end position" (limit evaluation) – for actuators with electromechanical control unit

Proof test checklist for version or configuration:

- Actuator with electromechanical control unit

- One of the following safety functions:
  - Safe ESD function: “Safe CLOSING" (Safe ESD in direction CLOSE)
  - Safe ESD function “Safe OPENING" (Safe ESD in direction OPEN)
- "SIL seating" configuration
  = **“Forced limit seating in end position”**

Also valid for combination of SafeESD with Safe STOP.

Table 20: Proof test checklist

Configuration **Safe CLOSING (Safe ESD in direction CLOSE)**	✎	**Configuration** **Safe OPENING (Safe ESD in direction OPEN)**	✎
1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓	1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓
2. Switch compartment opened?	☐ ✓	2. Switch compartment opened?	☐ ✓
3. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓	3. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓
↪ Check actuator reaction: Safety operation initiated?	☐ Yes ☐ No	↪ Check actuator reaction: Safety operation initiated?	☐ Yes ☐ No
4. Limit switch CLOSE operated until step 5.1 was executed? (Test button [1] turned in direction of the LSC arrow?)	☐ ✓	4. Limit switch OPEN operated until step 5.1 was executed? (Test button [2] turned in direction of the LSO arrow?)	☐ ✓
↪ Check actuator reaction: Safety operation stopped?	☐ Yes ☐ No	↪ Check actuator reaction: Safety operation stopped?	☐ Yes ☐ No
5.1 `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓	5.1 `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓
5.2 Actuator operated via local controls or from REMOTE to end position OPEN and then to end position CLOSED?	☐ ✓	5.2 Actuator operated via local controls or from REMOTE to end position OPEN and then to end position CLOSED?	☐ ✓
6. Switch compartment closed?	☐ ✓	6. Switch compartment closed?	☐ ✓
☒ ✓ = Executed ☒ Yes = Condition met ☒ No = Condition not met If the answer to one of the questions is no, the safety instrumented system must be checked.			

11.2.6. Safe ESD reaction to "Forced limit seating in end position" (limit evaluation) – for actuators with electronic control unit and limit switches

Proof test checklist for version or configuration:

- Actuator with electronic control unit and limit switches
- One of the following safety functions:
  - Safe ESD function: “Safe CLOSING" (Safe ESD in direction CLOSE)
  - Safe ESD function “Safe OPENING" (Safe ESD in direction OPEN)
- "SIL seating" configuration
  = **“Forced limit seating in end position”**

Also valid for combination of SafeESD with Safe STOP.

Table 21: Proof test checklist

Configuration **Safe CLOSING (Safe ESD in direction CLOSE)**	✎	**Configuration** **Safe OPENING (Safe ESD in direction OPEN)**	✎
1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓	1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓
2. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓	2. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓
↪ Check actuator reaction: Safety operation initiated?	☐ Yes ☐ No	↪ Check actuator reaction: Safety operation initiated?	☐ Yes ☐ No
3. Wait until actuator limit switch trips. ↪ Check actuator reaction: Safety operation stopped when reaching limit switch CLOSED?	☐ Yes ☐ No	3. Wait until actuator limit switch trips. ↪ Check actuator reaction: Safety operation stopped when reaching limit switch OPEN?	☐ Yes ☐ No
4. `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓	4. `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓
☒ ✓ = Executed ☒ Yes = Condition met ☒ No = Condition not met If the answer to one of the questions is no, the safety instrumented system must be checked.			

11.2.7. Safe ESD reaction to "Forced torque seating in end position" (torque after limit evaluation)

Proof test checklist for version or configuration:

- Actuator with electromechanical control unit
- One of the following safety functions:
  - Safe ESD function: “Safe CLOSING" (Safe ESD in direction CLOSE)
  - Safe ESD function “Safe OPENING" (Safe ESD in direction OPEN)
- "SIL seating" configuration
  = **“Forced torque seating in end position”**

Also valid for combination of SafeESD with Safe STOP.

Table 22: Proof test checklist

Configuration **Safe CLOSING (Safe ESD in direction CLOSE)**	✎	**Configuration** **Safe OPENING (Safe ESD in direction OPEN)**	✎
1. Actuator operated to end position CLOSED via **standard controls** (until limit switch in end position trips)?	☐ ✓	1. Actuator operated to end position OPEN via **standard controls** (until limit switch in end position trips)?	☐ ✓
2. Switch compartment opened?	☐ ✓	2. Switch compartment opened?	☐ ✓
3. + 4. Torque switch CLOSE operated and safety operation initiated for operated switch? (Test button [1] turned in direction of the TSC arrow?) `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓	3. + 4. Torque switch OPEN operated and safety operation initiated for operated switch? (Test button [2] turned in direction of the TSO arrow?) `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓
↪ Check actuator reaction: Safety operation **not** initiated?	☐ Yes ☐ No	↪ Check actuator reaction: Safety operation **not** initiated?	☐ Yes ☐ No
↪ Check SIL module signal behaviour: **No** SIL fault signal? `SIL failure` output (NC contact) = open)	☐ Yes ☐ No	↪ Check SIL module signal behaviour: **No** SIL fault signal? `SIL failure` output (NC contact) = open)	☐ Yes ☐ No
5. `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓	5. `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high)?	☐ ✓
6. Switch compartment closed?	☐ ✓	6. Switch compartment closed?	☐ ✓
☒ ✓ = Executed ☒ Yes = Condition met ☒ No = Condition not met If the answer to one of the questions is no, the safety instrumented system must be checked.			

11.2.8. Safe ESD reaction to "No seating"

Proof test checklist for version or configuration:

- Actuator with electromechanical control unit:

- One of the following safety functions:
  - Safe ESD function: “Safe CLOSING" (Safe ESD in direction CLOSE)
  - Safe ESD function “Safe OPENING" (Safe ESD in direction OPEN)
- "SIL seating" configuration
  = **“No seating”**

Also valid for combination of SafeESD with Safe STOP.

Table 23: Proof test checklist

Configuration **Safe CLOSING (Safe ESD in direction CLOSE)**	✎	**Configuration** **Safe OPENING (Safe ESD in direction OPEN)**	✎
1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓	1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓
2. Switch compartment opened?	☐ ✓	2. Switch compartment opened?	☐ ✓
3. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓	3. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓
↪ Check actuator reaction: Safety operation initiated?	☐ Yes ☐ No	↪ Check actuator reaction: Safety operation initiated?	☐ Yes ☐ No
4. Limit switch CLOSE operated? (Test button [1] turned in direction of the LSC arrow?)	☐ ✓	4. Limit switch OPEN operated? (Test button [2] turned in direction of the LSO arrow?)	☐ ✓
↪ Check actuator reaction: Safety operation **not** stopped?	☐ Yes ☐ No	↪ Check actuator reaction: Safety operation **not** stopped?	☐ Yes ☐ No
5.1 `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high) before reaching the end position?	☐ ✓	5.1 `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high) before reaching the end position?	☐ ✓
5.2 Actuator operated via local controls or from REMOTE to end position OPEN and then to end position CLOSED?	☐ ✓	5.2 Actuator operated via local controls or from REMOTE to end position OPEN and then to end position CLOSED?	☐ ✓
5.3 Actuator operated to mid-position or at sufficient distance from the end positions?	☐ ✓	5.3 Actuator operated to mid-position or at sufficient distance from the end positions?	☐ ✓
6. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓	6. `Safe ESDa` and `Safe ESDb` input signals set to 0 V (low)?	☐ ✓
7. Torque switch CLOSE operated? (Test button [1] turned in direction of the TSC arrow?)	☐ ✓	7. Torque switch OPEN operated? (Test button [2] turned in direction of the TSO arrow?)	☐ ✓
↪ Check actuator reaction: Safety operation **not** stopped? Display illuminated in red?	☐ Yes ☐ No	↪ Check actuator reaction: Safety operation **not** stopped? Display illuminated in red?	☐ Yes ☐ No
↪ Check SIL module signal behaviour: SIL fault signal? `SIL failure` output (NC contact) = closed)	☐ Yes ☐ No	↪ Check SIL module signal behaviour: SIL fault signal? `SIL failure` output (NC contact) = closed)	☐ Yes ☐ No
8. `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high) before reaching the end position?	☐ ✓	8. `Safe ESDa` and `Safe ESDb` input signals set to +24 V DC (high) before reaching the end position?	☐ ✓
9. Torque fault of standard controls acknowledged?	☐ ✓	9. Torque fault of standard controls acknowledged?	☐ ✓
10. Switch compartment closed?	☐ ✓	10. Switch compartment closed?	☐ ✓
☒ ✓ = Executed ☒ Yes = Condition met ☒ No = Condition not met If the answer to one of the questions is no, the safety instrumented system must be checked.			

11.2.9. Safe STOP function

Proof test checklist for version or configuration:

“SIL function” = **”Safe STOP CLOSE/OPEN”** (safe stop) configuration.

Also valid for combination of SafeESD with Safe STOP.

Table 24: Proof test checklist

Safe stop in direction OPEN **Safe STOP OPEN**	✎	**Safe stop in direction CLOSE** **Safe STOP CLOSE**	✎
1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓	1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓
2. Operation command via standard controls in direction OPEN executed?	☐ ✓	2. Operation command via standard controls in direction CLOSE executed?	☐ ✓
3. Safe STOP CLOSE input signal set to 0 V (low)?	☐ ✓	3. Safe STOP OPEN input signal set to 0 V (low)?	☐ ✓
↪ Check actuator reaction: Does actuator continue its operation in direction OPEN?	☐ Yes ☐ No	↪ Check actuator reaction: Does actuator continue its operation in direction CLOSE?	☐ Yes ☐ No
↪ Check SIL module signal behaviour: **No** SIL fault signal? SIL failure output (NC contact) = open)	☐ Yes ☐ No	↪ Check SIL module signal behaviour: **No** SIL fault signal? SIL failure output (NC contact) = open)	☐ Yes ☐ No
4. Safe STOP OPEN input signal set to 0 V (low)?	☐ ✓	4. Safe STOP CLOSE input signal set to 0 V (low)?	☐ ✓
↪ Check actuator reaction: Does actuator stop?	☐ Yes ☐ No	↪ Check actuator reaction: Does actuator stop?	☐ Yes ☐ No
↪ Check SIL module signal behaviour: **No** SIL fault signal? SIL failure output (NC contact) = open)	☐ Yes ☐ No	↪ Check SIL module signal behaviour: **No** SIL fault signal? SIL failure output (NC contact) = open)	☐ Yes ☐ No
5. Safe STOP OPEN and Safe STOP CLOSE input signals set to +24 V DC (high)?	☐ ✓	5. Safe STOP OPEN and Safe STOP CLOSE input signals set to +24 V DC (high)?	☐ ✓
☒ ✓ = Executed ☒ Yes = Condition met ☒ No = Condition not met If the answer to one of the questions is no, the safety instrumented system must be checked.			

11.2.10. Combination of Safe ESD and Safe STOP

Proof test checklist for version or configuration:

- One of the following Safe ESD safety functions with any seating configuration:
  - Safe ESD function: “Safe CLOSING" (Safe ESD in direction CLOSE)
  - Safe ESD function: "Safe OPENING" (Safe ESD in direction OPEN)
- Safe STOP function

Table 25: Proof test checklist

Safe stop in direction CLOSE **Safe CLOSING (Safe ESD in direction CLOSE)**	✎	**Safe stop in direction OPEN** **Safe OPENING (Safe ESD in direction OPEN)**	✎
1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓	1. Is actuator in mid-position or at sufficient distance from the end positions?	☐ ✓
2 Safe STOP CLOSE input signal set to 0 V (low)?	☐ ✓	2 Safe STOP OPEN input signal set to 0 V (low)?	☐ ✓
3. Safe ESDa and Safe ESDb input signals set to 0 V (low)?	☐ ✓	3. Safe ESDa and Safe ESDb input signals set to 0 V (low)?	☐ ✓
↪ Check actuator reaction: Safety operation in direction CLOSE initiated?	☐ Yes ☐ No	↪ Check actuator reaction: Safety operation in direction OPEN initiated?	☐ Yes ☐ No
↪ Check SIL module signal behaviour: **No** SIL fault signal? SIL failure output (NC contact) = open)	☐ Yes ☐ No	↪ Check SIL module signal behaviour: **No** SIL fault signal? SIL failure output (NC contact) = open)	☐ Yes ☐ No
4. Safe ESDa, Safe ESDb, Safe STOP OPEN and Safe STOP CLOSE input signals set to +24 V DC (high)?	☐ ✓	4. Safe ESDa, Safe ESDb, Safe STOP OPEN and Safe STOP CLOSE input signals set to +24 V DC (high)?	☐ ✓
☒ ✓ = Executed ☒ Yes = Condition met ☒ No = Condition not met If the answer to one of the questions is no, the safety instrumented system must be checked.			

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