Safety manual for Fisher™ 685, 685SE, and 685SR Actuators

Purpose

This safety manual provides information necessary to design, install, verify and maintain a Safety Instrumented Function (SIF) utilizing the Fisher 685, 685SE, and 685SR actuator.

⚠ WARNING

This instruction manual supplement is not intended to be used as a stand-alone document. It must be used in conjunction with the following manuals:
Fisher 685 Piston Actuator Instruction Manual (D103626X012)
Fisher 685SE and 685SR Piston Actuator Instruction Manual (D103799X012)
Failure to use this instruction manual supplement in conjunction with the above referenced manuals could result in personal injury or property damage. If you have any questions regarding these instructions or need assistance in obtaining any of these documents, contact your Emerson sales office or Local Business Partner.

Introduction

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

Figure 1. Fisher 685 Actuators

X0922 **685**

X0993 **685SE**

Terms and Abbreviations

Safety: Freedom from unacceptable risk of harm.

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 / apparatus under control of the system.

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.

Safety Assessment: The investigation to arrive at a judgment - based on the facts - of the safety achieved by safety-related systems.

Fail-Safe State: State where valve actuator is de-energized and spring is extended.

Fail Safe: Failure that causes the valve to go to the defined fail-safe state without a demand from the process.

Fail Dangerous: Failure that does not 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 stroke testing.

Fail Dangerous Detected: Failure that is dangerous but is detected by automatic stroke 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 frequency of demands for operation made on a safety-related system is no greater than twice the proof test frequency.

Acronyms

FMEDA: Failure Modes, Effects and Diagnostic Analysis

HFT: Hardware Fault Tolerance

MOC: Management of Change. These are specific procedures often done when performing any work activities in compliance with government regulatory authorities.

PFD_{AVG}: Average Probability of Failure on Demand

SFF: Safe Failure Fraction, the fraction of the overall failure rate of a device that results in either a safe fault or a diagnosed unsafe 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 has the highest level of safety integrity and Safety Integrity Level 1 has 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).

Related Literature

Hardware Documents:

Bulletin:

61.2:685, Fisher 685 Piston Actuator: D103625X012
61.2:685SE/685SR, Fisher 685SE and 685SR Piston Actuators: D103791X012

Instruction Manual:

Fisher 685 Piston Actuator: D103626X012
Fisher 685SE and 685SR Piston Actuators: D103799X012

Guidelines/References:

- Safety Integrity Level Selection – Systematic Methods Including Layer of Protection Analysis, ISBN 1-55617-777-1, ISA
- Control System Safety Evaluation and Reliability, 2nd Edition, ISBN 1-55617-638-8, ISA
- Safety Instrumented Systems Verification, Practical Probabilistic Calculations, ISBN 1-55617-909-9, ISA

Reference Standards

Functional Safety

- IEC 61508:2010 Functional Safety of electrical/electronic/programmable electronic safety-related systems
- ANSI/ISA 84.00.01-2004 (IEC 61511 Mod.) Functional Safety-Safety Instrumented Systems for the Process Industry Sector

Product Description

Fisher 685 Series actuators are designed for use with a broad range of medium to large sliding-stem control valves. These actuators can be used with a valve controller or positioner for throttling applications or with switching valves for on/off control. Volume boosters are also available for installation onto these actuators for fast stroking requirements. Several models are available to suit a variety of applications:

- 685: double acting piston actuator
- 685SE: spring return, double acting piston actuator with fail-extend action
- 685SR: spring return, double acting piston actuator with fail-retract action

The 685 is a pneumatic, double acting piston actuator that provides high thrust output for short to long travel applications. Typical travel ranges from 25 to 610 mm (1 to 24 inches) and cylinder diameters range from 305 to 660 mm (12 to 26 inches). Thrust capabilities extend to 354 kN (79,000 lbf) and above with special constructions.

The 685SE and 685SR are pneumatic, spring-return, double-acting piston actuators that also provide high thrust output for short to long travel applications. These actuators feature an internal bias spring that forces the actuator piston rod to extend (685SE) or retract (685SR) upon a loss of supply pressure, thereby ensuring a fail-closed or fail-open mode of operation. This effectively eliminates the need for a trip valve and volume tank in most applications. Configurations are available to cover a wide range of application requirements. Typical travel ranges from 25 to 610 mm (1 to 24 inches) and cylinder diameters range from 254 to 711 mm (10 to 28 inches).

Designing a SIF Using a Fisher 685 Series Actuator

Safety Function

The 685 actuator will maintain functionality under all conditions so that the actuator can be moved into the application dependent safe state by means of the control medium. The 685SE and 685SR actuators will move into the application dependent safe state (either open or closed) when the control medium is cut off and vented.

The 685 actuator is intended to be part of final element subsystem as defined per IEC 61508 and the achieved SIL level of the designed function must be verified by the designer.

Environmental limits

The designer of a SIF must check that the product is rated for use within the expected environmental limits. Refer to the appropriate product Bulletins for environmental limits.

Application limits

The 685 series actuator materials of construction are specified in the product bulletins. A range of materials for certain parts are available for various applications. The serial card will indicate what the materials of construction are for a specific actuator. It is especially important that the designer check for material compatibility considering on-site chemical contaminants and air supply conditions. If the 685 series actuator is used outside of the application limits or with incompatible materials, the reliability data provided becomes invalid.

Diagnostic Response Time

A 685 series actuator does not perform any automatic diagnostic functions by itself and therefore it has no diagnostic response time of its own. However, automatic diagnostics of the final control subsystem may be performed such as Partial Valve Stroke Testing (PVST). This typically will exercise the actuator and valve over a small percentage of its normal travel without adversely affecting the flow through the valve. If any failures of this PVST are automatically detected and annunciated, the diagnostic response time will be the PVST interval time. The PVST must be performed 10 times more often than an expected demand in order for credit to be given for this test.

Design Verification

The achieved SIL of an entire SIF design must be verified by the designer via a calculation of PFD_{AVG} considering architecture, proof test interval, proof test effectiveness, any automatic diagnostics, 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 HFT requirements.

When using a 685 series actuator in a redundant configuration, a common cause factor of at least 10% should be included in the Safety Integrity calculations. This value is dependent on the level of common cause training and maintenance in use at the end user's facility.

The failure rate data listed in the SIL certificate is only valid for the useful lifetime of a 685 series actuator. The failure rates will increase after this time period. Reliability calculations based on the data listed in the SIL certificate for mission times beyond the useful lifetime may yield results that are too optimistic, i.e. the calculated Safety Integrity Level will not be achieved.

SIL Capability

Systematic Integrity

The product has met manufacturer design process requirements of SIL 2. These are intended to achieve sufficient integrity against systematic errors of design by the manufacturer. A SIF designed with this product must not be used at a SIL level higher than stated without “prior use” justification by the end user or diverse technology redundancy in the design.

Random Integrity

The Fisher 685 series actuator is classified as a Type A device according to IEC 61508, having a hardware fault tolerance of 0. The complete final element subsystem, with a 685 series actuator and sliding stem valve as the final control element, will need to be evaluated to determine the Safe Failure Fraction of the subsystem. If the SFF for the entire final element subsystem is between 60% and 90%, a design can meet SIL 2 @ HFT=0.

Safety Parameters

For detailed failure rate information refer to the SIL certificate for the Fisher 685 Series actuator.

Connection of the Fisher 685 Series Actuator to the SIS Logic-solver

The final element subsystem (consisting of a positioner, 685 series actuator, and a sliding-stem valve) is connected to the safety rated logic solver which is actively performing the Safety Function as well as any automatic diagnostics designed to diagnose potentially dangerous failures within the 685 series actuator, valve and any other final element components (i.e. Partial Valve Stroke Test).

General Requirements

The system's response time shall be less than process safety time. The final control element subsystem needs to be sized properly to assure that the response time is less than the required process safety time. The 685 series actuator will move the valve to its safe state in less than the required SIF's safety time under the specified conditions.

All SIS components including the 685 series actuator must be operational before process start-up.

The user shall verify that the 685 series actuator is suitable for use in safety applications.

Personnel performing maintenance and testing on the 685 series actuator and valve shall be competent to do so.

Results from the proof tests shall be recorded and reviewed periodically.

The useful life of the 685 series actuator is discussed in the SIL certificate for the 685 series actuator.

Installation and Commissioning

Installation

WARNING

To ensure safe and proper functioning of equipment, users of this document must carefully read all instructions, warnings, and cautions in each applicable instruction manual.

The Fisher 685 series actuator must be installed per standard practices outlined in the instruction manual.

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

The 685 series actuator must be accessible for physical inspection.

Physical Location and Placement

The 685 series actuator shall be accessible with sufficient room for the valve, actuator, pneumatic connections, and any other components of the final control element. Provisions shall be made to allow for manual proof testing.

Pneumatic piping to the actuator shall be kept as short and straight as possible to minimize the airflow restrictions and potential clogging. Long or kinked pneumatic tubes may also increase the valve closure time.

The 685 series actuator shall be mounted in a low vibration environment. If excessive vibration can be expected special precautions shall be taken to ensure the integrity of pneumatic connectors or the vibration should be reduced using appropriate damping mounts.

Pneumatic Connections

Recommended piping for the inlet and outlet pneumatic connections to the 685 series actuator is stainless steel tubing. The length of tubing between the 685 series actuator and the control device, such as a solenoid valve, shall be kept as short as possible and free of kinks.

The process air pressure shall meet the requirements set forth in the installation manual.

The process air capacity shall be sufficient to move the valve within the required time.

Operation and Maintenance

Suggested Proof Test

The objective of proof testing is to detect failures within a 685 series actuator 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 the proof test interval, is to be determined in reliability calculations for the Safety Instrumented Functions for which a 685 series actuator is applied. The proof tests must be performed more frequently than or as frequently as specified in the calculation in order to maintain the required Safety Integrity of the Safety Instrumented Function.

The proof test shown in table 1 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 Emerson. The suggested proof test consists of a full stroke of the 685 series actuator.

The person(s) performing the proof test of a 685 series actuator should be trained in SIS operations, including bypass procedures, valve maintenance and company Management of Change procedures. No special tools are required.

Table 1. Recommended 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 685 series 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 685 series actuator and confirm that the normal operating state was achieved.
4	Inspect the 685 series actuator and the other final control 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.

Repair and replacement

Repair and replacement procedures in the instruction manuals must be followed.

Manufacturer Notification

Any failures that are detected and that compromise functional safety should be reported to Emerson. Please contact your Emerson sales office or Local Business Partner.

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