

Masoneilan

a Baker Hughes business

Safety Manual for Valves and Actuators Conforming to SIL III

Instruction Manual (Rev. D)

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1. Introduction

This Safety Manual provides information necessary to design, install, verify and maintain a Safety Instrumented Function (SIF) utilizing the following products:

Masoneilan™ Control Valve Models:

- 10000 Series Double Ported Globe Valve
- 21000 Series Top Guided Globe Valve
- 28000 Series **VariPak™** Adjustable Cv Control Valve
- 31000 Series Eccentric Rotary Control Valve with PFA Liner
- 33000 Series Butterfly Control Valve
- 35002 Series **Camflex™** Rotary Control Valve
- 36005 Series **V-Max™** High Capacity Ball Valve
- 41005 Series Cage Guided Control Valve
- 49000 Series Energy Management Control Valve
- 72000 Series Large Mass Flow Energy Management Control Valve
- 75000 Series Tank Drain and Level Control Valve
- 77000 Series Labyrinth Trim Control Valve
- 80000 Series Three-Way Control Valves for Combining and Diverting Service
- 84003 Series **SteamForm™** Valve
- 18400/78400 Series **LincolnLog™** High Pressure Anti-Cavitation Control Valve

Masoneilan Actuator Models:

- 28 Spring-opposed Rolling Diaphragm Actuator
- 31, 32, 33 Rotary Valve Actuators
- 35 Diaphragm Actuator
- 5S Piston spring Actuator
- 37/38 Spring Diaphragm Actuators
- 51/52/53 Piston Actuators
- 87/88 Spring Diaphragm Actuators

This manual provides necessary user information and requirements for meeting the IEC 61508 and/or IEC 61511 functional safety standards.

1.1 Terms and Abbreviations

Safety	Freedom from unacceptable risk of harm.
Basic Safety	The equipment must be designed and manufactured such that it protects against risk of damage to persons by electrical shock and other hazards, and against resulting fire and explosion. The protection must be effective under all conditions of the nominal operation and under single fault condition.
Functional Safety	The ability of a system to carry out the actions necessary to achieve or to maintain a defined safe state for the equipment, machinery, plant or apparatus under control of the system.
Safety Assessment	The investigation to arrive at a judgment, based on evidence of the safety achieved by safety-related systems.
Element	Part of a subsystem comprising a single component or any group of components that performs one or more element safety functions.
Fail-Safe State	State of the process when safety is achieved; fail position will depend on the needs of the customer's system. The control valves and actuators described in this manual will fail either open, closed or in position depending on desired configuration.
Fail Safe	Failure that causes the valve or actuator to go to the defined fail-safe state without a demand from the process.
Fail Dangerous	Failure that does not permit the SIF to respond to a demand from the process (i.e. being unable to go to the defined fail-safe state).
Fail Dangerous Undetected	Failure that is dangerous and that is not being diagnosed by automatic testing.
Fail Dangerous Detected	Failure that is dangerous, but is detected by automatic testing.
Fail Annunciation Undetected	Failure that does not cause a false trip or prevent the safety function, but does cause loss of an automatic diagnostic, and is not detected by another diagnostic.
Fail Annunciation Detected	Failure that does not cause a false trip or prevent the safety function, but does cause loss of an automatic diagnostic or false diagnostic indication.
Fail No Effect	Failure of a component that is part of the safety function, but that has no effect on the safety function.
Low demand mode	Mode where the safety function is only performed on demand in order to transfer the EUC into a specified safe state, and where the frequency of demands is no greater than one per year and no greater than twice the proof test frequency.
High demand mode	Mode where the safety function is only performed on demand in order to transfer the EUC into a specified safe state, and where the frequency of demands is greater than one per year or greater than twice the proof test frequency.
Continuous Mode	Mode where the safety function maintains the EUC in a safe state as part of normal operation.

1.2 Acronyms

EUC	Equipment Under Control
FMEDA	Failure Modes, Effects and Diagnostic Analysis
HFT	Hardware Fault Tolerance
IOM	Installation, Operation and Maintenance Manual
MOC	Management of Change. These are specific procedures to follow for any work activities in compliance with government regulatory authorities or requirements of a standard.
PFDavg	Average Probability of Failure on Demand
PFH	Probability of Failure per Hour
SFF	Safe Failure Fraction, the fraction of the overall failure rate of an element that results in either a safe fault or a diagnosed dangerous fault.
SIF	Safety Instrumented Function, a set of equipment intended to reduce the risk due to a specific hazard (a safety loop).
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 is the highest level and Safety Integrity Level 1 is the lowest.
SIS	Safety Instrumented System – Implementation of one or more Safety Instrumented Functions. A SIS is composed of any combination of sensor(s), logic solver(s), and final element(s).

1.3 Product Support

Product support can be obtained from Baker Hughes Technical Support at: valvesupport@bakerhughes.com

1.4 Related Literature

Hardware Documents:

For Installation, Operation and Maintenance Instructions, please consult the following documents for the following products. These documents can be found at:

<https://valves.bakerhughes.com/resource-center>

Masoneilan Product
Valves
10000 Series Double Ported Globe Valve
21000 Series Top Guided Globe Valve
28000 Series VariPak Adjustable Cv Control Valve
31000 Series Eccentric Rotary Control Valve with PFA Liner
33000 Series Butterfly Control Valve
35002 Series Camflex Rotary Control Valve
36005 Series V-Max High Capacity Ball Valve
41005 Series Cage Guided Control Valve
49000 Series Energy Management Control Valve
72000 Series Large Mass Flow Energy Management Control Valve
75000 Series Tank Drain and Level Control Valve
77000 Series Labyrinth Trim Control Valve
80000 Series Three-Way Control Valve for Combining and Diverting Service
84003 Series SteamForm Valve
18400/78400 Series LincolnLog High Pressure Anti-Cavitation Control Valve
Actuators
28 Spring-opposed Rolling Diaphragm Actuator
31, 32, 33 Rotary Valve Actuators
35 Diaphragm Actuator
5S Piston spring Actuator
37/38 Spring Diaphragm Actuators
51/52/53 Piston Actuators
87/88 Spring Diaphragm Actuators

Guidelines/References:

- Practical SIL Target Selection – Risk Analysis per the IEC 61511 Safety Lifecycle, ISBN 978-1-934977-03-3, exida
- Control System Safety Evaluation and Reliability, 3rd Edition, ISBN 978-1-934394-80-9, ISA
- Safety Instrumented Systems Verification, Practical Probabilistic Calculations, ISBN 1-55617-909-9, ISA

1.5 Reference Standards

Functional Safety

- IEC 61508: 2010 Functional safety of electrical/electronic/ programmable electronic safety-related systems
- IEC 61511:2016 Functional Safety – Safety Instrumented Systems for the Process
- Industry Sector (or ISA 84.00.01 if it is more appropriate)

2. Product Description

Product	Description
10000 Series	Double Ported Globe Valve
21000 Series	Top Guided Globe Valve
28000 Series	VariPak Adjustable C _v Control Valve
31000 Series	Eccentric Rotary Control Valve with PFA Liner
33000 Series	Triple Offset Butterfly Control Valve
35002 Series	Camflex Rotary Control Valve
36005 Series	V-Max High Capacity Ball Valve
41005 Series	Cage Guided Control Valve
49000 Series	Energy Management Control Valve
72000 Series	Large Mass Flow Energy Management Control Valve
75000 Series	Tank Drain and Level Control Valve
77000 Series	Labyrinth Trim Control Valve
80000 Series	Three-Way Control Valve for Combining and Diverting Service
84000 Series	SteamForm Valve
18400/78400 Series	LincolnLog High Pressure Anti-Cavitation Control Valve
28	Spring-opposed Rolling Diaphragm Actuator
31, 32, 33	Rotary Valve Actuators
35	Diaphragm Actuator
5S	Piston Spring Actuator
37/38	Spring Diaphragm Actuators
51/52/53	Piston Actuators
87/88	Spring Diaphragm Actuators

See Installation and Maintenance Manual for additional setup and configuration details.

3. Designing A SIF Using a Manufacturer Product

3.1 Safety Function

The product will perform its function based on the input of the control system selected by the end user.

When faults occur, the product will move to its fail-safe state. Fail action on loss of signal varies by product and configuration.

When de-energized, the valve or actuator moves to its fail-safe position. This can be configured to be fail-closed, fail-open or fail in position, depending on the desired failure mode for the application.

The products listed above are intended to be part of a SIF subsystem as defined per IEC 61508 and the achieved SIL level of the designed function must be verified by the designer.

3.2 Environmental limits

The designer of a SIF must check that the product is rated for use within the expected environmental limits. Refer to the Specification Data documents published on the Baker Hughes website for environmental limits.

3.3 Application limits

The products listed above are intended for use in a wide variety of industries and for a wide application range. These valves or actuators should not be used for applications that fall outside of the published application range.

The materials of construction of each product are provided in the Specification Data documents published on the Baker Hughes website. It is especially important that the designer check for material compatibility considering on-site chemical contaminants and air supply conditions. If the control valve or actuator is used outside of the application limits or with incompatible materials, the reliability data provided becomes invalid.

3.4 Design Verification

Certificates and Assessment Reports are published on the Exida website in the Safety Automation Equipment List at <http://www.exida.com/SAEL>. The certificates are listed under final element manufacturer "Dresser, LLC".

A detailed Failure Mode, Effects, and Diagnostics Analysis (FMEDA) report is also available from Baker Hughes - Masoneilan. This report details all failure rates and failure modes as well as the expected lifetime. Assumptions made during the FMEDA are listed in the report.

The achieved Safety Integrity Level (SIL) of an entire Safety Instrumented Function (SIF) design must be verified by the designer via a calculation of PFD_{AVG} or PFH, considering safety architecture, proof test interval, proof test effectiveness, any automatic diagnostics and worst case fault detection interval, average repair time and the specific failure rates of all products included in the SIF. Each subsystem must be checked to assure compliance with minimum hardware fault tolerance (HFT) requirements. The exida exSILentia[®] tool is recommended for this purpose as it contains accurate models for the above listed valves and actuators and their failure rates.

The failure rate data listed the FMEDA report are only valid for the useful life time of the specified product. The failure rates will increase sometime after this time period. Reliability calculations based on the data listed in the FMEDA report for mission times beyond the lifetime may yield results that are too optimistic, i.e. the required Safety Integrity Level will not be achieved.

An appropriate MTTR shall be selected based on plant operation and maintenance procedures.

3.5 SIL Capability

3.5.1 Systematic Integrity

The product has met manufacturer design process requirements of Safety Integrity Level (SIL) 3. These are intended to achieve sufficient integrity against systematic errors of design by the manufacturer. A Safety Instrumented Function (SIF) designed with this product must not be used at a SIL level higher than the statement without “prior use” justification by the end user or diverse technology redundancy in the design.

3.5.2 Random Integrity

The products listed above are Type A Elements. Therefore, based on the SFF between 60% and 90%, a design can meet SIL 3 @ HFT=1 when the product is used as the only component in a SIF subassembly.

When the SIF consists of many components (list components if applicable), the SIL must be verified for the entire assembly using failure rates from all components. This analysis must account for any hardware fault tolerance and architecture constraints.

3.5.3 Safety Parameters

For detailed failure rate information, refer to the product specific Failure Modes, Effects and Diagnostic Analysis Report.

4. Installation and Commissioning

4.1 Installation

The valve or actuator must be installed per standard practices outlined in the Installation Manual.

The environment must be checked to verify that environmental conditions do not exceed the ratings.

The location and placement of the valve or actuator must be accessible for physical and/or visual inspection and allow for manual proof testing.

4.2 Connections

Verifying the connection between the valve and the end user’s piping is the responsibility of the end user.

5. Operation and Maintenance

5.1 Proof test without automatic testing

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

The frequency of proof testing, or proof test interval, is to be determined in reliability calculations for the safety instrumented functions for which the product is applied. The proof tests must be performed at least as frequently as specified in the calculation in order to maintain the required safety integrity of the safety instrumented function.

The following proof test is recommended. The results of the proof test should be recorded and any failures that are detected and that compromise functional safety should be reported to Baker Hughes. The suggested proof test consists of partially stroking the product using the chosen control interface and analyzing the performance and response of the product.

Table1: Recommended 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 the fail-safe state and confirm that the safe state was achieved within the correct time.
3	Restore the supply/signal to the actuator and inspect for any visible damage or contamination and confirm that the normal operating state was achieved.
4	Inspect the valve and actuator for any leaks, visible damage or contamination.
5	Record any failures in your company's SIF inspection database.
6	Remove the bypass and otherwise restore normal operation.

Consult Appendix B of the product specific FMEDA for proof test coverage percentages.

The person(s) performing the proof test should be trained in SIS operations, including bypass procedures, valve maintenance and company Management of Change procedures.

It is recommended that a physical inspection (Step 4 from Table 1) be performed on a periodic basis with the time interval determined by plant conditions. A maximum inspection interval of 1 year is recommended.

5.2 Repair and replacement

Repair procedures in the product specific Installation, Operation and Maintenance manual must be followed.

5.3 Useful Life

A useful life period of approximately 10 years or 10,000 cycles is expected for the Masoneilan 87/88 Series pneumatic spring diaphragm actuators. Based on general field data, a product life of approximately 20 years is expected for the Masoneilan 87/88 Series pneumatic spring diaphragm actuators if the lower level components are renewed before the end of their useful life and the device is maintained per the manufacturer's instructions.

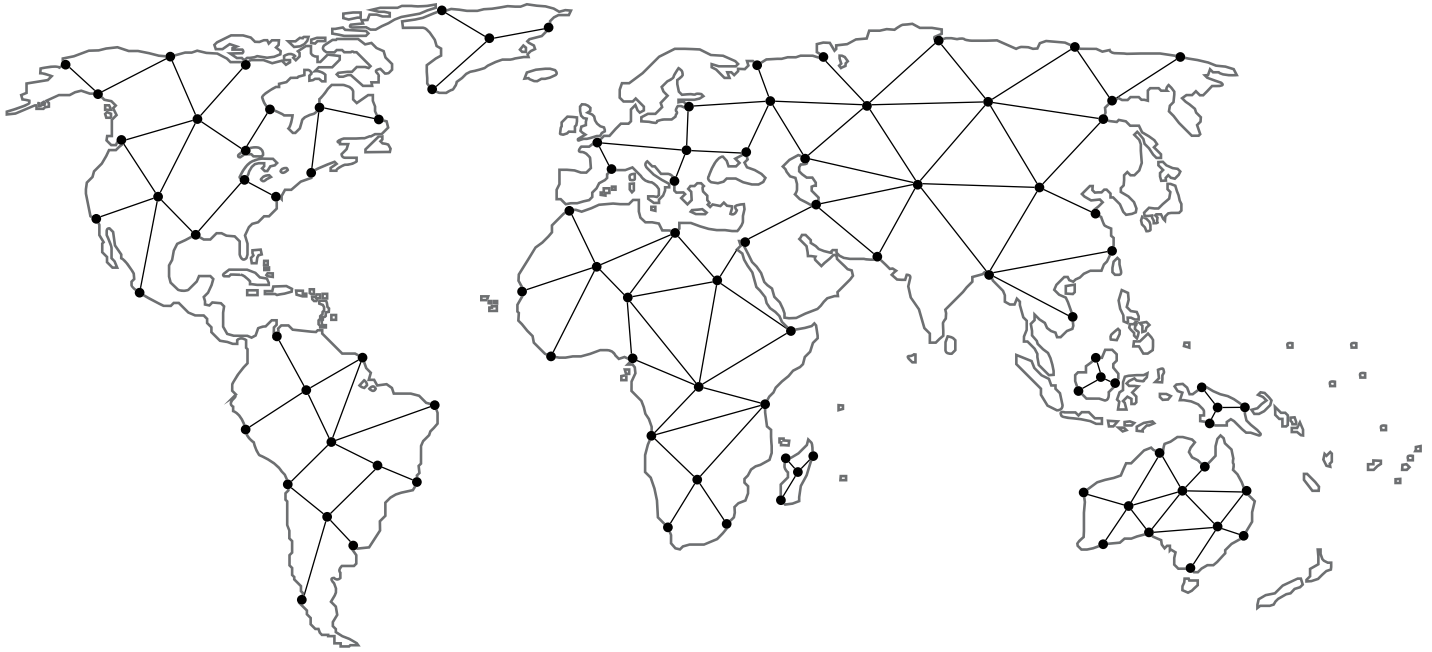
The useful life of the valves and actuators described in this document is 10 to 15 years, or 10,000 cycles when used in a safety instrumented system.

5.4 Manufacturer Notification

Any failures that are detected and that compromise functional safety should be reported to Baker Hughes at: valvesupport@bakerhughes.com

Find the nearest local Channel Partner in your area:

valves.bakerhughes.com/contact-us



Tech Field Support and Warranty:

Phone: +1-866-827-5378

valvesupport@bakerhughes.com

valves.bakerhughes.com

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