SOMAS®

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Mi-902 EN

Safety manual
Somas valves and actuator
Functional safety

TÜVRheinland® CERTIFIED

SIL/PL Capability

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Foreword

This safety manual is intended to be used in conjunction with Somas instruction for installation, operation and maintenance.

We keep the right to do any technical changes which are necessary to improve the product without prior notice.

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Table of contents

1 Introduction

1.1 Scope

This manual provides necessary requirements for a Somas valve and an actuator for meeting the IEC 61508, IEC 61511 and ISO 13849 functional safety standards and information necessary to design, install, verify and maintain a final element in a Safety Instrumented Function (SIF).

1.2 Responsibilities for safety

The safety of design and operation of a safety-related system, in which the valve and the actuator is implemented, must be ensured by the manufacturer and the operator.

1.2.1 Responsibility of the valve manufacturer

- Safe design of the valve and the actuator
- Providing of all safety-related Information to the operator of the overall system
- Compliance to all regulations and guidelines that allow a safe commissioning

1.2.2 Responsibility of the operator

- Instructing personnel working on the overall system
- Maintaining the safe operation of the overall system
- Compliance to all regulations and guidelines regarding occupational safety
- Ensuring of periodic test of the overall system by qualified employees

1.3 Terms and abbreviations

FMEDA	Failure Modes, Effects and Diagnostic Analysis
HFT	Hardware Fault Tolerance
PFD_{AVG}	Average Probability of Failure on Demand
SFF	Safe Failure Fraction
SIL	Safety Integrity Level discrete level (one out of a possible four) for specifying the safety integrity requirements of the safety functions to be allocated to the E/E/PE safety-related systems where Safety Integrity Level 4 has the highest level of safety integrity and Safety Integrity Level 1 has the lowest.
SIF	Safety Instrumented Function a set of equipment intended to reduce the risk due to a specific hazard (a safety loop), Safety instrumented control/protection function.
SIS	Safety Instrumented System Implementation system of one or more Safety Instrumented Functions. A SIS is composed of any combination of sensor(s), logic solver(s), and final element(s).
DC	Diagnostic Coverage Factor (if diagnostic measures exist).
PTC	Proof Test Coverage Factor
PFH	Probability of a Dangerous Failure per Hour
$MTTF_D$	Mean Time To Failure $_{\text{Dangerous}}$
FST	Full stroke test
PST	Partial stroke test
PL	Performance level

1.4 Reference documents

- TÜV Report no. V 518.01/16
- TÜV Report no. V 1005.00/17
- TÜV Report no. V 1004.00/17
- TÜV Report no. V 1003.00/17
- Somas Instruction Mi-203EN
- Somas Instruction Mi-205EN
- Somas Instruction Mi-207EN
- Somas Instruction Mi-209EN
- Somas Instruction Mi-101EN
- Somas Instruction Mi-105EN
- Somas Instruction Mi-110_111_112EN
- Somas Instruction Mi-113_114EN
- Somas Instruction Mi-115EN
- Somas Instruction Mi-706EN
- Somas Instruction Mi-503EN
- Somas Data sheet Si-202EN
- Somas Data sheet Si-203EN
- Somas Data sheet Si-204EN
- Somas Data sheet Si-205EN
- Somas Data sheet Si-206EN
- Somas Data sheet Si-207EN
- Somas Data sheet Si-208EN
- Somas Data sheet Si-209EN
- Somas Data sheet Si-210EN
- Somas Data sheet Si-211EN
- Somas Data sheet Si-101EN
- Somas Data sheet Si-105EN
- Somas Data sheet Si-110EN

- Somas Data sheet Si-111EN
- Somas Data sheet Si-112EN
- Somas Data sheet Si-113EN
- Somas Data sheet Si-114EN
- Somas Data sheet Si-115EN
- Somas Data sheet Si-706EN
- Somas Data sheet Si-503EN

1.5 Related standards

- IEC 61508 Parts 1-2 and 4-7:2010 Functional safety of electrical/electronic/ programmable electronic safety-related systems
- IEC 61511 Parts 1-3:2010 Functional safety - Safety instrumented systems for the process industry sector
- ISO 13849-1:2015 Safety of machinery – Safety-related parts of control systems

2 Description of the valves and the actuator

2.1 Description of the butterfly valves

A detailed description of the butterfly valves can be found in the data sheets

- Somas Data sheet Si-202EN FSV/VSS DN80-DN500 PN25-PN40 Class150-Class 300
- Somas Data sheet Si-203EN VSS DN80-DN1200 PN25/ Class150
- Somas Data sheet Si-204EN VSS DN80-DN600 PN50/ Class300
- Somas Data sheet Si-205EN MTV DN80-DN500 PN25/ Class150
- Somas Data sheet Si-206EN MTVC/MTVCL DN80-DN500 PN25/ Class150 Cargo valve
- Somas Data sheet Si-207EN VSS DN80-DN1200 PN25/ Class150 Exhaust gas valve
- Somas Data sheet Si-208EN MTV DN80-DN500 PN25/ Class150 Oil & gas valve
- Somas Data sheet Si-209EN VSS DN80-DN600 PN100/ Class600
- Somas Data sheet Si-210EN VSS DN80-DN500 PN25/ Class150 Low temperature
- Somas Data sheet Si-211EN VSS DN80-DN600 PN25/ Class150 Low noise

2.2 Description of the ball segment valves

A detailed description of the ball segment valves can be found in the data sheets

- Somas Data sheet Si-101EN KVTF DN25-DN65 PN50/ Class300
- Somas Data sheet Si-105EN KVT DN25-DN150 PN100/ Class600
- Somas Data sheet Si-110EN KVTF DN80-DN700 PN25/ Class150
- Somas Data sheet Si-111EN KVTF DN80-DN250 PN50/ Class300
- Somas Data sheet Si-112EN KVTF DN80-DN400 PN25/ Class150
- Somas Data sheet Si-113EN KVTW DN80-DN250 PN25/ Class150
- Somas Data sheet Si-114EN KVTW DN80-DN250 PN25/ Class150
- Somas Data sheet Si-115EN HVVW/HVVF DN40/32-DN250 PN10/ Class300

2.3 Description of the ball valve

A detailed description of the ball valve can be found in the data sheet

- Somas Data sheet Si-706EN SKV DN25-DN400

2.4 Description of the actuator

A detailed description of the actuator can be found in the data sheet

- Somas Data sheet Si-503EN A10-A50

3 Functional safety specifications

3.1 Safety function

The safety function is to open or shut off a flow rate, depending on the actuator configuration, while maintaining internal and external tightness.

3.2 Environmental limits

The valve and the actuator is intended for use in an industrial environment, indoor, outdoor and/or hazardous area.

The designer of a SIF must verify that the valve and the actuator is rated for use within the expected environmental limits. Extreme environments may require special attention.

- Operating medium temperatures for a valve below -40°C or above 350°C, may require low temperature design or high temperature design, and special materials
- Operating medium temperatures for an actuator below -40°C or above 90°C, may require low temperature design or high temperature design.
- Vibrations from the piping system
- Hazardous area/ explosive atmosphere
- Risk for ice formation

In case of uncertainties, please consult Somas.

3.3 Application limits

The valve is intended for fluids, powders, pellets and mixtures. The pressure rating is from PN 6 up to and including PN 100, and from Class 150 up to and including Class 600. The temperature rating is between -196°C and up to 600°C.

The actuator is intended for instrument air supply, and the temperature rating is between -40°C and up to 120°C.

For a detailed configuration and materials of construction see Somas data sheets for the specific valve and actuator.
The designer of a SIF must verify that the valve and the actuator is rated for use within the expected application limits. Application limits are normally to be found in Somas data sheets.

The compatibility of the operating medium with the materials of construction must be verified in accordance with Somas.
The valve dimension must be calculated in the calculation tool SOMSIZE, or be verified in accordance with Somas.
Extreme applications may require special attention.

- Operating medium temperatures for a valve below -40°C or above 350°C, may require low temperature design or high temperature design, and special materials
- Operating medium temperatures for an actuator below -40°C or above 90°C, may require low temperature design or high temperature design.
- Vibrations from the piping system
- Hazardous area/ explosive atmosphere

In case of uncertainties, please consult Somas.

3.4 Design verification

Failure Mode and Effects Analysis for the valves and the actuator has been carried out to define what kind of failure are safe or dangerous. This document presents failure modes in function of the valves and the actuator (see TÜV reports).

Furthermore, the suitability of the design has been confirmed by field experience of the device.

3.5 SIL / PL capability

The valves and the actuator are suitable for use in a safety instrumented system up to Safety Integrated Level (SIL) 2 according IEC 61508 / IEC 61511. Under consideration of the minimum required hardware fault tolerance HFT=1 the valves and the actuator may be used in a redundant structure up to SIL 3.

The achieved Safety Integrity Level (SIL) of an entire Safety Instrumented Function (SIF) design must be verified by the designer via a calculation of PFDavg or PFH considering architecture, proof test interval, proof test effectiveness, any automatic diagnostics, average repair time and the specific failure rates of all components included in the SIF. Each subsystem must be checked to assure compliance with minimum hardware fault tolerance (HFT) requirements.

The valves and the actuator are also suitable for operation in safety related systems with a Performance Level (PL) of up to PL c according ISO 13849-1. If redundant structure (HFT≥1), sufficient external diagnostics (DC low for PL d, resp. DC medium for PL e) and plausibility checks by the upstream safety controller are realized, the valves and the actuator may be used up to PL e.

3.5.1 Specific parameters for butterfly valves MTV and VSS

Route of assessment		$2_H/1_S$
Assumed test interval	Ti	1 a
Hardware fault tolerance	HFT	0
Diagnostic coverage	DC	0 %
Type of sub system		Type A
Mode of operation		Low and high demand (<100/year)

Close on demand

Assumed demands per year	n_{op}	1 / a	
Dangerous failure rate	λ_D	1.42 E-07/h	142 FIT
Average probability of failure on demand 1oo1	PFDavg (T_i)	6.32 E-04	
Average probability of failure on demand 1oo2	PFDavg (T_i)	6.37 E-05	

Open on demand

Assumed demands per year	n_{op}	1 / a	
Dangerous failure rate	λ_D	1.40 E-07/h	140 FIT
Average probability of failure on demand 1oo1	PFDavg (T_i)	6.23 E-0,4	
Average probability of failure on demand 1oo2	PFDavg (T_i)	6.28 E-05	

Assumptions for calculations above MRT=72 h, β_{1oo2}= 10%

High demand mode

Maximum demands per year	n_{op}	100 / a	1.14 E-02 / h
Mean time to dangerous failure	$MTTF_D$		804 a
Average frequency of dangerousfailure per hour (close on demand)	λ_{DU}=PFH	1.42 E-07	
Average frequency of dangerousfailure per hour (open on demand)	λ_{DU}=PFH	1.40 E-07	

3.5.2 Specific parameters for ball segment valves KVT, KVTW, KVTF, KVX, KVXW, KVXF

Route of assessment		$2_H/1_S$
Assumed test interval	Ti	1 a
Hardware fault tolerance	HFT	0
Diagnostic coverage	DC	0 %
Type of sub system		Type A
Mode of operation		Low demand mode (<100/year)
Systematic capability		SC 3

Close on demand

Dangerous failure rate	λ_D	8.40 E-08/h	84 FIT
Average probability of failure on demand 1oo1	PFDavg (T_i)	3.74 E-04	
Average probability of failure on demand 1oo2	PFDavg (T_i)	3.75 E-05	

Open on demand

Dangerous failure rate	λ_D	7.20 E-08/h	72 FIT
Average probability of failure on demand 1oo1	PFDavg (T_i)	3.21 E-04	
Average probability of failure on demand 1oo2	PFDavg (T_i)	3.22 E-05	

Assumptions for calculations above MRT=72 h, β_{1oo2}= 10%

Maximum demands per year	n_{op}	100 / a	1.14 E-02 / h
Mean time to dangerous failure	$MTTF_D$		2.674 a

3.5.3 Specific parameters for ball valves SKV

Route of assessment		$2_H/1_S$
Assumed test interval	Ti	1 a
Hardware fault tolerance	HFT	0
Diagnostic coverage	DC	0 %
Type of sub system		Type A
Mode of operation		Low demand mode (<100/year)
Systematic capability		SC 3

Close on demand

Dangerous failure rate	λ_D	8.10 E-08/h	81 FIT
Average probability of failure on demand 1oo1	PFDavg (T_i)	3.61 E-04	
Average probability of failure on demand 1oo2	PFDavg (T_i)	3.62 E-05	

Open on demand

Dangerous failure rate	λ_D	7.30 E-08/h	73 FIT
Average probability of failure on demand 1oo1	PFDavg (T_i)	3.25 E-04	
Average probability of failure on demand 1oo2	PFDavg (T_i)	3.26 E-05	

Assumptions for calculations above MRT=72 h, β_{1oo2}= 10%

Maximum demands per year	n_{op}	100 / a	1.14 E-02 / h
Mean time to dangerous failure	$MTTF_D$		2.773 a

3.5.4 Specific parameters for actuator A-DA, A-SC, A-SCL, A-SO, A-SOL

Route of assessment		$2_H/1_S$
Assumed test interval	Ti	1 a
Hardware fault tolerance	HFT	0
Diagnostic coverage	DC	0 %
Type of sub system		Type A
Mode of operation		Low demand mode (<100/year)
Systematic capability		SC 3

Move an attached valve to its safe position (open or close)

		A-DA		A-SO / SOL A-SC / SCL	
Dangerous failure rate	λ_D	2.06 E-07 / h	206 FIT	1.99 E-07 / h	199 FIT
Average probability of failure on demand 1oo1	PFD_{avg} (T_1)	9.17 E-04		8.86 E-04	
Average probability of failure on demand 1oo2	PFD_{avg} (T_1)	9.26 E-05		8.94 E-05	

Assumptions for calculations above MRT=72 h, β_{1oo2}= 10%

Maximum demands per year	n_{op}	100 / a	1.14 E-02 / h
Mean time to dangerous failure	$MTTF_D$	1,090 a	1,129 a

3.6 Requirements of other components

To determine whether a valve or an actuator is suitable for use in a certain safety-related system, it is necessary to determine the PFDavg or the PFH value of the overall system. An ordinary system consists of transmitters, logic solvers, final elements and others. Final elements usually consist of valves, actuators, solenoid valves and others.
Usually it is presumed that a final element (valve + actuator) uses up to 50 % of the total available PFDavg value.

4 Installation, operation and maintenance

4.1 Requirements for installation, operation and maintenance of butterfly valves

The installation, operation and maintenance of the valves shall be done per the requirements in the following instructions

- Somas Instruction Mi-203EN	VSS PN25, PN50, Class150, Class300
- Somas Instruction Mi-205EN	MTV
- Somas Instruction Mi-206EN	MTVC/MTVCL PN25, Class150 Cargo Valve
- Somas Instruction Mi-207EN	VSS Exhaust gas valves
- Somas Instruction Mi-209EN	VSS PN63, PN100, Class600

4.2 Requirements for installation, operation and maintenance of ball segment valves

The installation, operation and maintenance of the valves shall be done per the requirements in the following instructions

- Somas Instruction Mi-101EN	KVT, KVTF DN25-DN65 PN50, Class300
- Somas Instruction Mi-105EN	KVT PN100, Class600
- Somas Instruction Mi-110_111_112EN	KVTF DN80-DN700
- Somas Instruction Mi-113_114EN	KVTW DN80-DN250
- Somas Instruction Mi-115EN	HVVW/HVVF DN40/32-DN250 PN10/ Class300

4.3 Requirements for installation, operation and maintenance of ball valve

The installation, operation and maintenance of the valve shall be done per the requirements in the following instruction

- Somas Instruction Mi-706EN SKV

4.4 Requirements for installation, operation and maintenance of actuator

The installation, operation and maintenance of the actuator shall be done per the requirements in the following instruction

- Somas Instruction Mi-503EN A10-A50

4.5 Maintenance interval and maintenance coverage factor

Soft sealing materials especially and components in general are affected by ageing and wear. The time until a reconditioning of the valve and the actuator must be performed, the maintenance interval, depends strongly on the application.

A maintenance interval of more than 5 years (+1.5 years of storage) can only be favored under the responsibility of the operator, consideration of specific external conditions (securing of required quality of media, maximum temperature, time of impact) and adequate test cycles.

In demanding applications, the maintenance interval may be less than 5 years. In good operating conditions, the maintenance interval may be extended up to 10 years.

At maintenance, a complete reconditioning of the valves and the actuator shall be performed. Aged and worn components shall be changed. Due to the intensive proof the Maintenance Coverage Factor is set to:

MTC = 100%

5 Proof test

5.1 Proof test interval

The objective of proof testing is to detect failures within the device that are not detected by any automatic diagnostics of the system. Of main concern are undetected failures that prevent the SIF from performing its intended safety function.

The frequency of proof testing, or the proof test interval, is to be determined in reliability calculations for the SIF for which a device is applied. The proof tests must be performed at least as frequently as specified in the calculation to maintain the required safety integrity of the SIF. Recommended is at least once a year.

5.2 Proof test coverage

Proof Test Coverage Factor PTC names how many of the dangerous undetected failures can be detected by a proof test. It has been determined within the FMEA.

For Full Stroke and Partial Stroke testing, the coverage factors have been determined to

For the butterfly valves

PTC_{FST} = 87.5 %

PTC_{PST} = 50.0 %

For the ball valves

PTC_{FST} = 88.0 %

PTC_{PST} = 50.0 %

For the ball segment valves

PTC_{FST} = 88.0 %

PTC_{PST} = 50.0 %

For the actuator

PTC_{FST} = 95.0 %

PTC_{PST} = 70.0 %

The following requirements must be applied:

- A diagnostic measure (DC) must be an automatic online testing, for instance a partial stroke test
- A partial stroke test normally can reach a coverage factor of up to 70 % maximum
- A full stroke proof test is no diagnostic measure (DC) and can therefore not be used to increase the SFF

5.3 Proof test procedures

To maintain the functionality and reliability of the valves periodic tests are necessary. Test intervals must be determined by the end user depending on the complete system. The procedure should be conducted as follows.

Procedure for full stroke proof test

Step	Action
1	Bypass the safety function and take appropriate action to avoid a false trip
2	Interrupt or change the signal/supply to the actuator to force the actuator and valve to perform a full stroke to the Fail-Safe state and confirm that the Safe State was achieved and within the correct time.
3	Restore the supply/signal to the actuator and confirm that the normal operating state was achieved.
4	Inspect device and the other final element components for any leaks, visible damage or contamination.
5	Record the test results and any failures in your company's SIF inspection database
6	Remove the bypass and restore normal operation

Procedure for partial stroke proof test

Step	Action
1	On the positioner controlling the partial stroke testing, set the frequency for the partial stroke testing to minimum the number of cycles specified in the SIF calculation
2	During commissioning, make tests to confirm that the partial stroke test performs as intended.
4	If an alarm is triggered during operation, but the safety function is restored and undisputed, record the incident in your company´s SIF inspection database.
5	If an alarm is triggered during operation and the safety function can not be restored, follow the operators instructions approved by the notified body responsible for approval of functional safety at the operators site.

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