auma®

Solutions for a world in motion

Multi-turn actuators

SA3 – SA100

SAR3 - SAR100

with epac controls in SIL version

Manual

Functional Safety

NOTICE for use!

This document is only valid with the latest operation instructions attached to the device, the attached manual as well as the pertaining technical and electrical data sheets respectively. They are understood as reference documents.

Purpose of the document:

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

Reference documents:

- Operation instructions (Assembly, operation, commissioning) for actuator.
- Manual (Operation and setting) 3.XX NI.
- Manual (Device integration Fieldbus) 3.XX NI Profibus.
- Technical data on multi-turn actuator and actuator controls.

Reference documents can be downloaded from the internet (www.auma.co.in).

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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:

Abbreviation	Full expression	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**ndetected	Number of undetected dangerous failures
λ_{DD}	Lambda **D**angerous **D**etected	Number of detected dangerous 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**ailures	Mean time between the occurrence of two subsequent failures
SFF	**S**afe **F**ailure **F**raction	Fraction of safe failures as well as of detectable dangerous 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 Integrity Level

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 dangerous event.

Safety instrumented function (SIF) Function with specified 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 is 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 for the safety function. The time for detecting the failure, planning tasks, as well as operating resources is also included. This 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 for safety operation. The MRT should preferably be small.

Device type (type A and type B) Actuator controls version 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 behavior 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 behavior 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 / IEC 61511.

2.2 Standards

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

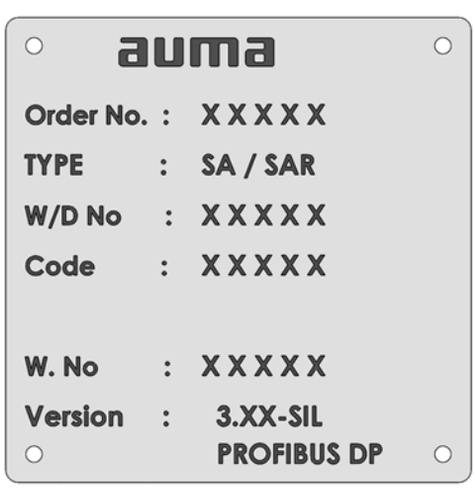
Type		Power supply
Actuator	**Controls**	**Motor**
SA3 – SA100	EPAC controls in SIL version	3-phase AC current
SAR3 – SAR100	EPAC controls in SIL version	3-phase AC current

Hardware, software and configuration of actuator and actuator controls must not be modified without prior written consent by AUMA. Unauthorized modification may have a negative impact on both safety figures and SIL capability of the products.

Information In applications with requirements on functional safety, only AUMA actuator controls and actuators in SFC or SIL version may be used.

AUMA actuator controls and actuators in SIL version can be identified by the letters “SIL” on the nameplate.

Figure 1: Example of name plate with “SIL” marking on EPAC.



3 Architecture, configuration and applications

3.1 Architecture (actuator sizing)

For actuator architecture (actuator sizing) the maximum torques, run 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 of cables 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 STOP function

Actuators with electromechanical control unit:

For end position signaling (limit switching) and torque signaling via the electromechanical control unit are safe signals which may be integrated into a safety-related system. However, this signal is not part of the certification by TÜV Nord. Please refer to the specific safety manual for details regarding this signal.

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.

Actuators with electronic control unit MWG:

Information For end position signaling (limit switching) and torque signaling 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 signaling can exclusively be ensured via limit switches. However, this signal is not part of the certification by TÜV Nord. Please refer to the specific safety manual for details regarding this signal.

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 small. However, for unfavorable configurations (low number of turns per stroke), this range can amount to more than 10 % of the total stroke.

Should within the framework of unfavorable 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 defined in the factory during actuator 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) 3.XX EPAC actuator.

Configuration of safety-related functions is listed in the order-related technical data sheet.

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

When configuring a Safe ESD function and a Safe STOP function, the Safe ESD function is always prioritized compared to the Safe STOP function when requested simultaneously.

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 Protection against uncontrolled operation (self-locking/brake)

For self-locking AUMA actuators, it can be assumed that a load up to nominal torque will not result in uncontrolled valve operation from standstill due to valve torque load. Consequently, in these cases, further protection against uncontrolled operation is not imperatively required. However, certain applications may require active position locking, for example by using a brake. There are user-specific standards demanding this type of protection. Therefore, each project must be subject to individual verification if any further protection is required. In any case this protection is required for actuators without self-locking.

Table 8: Overview self-locking for AUMA actuators (at the time of printing of this document)

Type	Output speed		Self-locking
	50 Hz	60 Hz	
SA 3 – SA 100 SAR 3 – SAR 100	90 rpm or below	108 rpm or below	Self-locking
	125 rpm or above	150 rpm or above	NOT self-locking

If actuators with insufficient self-locking function paired with “Forced torque seating in end position” SIL seating type are used for the safety function, the following effect might occur: During ESD, the actuator operates to the end position and switches off due to reaching the travel position and the tripping torque. Thereafter, the gear train is relieved and the torque falls below the preset limit value. As a matter of fact, the actuator controls detect this incident and switch the actuator on again since the behavior is correctly considered as termination of the ESD condition. The latter generates additional torque until the switching off condition is reached again, and so on. The “pumping effect” of the actuator is the consequence.
To successfully avoid this incident, we recommend either selecting actuator or other elements with sufficient self-locking within the gear train or – if acceptable from a process and safety point of view – selecting “Forced limit seating in end position” as safety function.

3.4 Operation mode (low/high demand mode)

The safety functions of the actuators supplied by AUMA are suitable for the low demand mode and may only be used in this operation mode. If a non-safety instrumented function of basic process control system is executed via the same actuator in addition to the safety function, note that while considering the sum of non-safety instrumented function, required tests and safety function, the defined number of maximum permissible cycles[1)] for the respective actuator as well as the maximum number of starts[2)] may not be exceeded during deployment of the actuator within a safety instrumented system.

3.5 Further notes and indications on architecture

HFT is 0.

The systematic capability is 3 (SC=3)

Only flanges of F07 or FA07 sizes or larger may be used for valve attachment.

If the actuator is equipped with a position transmitter like MWG, RWG or EWG, they may not be integrated within the safety instrumented system.

The actuator safety functions can be considered as type A device.

The operating time for a complete stroke must exceed 4 seconds. Attention: Any modification of the nominal stroke results in operating time change.

Safety function(s) and their feedback signals may only be issued via the digital inputs and outputs of the SIL module.

The signal issued via `SIL fault` output must be permanently evaluated. If the output signals a fault, assumption can be made that the safety function is not available. The safety function must be checked without delay. Possibly further safety measures are to be taken until the safety function is restored without fault.

3.6 Applications (environmental conditions)

When specifying and using the actuators within safety instrumented systems, make sure that the permissible service conditions and the EMC requirements by the peripheral devices are met. Service conditions are indicated in the technical data sheets:

1) Definition of “cycles” according to EN 15714-2:2010
2) Definition of “starts” according to DIN EN 15714-2:2010

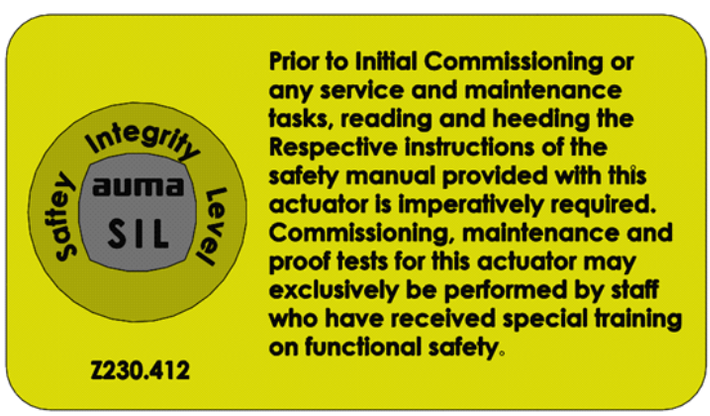
- Enclosure protection test
- Corrosion protection test
- Ambient temperature
- Definition of “cycles” test
- Definition of “starts” test
- Vibration resistance

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 specified to 2.5.

For environmental test, actuator and actuator controls will be subjected to the following tests:

- Dry heat test
- Damp heat test
- Vibration test
- Induced seismic vibration (earthquake)
- Enclosure protection IP68 test
- Salt spray test
- Immunity requirements test
- Emission test

NOTICE All SIL actuators will be with below caution label for identification.

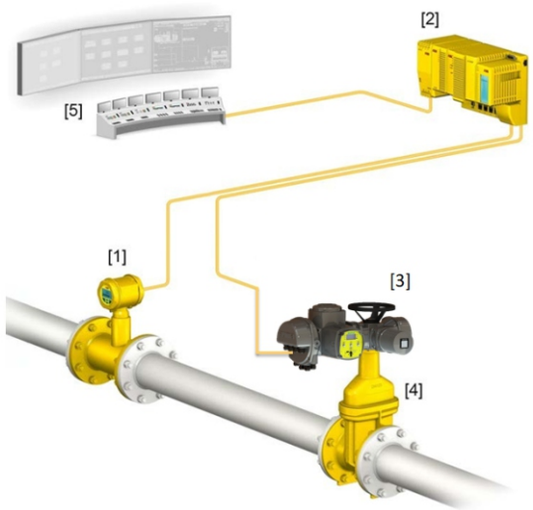


4 Safety instrumented systems and safety functions

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 2: Typical safety instrumented system



[1] Sensors

[2] Controls (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 figures are determined. These figures 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 figures of actuators, the following safety functions are taken into account:

- Safe ESD function (Emergency Shut Down): 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).

“Safe end position feedback” is not part of the certification by TÜV Nord and neither part of this safety manual. Please refer to the specific safety manual for details regarding this function.

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 fault`
- `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 with actuator controls achieve SIL 3 in accordance with IEC 61508.

Figure 3: Redundant system with Safe ESD for Safe CLOSING

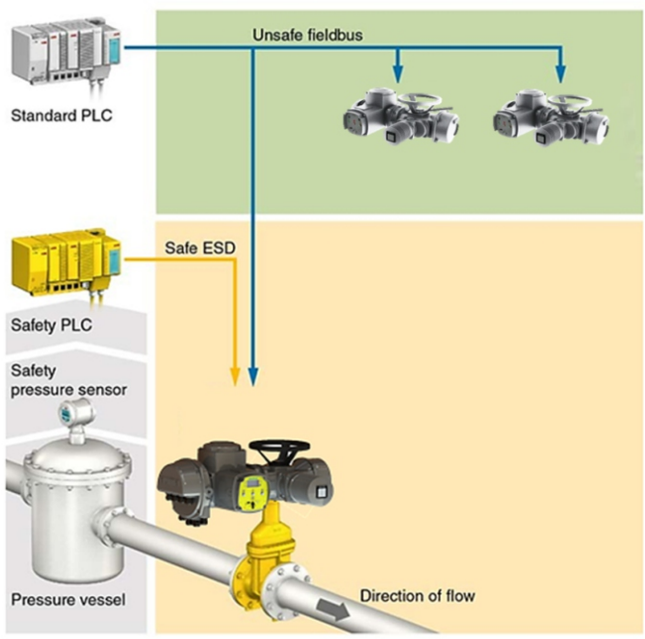
Figure 4: Redundant system with Safe ESD for Safe OPENING

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.

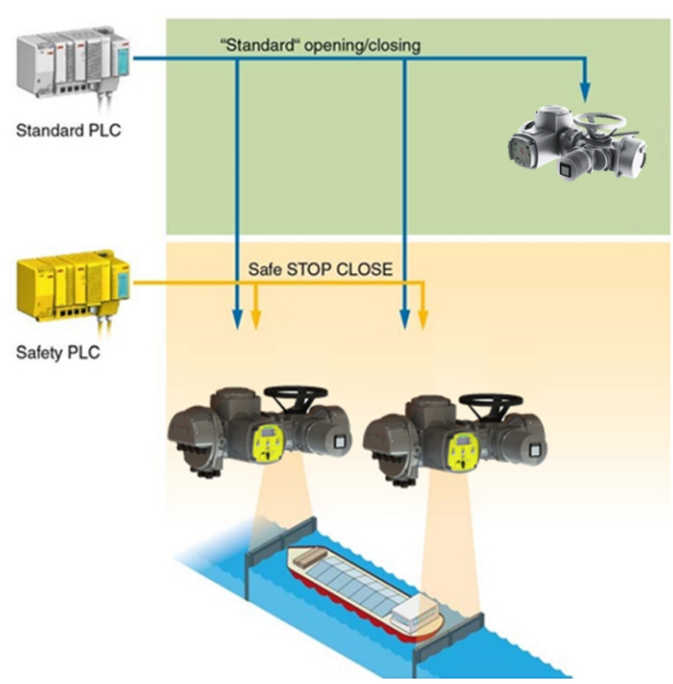
Figure 5: Application example: Pressure vessel



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.

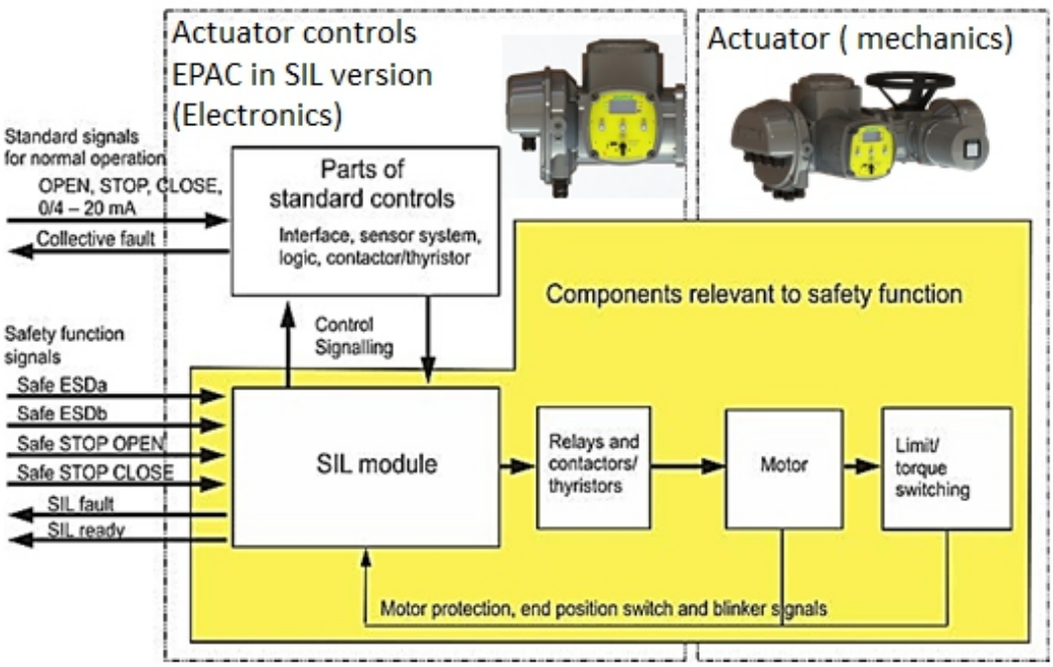
Figure 6: Application example: Lock



4.6 System representation

The representation below shows the simplified design of an epac in SIL version.

Figure 7: 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 and commissioning may only be performed by authorised personnel who have been trained on functional safety.

The plant operator is responsible for ensuring power supply protection against over-voltage and under-voltage during execution of a safety function.

5.1 Installation

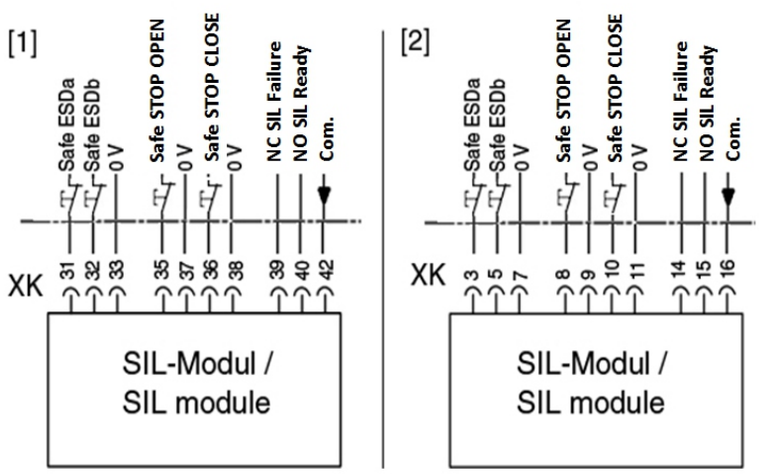
Information The PIN assignments (XK ...) mentioned in this chapter (and also in other chapters) are considered as standard assignments of SA series with controls 3.XX /NI/SIL. In certain configurations, this PIN assignment could be different and for the typical assignment refer to wiring diagram as applicable.

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.

Safety functions are connected via the SIL module integrated in the SA series with 3.XX /NI/SIL actuator controls.

SIL fault must be connected to a SIL2 compatible input of a safety PLC and subsequently analyzed.

Figure 8: Connections for safety functions via SIL module



[1] Typical connection assignment for parallel control

[2] Typical connection assignment for fieldbus control

Input switching behavior 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 behavior of `SIL ready` and `SIL failure` outputs:

- `SIL ready`/ Absence of fault to be detected by diagnostics:

  NO (NO contact) output = **closed**

  NC (NC contact) output = **open**

Designation Wiring diagram	Signal	Customer connections for control (typical assignment)	
		[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
Power supply failure	The safety-related part of controls is without power supply.
Failure of actuator monitoring	Actuator not operated on Safe ESDa and ESDb command.
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 In case of mains failure, the SIL module would no longer be operable.

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, the actuator can start by triggering the safety function.

⚠ CAUTION

Risk of immediate actuator start 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 figures indicated in the <Safety figures> chapter are valid for T_{proof} = 1 year.

For operation, both the pertaining operation instructions and the manual (Operation and setting) SA series with epac 3.XX /NI/SIL 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. 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 figures are valid for the cycles or modulating steps defined in the technical data specifications for typical periods of up to 10 years (the criterion achieved first is valid). After this period, the probability of failure increases.

Extending this period is basically feasible in many cases provided both manufacturer and operator introduce respective actions in compliance with footnote N3 of IEC 61508-2:2010 7.4.9.5 b). This is the responsibility of the operator who will have to take appropriate and suitable measures. Please contact us if you need support in identifying suitable measures.

5.5 Decommissioning

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

- Impact of decommissioning on relevant devices, equipment on 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) SA series with epac 3.XX /NI/SIL.

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, to understand the safety function status easily.

6.1 Status indications on SIL functions

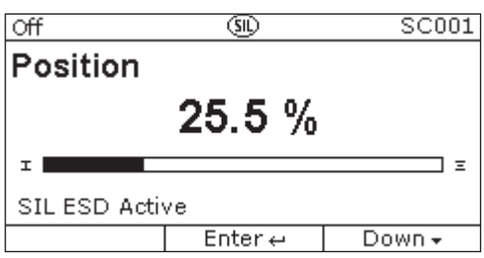
Actuator controls may indicate status information on safety-related functions on the display.

SIL status (S001)

Indication S001 Signals the safety function and the SIL fault indication status.

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

Figure 9: Safety function and SIL fault indication status



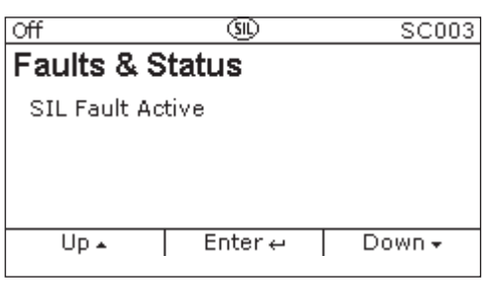
Status indications on display	Status
Safe ESD	Safe ESD function (Safe OPENING/CLOSING) is active: Actuator is operated in the configured direction (CLOSE/OPEN) (inputs Safe ESDa/Safe ESDb = 0 V or open)
Safe STOP	Safe STOP function is active, actuator stops (Safe STOP OPEN or Safe STOP CLOSE = 0 V or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

Warnings (S003)

Indication S003 shows the numbers of warnings having occurred.

In case a SIL fault occurs, the SIL fault message is listed in indication S003. Refer to Details > Status for further details.

Figure 10: Warning: SIL fault

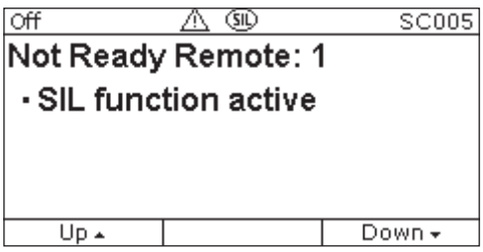


Not ready REMOTE (S0006)

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 11: 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 “standard 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:

- `Non-Inching Local=OPENCLOSE`
- `Non-Inching Remote=OPENCLOSE`

If one of these configurations is selected in the standard controls, it does not mean that the safety function will work in the Non-Inching manner and the Safety function will be active as long as the signal is present.

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 “fault” in the manual (Operation and setting) 3.XX /NI.

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 behavior 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) 3.XX /NI.

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

Table 9: Individual signals of SIL fault collective signal

Indication on display Standard controls	Description/ Cause of the fault	Impact on safety function -- Remedy
Thermal fault	Thermo Switch provided in the MOTOR is tripped.	• The Safe ESD safety 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).	• The Safe ESD safety function cannot be executed. • If the fault is triggered during safety operation, operation is stopped. **Remedy** -- Execute operation command in opposite direction. -- Verify torque setting. -- Check whether foreign object prevents the valve from closing. -- Possibly problems with the valve.
Wrn range act.pos.	Both limit switches (OPEN and CLOSED) are operated simultaneously. Possibly defect at actuator mechanics.	• The Safe ESD safety 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 safety 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.
Control Supply Fault 110 V AC	Fault of internal 110 V AC power supply. The safety-related part of controls is without power supply	• The Safe ESD safety 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.
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
	Fault of redundant wiring of Safe ESD input. Both signals Safe ESDa and Safe ESDb are not simultaneously on the same level.	The Safe ESD safety function can be executed. A SIL fault is indic- ated via `SIL fault` output. **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 signaling 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 used in lieu of safety-related signals within a safety instrumented system. However, they can be used as additional information on the standard PLC.

Information If digital inputs or outputs of standard controls are connected to the safety PLC, imperatively ensure sufficient absence of interference of all non-safety-related system components with regard to the safety function. The absence of interference must be guaranteed even in case of standard component faults. For this, galvanic isolation between safety-related and non safety-related system components is important (but not necessarily sufficient).

Available signals:

Safe ESD

Safe STOP

SIL FAULT

SIL Function active

7.4 Signal via fieldbus of standard controls

For actuator controls in fieldbus interface 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:

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. Impact of testing/maintenance on relevant devices, equipment or other work must be evaluated.

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 schedule for the entire safety lifecycle of the SIS to avoid systematic faults. 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 signaled via the output contact of the SIL module (`SIL failure`).

To ensure the safety figures 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 signaling 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 —

There are two options for performing the PVST.

1. **Performing the PVST using safe inputs `Safe ESDa` and `Safe ESDb`:** The PVST must be controlled by the external safety PLC. The safety PLC uses safe inputs `Safe ESDa` and `Safe ESDb`. Desired diagnostics is performed by evaluating the SIL output contact (SIL module: `SIL failure`). Both control signals and related actuator operation have to be present for at 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.

2. **Performing the PVST using the PVST function of 3.XX /NI/SIL:** If standard controls of 3.XX /NI/SIL are configured with PVST input, this input can be used for diagnostics of the safety relevant part of the controls under certain conditions.

Conditions and required settings:

- Additional non-interacting end position switches for safe and reliable end position feedback signals are available and wired to the safety PLC.
- A digital input of standard controls (galvanically separated from the other inputs) is configured to the following value:
- The safety PLC directly controls the PVST or will also receive the control signal if the PVST input is controlled.
- The PVST may only be performed from one of the end positions.
- Parameter `PVST operating time` must amount to > 4 seconds.
- Signals `PVST fault` and `PVST abort` of the standard controls are sent via digital outputs (galvanically separated from the other outputs) of the standard controls to the safety PLC.

PVST is either directly requested at the PVST input of the standard controls by the safety PLC or the signal for requesting the PVST is also sent to the safety PLC. While the 3.XX /NI standard controls perform the PVST, the safety PLC monitors whether

- the actuator was in one of the end positions prior to the PVST (check via safe end position feedback).
- the actuator left one of the end positions within the set PVST operation time (check via safe end position feedback).
- If a fault was signaled via the SIL output contact (SIL module: `SIL failure`).

Only if the actuator was in one of the end positions prior to the PVST, has left this end position during the PVST, the standard controls have neither issued a `PVST fault` nor a `PVST abort` signal from standard controls, nor the SIL module signaled a `SIL fault`, was the PVST was successfully completed. If this is not the case the device has to be checked in accordance with the steps in the <Proof test> chapter.

Information If digital inputs or outputs of standard controls are connected to the safety PLC, imperatively ensure sufficient absence of interference of all non-safety-related system components with regard to the safety function. The absence of interference must be guaranteed even in case of standard component faults. For this, galvanic isolation between safety-related and non safety-related system components is important (but not necessarily sufficient).

Performing a PVST includes diagnostics of the safety-related components. This ensures improved safety figures 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 for “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.

5. Check Safe ESD reaction to “Forced limit seating in end position” (limit evaluation) – for actuators with electronic control unit and limit switches.
6. Check Safe ESD reaction to “Forced torque seating in end position” (torque after limit evaluation).
7. Check Safe ESD reaction for “no seating” (no evaluation of limit and torque).
8. Check Safe STOP function.
9. Check combination of Safe ESD and Safe STOP function.

Information 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 at appropriate intervals. The intervals are to be defined by the plant operator. Safety-related figures depend on the selected proof test interval; in our example, they are valid for T_{proof} = 1 year (refer to <Safety-related figures> 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.

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”: check

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 be- fore 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 sequence

1. Operate actuator in mid-position or at sufficient distance from the end positions.
2. Execute operation command in opposite direction of the configured Safe ESD safety function:

Test sequence

- 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).

2. 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.

3. 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 signaled.

Test sequence

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:

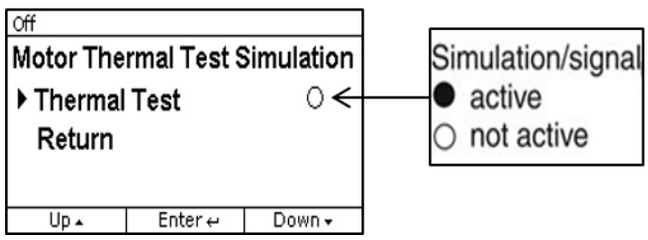
- For “**SIL motor protection**” = **active** configuration
  = safety operation is stopped.
- For “**SIL motor protection**” = **inactive** configuration
  = safety operation is not stopped.

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

Required user level: Specialist (4) or higher.

Simulation value: Thermal test

Figure 12: 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 sequence

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.) parameter M1021 (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 (MWG.2)
- 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)
- Configuration of "SIL seating"

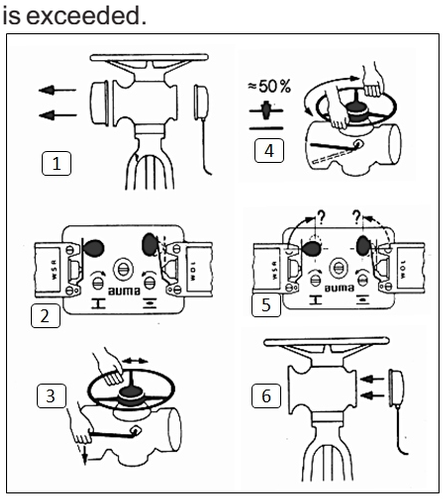
  = **"Limit seating with overload protection"**

  (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 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 MWG.2 is exceeded.



Test sequence

1. Remove cover at switch compartment (fig.1)
2. Check whether limit-switch has tripped (fig.2)Valve completely closed : WSR tripped Valve completely opened : WOL tripped
3. Engage manual drive :

   Push declutch lever as indicated by arrow (fig. 3). If resistance is felt, turn handwheel slowly while lever is pressed till manual drive engages.
4. Operate valve to intermediate position manually (fig.4) Direction OPEN (⊼) turn handwheel anti-clockwise. Direction CLOSED (⊻) turn handwheel clockwise. Switch cam at ⊻ (Z) or ⊼ (O) should rotate 90°and release the switch (fig. 5) if set properly.

   Initiate safety operation: Set `Safe ESDa` and `Safe ESDb` input signals to 0 V (low).
5. Ensure sealing faces at control plug are clean and check whether O-ring is ok. Apply thin film of non - acid grease to sealing faces and then replace plug cover (fig. 6).

   Check seating via limit switches
6. Operate limit switches until test is complete:
   - → For “Safe CLOSING” (Safe ESD in direction CLOSE) configuration: Activate `SIL ESDa/ ESDb` command until close limit switch trips, then validate the valve position on EPAC display as 0.00%.
   - → For "Safe OPENING” (Safe ESD in direction OPEN) configuration: Activate `SIL ESDa/ ESDb` command until Open limit switch trips, then validate the valve position on EPAC display as 100%
   - ✓ The safety function reaction to the limit switch signals is correct if safety operation is stopped.
7. After limit switching evaluation:
   - Set `Safe ESDa` and `Safe ESDb` input signals to +24 V DC (high).
   - Operate actuator via local controls or from REMOTE to end position OPEN and then to end position CLOSED.
   - Operate actuator to mid-position or at sufficient distance from the end positions.

NOTICE

☑ Thermo switches are provided to protect Motor windings.

☑ Be connected in panel control circuit (Refer Terminal Plan), else our warranty is void

8.4.5 Check Safe ESD reaction to “Forced limit seating in end position” (limit evaluation) – for actuators with electromechanical control unit

Configuration

This test is required for the following versions or configurations:

- Actuator with electromechanical control unit(MWG.2)
- 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)
- Configuration of “SIL seating”

  = “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 sequence

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:

   Operate limit switches until test is complete:

   → For “Safe CLOSING” (Safe ESD in direction CLOSE) configuration: Activate `SIL ESDa / ESDb` command until close limit switch trips, then validate the valve position on EPAC display as 0.00%

   → For "Safe OPENING” (Safe ESD in direction OPEN) configuration: Activate `SIL ESDa/ ESDb` command until Open limit switch trips, then validate the valve position on EPAC display as 100%.

   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.
5. Close switch compartment.

8.4.6 Safe ESD reaction to “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 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)
- Configuration of “SIL seating”

  = “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 sequence

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 2.

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 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)
- Configuration of “SIL seating”

  = **“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 and of the control unit are used for the test. These can be used to operate the switches manually.

- Turn test button in direction of the TSC arrow: Torque switch CLOSE trips.
- Turn test button in direction of the TSO arrow: Torque switch OPEN trips.

Test sequence

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.
3. Operate torque switches and hold activated.

   – For Safe CLOSING (Safe ESD in direction CLOSE) configuration: Turn test button in direction of the TSC arrow:
   – For ""Safe OPENING” (Safe ESD in direction OPEN) configuration: Turn test button 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 the `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:

- Actuators with electromechanical control unit or 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)
- Configuration of “SIL seating”

  = “**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 sequence

1. Operate actuator in mid-position or at sufficient distance from 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 in direction of the LSC arrow.
   → For "“Safe OPENING” (Safe ESD in direction OPEN) configuration: Turn test button 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:
   - Set `Safe ESDa` and `Safe ESDb` input signals to +24 V DC (high) **before** reaching the end position.
   - Operate actuator via local controls or from REMOTE to end position OPEN and then to end position CLOSED. (Positions will be recorded anew).
   - Operate actuator to mid-position or at sufficient distance from the end positions.
6. Close switch compartment.

8.4.9 Safe STOP function: check

Configuration

The test applies to the "SIL function" = **"Safe STOP OPEN/CLOSE"** (Safe STOP) configuration. 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 sequence

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 thyristor, 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 sequence

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.

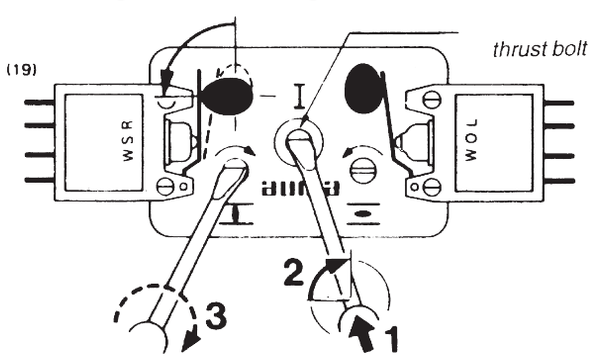
NOTICE

   ➢ **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 relating to the individual safety functions (Safe STOP or ESD) in this manual have to be performed for the combination of Safe ESD and Safe STOP.

Resetting limit-switching:



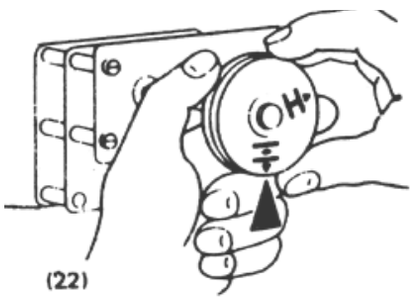
Operate the valve away from end-position to account for over-run or to the desired switch tripping point.

- Push thrust bolt I inwards and turn (fig. 19). The bolt remains in this position.
- For CLOSED position turn spindle marked ⊥ (Z), (for OPEN position spindle marked ,= O) slowly as indicated by arrow (fig.19). Distinct "clicks" can be felt and heard. Continue turning the spindle until the cam operates the switch. At this stage, the spindle should not "click" any more and should not be turned any further.

  If inadvertently you override the tripping point, continue turning the spindle slowly in the same direction till the switch cam goes back to its original position. Repeat setting instructions as above described.
- Turn thrust bolt I till it snaps back into its original position by spring action.

1. Immediately after start-up: Ensure sealing faces at cover and housing are clean. Check whether O-ring is correctly in position and apply a thin film of non-acid grease. Replace the cover and fasten with 4 screws (fig. 21).
2. Fasten control cover screws and tighten glands at conduit entries.

Setting of Mechanical position indicator



The two dials have a slip clutch for easy adjustment. At valve fully closed, turn dial (CLOSED) till the arrow is in alignment with the mark on the show glass. Operate valve into fully OPEN position and adjust dial marked (OPEN) till the arrow mark is in alignment with the mark on the cover.

Note: The dial (CLOSED) must be held in position while adjusting dial (OPEN). (fig. 22).

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 India Private Limited.

Information AUMA actuators prioritize motor operation to manual operation. This means that the actuator automatically switches to motor operation if requested. However, we recommend activating motor operation after any maintenance and service interventions.

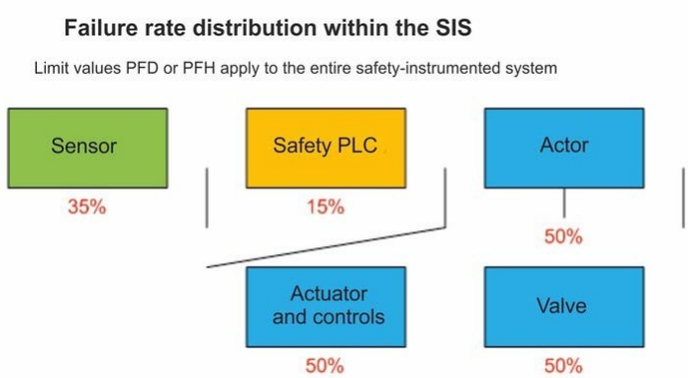
9 Safety-related figures

9.1 Determination of the safety-related figures

- The calculation of the safety figures 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 calculate mechanical 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: = 10^{-3} to < 10^{-2}
  - SIL 3 safety functions: = 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: ≲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 16: 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.

Information The safety figures mentioned in this safety manual are only valid if all the conditions stipulated in this safety manual and the mentioned activities are respected.

The PFD values specified in this safety manual are only examples and subject to certain assumptions e.g. on T_{proof}, MTTR, …

The PFD calculation should always be performed individually for each system using the parameters and conditions applicable for the respective system. The λ_{DU} and λ_{DD} values should be used as input. When observing the proof test procedures indicated in this safety manual, we recommend using a proof test coverage (PTC) of 90 % for the calculations.

9.2 Specific figures for SA series with EPAC controls 3.XX/NI in SIL version with actuators

Information

The following key figure tables provide an example of safety-related figures for the different versions. Complete data records of safety-related figures of all variants are available within the exida test report. For the relevant figures, refer to the pertaining order-related Declaration of Incorporation.

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 [%])
- T1 = 1 year (proof test interval [h])
- T2 = 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 10: SA series with EPAC controls in SIL version

SA3 to SA100 Switchgear version: Contactors			
Safety function	**Safe ESD CLOSE**	**Safe ESD OPEN**	**Safe STOP**
λ_S	230	226	402
$\lambda_{DD(FIT)}$	853	857	310
$\lambda_{du(FIT)}$	374	354	278
SFF	74 %	75%	72 %
DC	70 %	71%	53 %
SIL capability	SIL 2 (HFT = 0) SIL 3 (HFT = 1)	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: SAR series with EPAC controls in SIL version

SAR3 to SAR100 Switchgear version: Thyristor			
Safety function	**Safe ESD CLOSE**	**Safe ESD OPEN**	**Safe STOP**
λ_S	183	179	392
$\lambda_{DD(FIT)}$	880	884	310
$\lambda_{du(FIT)}$	383	363	227
SFF	74 %	75%	76 %
DC	70 %	71%	58 %
SIL capability	SIL 2 (HFT = 0) SIL 3 (HFT = 1)	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

C E R T I F I C A T E

This certifies, that the company

Auma India Private Limited
38A & 39B, 2nd Phase, Peenya Industrial Area
Bengaluru-560058 – Karnataka, India

Is authorized to provide the product mentioned below

Description of product:	**ELECTRIC ACTUATORS WITH EPAC CONTROLS IN SIL VERSION** **SA3 - SA100** **SAR3 - SAR100**
In accordance with:	**IEC 61508:2010 Parts 1, 2, 3, 4, 5, 6, 7**

Registration No 20 21041 01
Test Report No PS-21041-20-L-01
File reference 21041-01

Validity
from 2020-12-11
until 2023-12-11

TÜV NORD Italia S.r.l. (TÜV NORD Group)
Via Turati, 70 20023 Cerro Maggiore (MI) www.tuev-nord.it

Cerro Maggiore, 2020-12-11
prodotto@tuev-nord.it

Please also pay attention to the information stated overleaf

11 Checklists

11.1 Commissioning checklist

Information Table 16: Commissioning checklist

1. Actuator and controls correctly wired?	☐ ✓
2. Limit and torque switching set?	☐ ✓
3. Safety 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)

Information 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 Safe ESD 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. 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 Safe ESD with Safe STOP.

Table 18: 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 for “Motor protection (thermal fault)” signal

Information 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 Safe ESD with Safe STOP.

Table 19: 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 in parameter Proof test (motor prot.)M1021 (required user level: Specialist (4))? Display indicates: CMD0078 Thermal test ○ (white dot)	☐ ✓	3.Simulation value : Thermal test selected in parameter Proof test (motor prot.)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: SIL fault signal? SIL failure output (NC contact) = closed)	☐ 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 selector switch reset to initial position?	☐ ✓	7. Simulation reset or simulation menu exit and selector 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)
- Configuration of “SIL seating”
  = “Limit seating with overload protection”

Also, valid for combination of Safe ESD 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?	☐ ✓
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)
- Configuration of “SIL seating”

  = “Forced limit seating in end position”

Also, valid for combination of Safe ESD 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. 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)
- Configuration of “SIL seating”

  = “Forced limit seating in end position”

Also, valid for combination of Safe ESD 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. 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)
- Configuration of “SIL seating”

  = “Forced torque seating in end position”

Also, valid for combination of Safe ESD 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. 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:

- Actuators with electromechanical control unit or 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)
- Configuration of “SIL seating”

  = “no seating”

Also, valid for combination of Safe ESD with Safe STOP.

Information For version of electronic control unit with limit switches, steps 6 – 9 are obsolete.

Table 24: 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) **prior** to reaching the end position?	☐ ✓	5.1 Safe ESDa and Safe ESDb input signals set to +24 V DC (high) **prior** to 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) **prior** to reaching the end position?	☐ ✓	8. Safe ESDa and Safe ESDb input signals set to +24 V DC (high) **prior** to 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 OPEN/CLOSE"** (safe stop) configuration.

Also, valid for combination of Safe ESD with Safe STOP.

Table 25: 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

Safety function

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 26: 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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