Safety Manual for Fisher™ 657 and 667 Actuators

Purpose

This safety manual provides information necessary to design, install, verify and maintain a Safety Instrumented Function (SIF) utilizing the Fisher 657 and 667 spring and diaphragm sliding stem actuators.

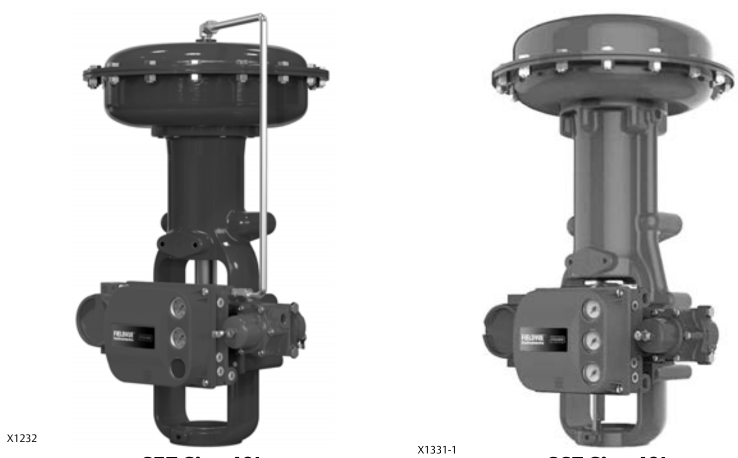
⚠ WARNING

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 657 Diaphragm Actuators, Size 30/30i through 70/70i and 87 Instruction Manual (D100306X012)
Fisher 657 Diaphragm Actuators Size 80 and 100 Instruction Manual (D100307X012)
Fisher 667 Diaphragm Actuators, Size 30/30i through 76/76i and 87 Instruction Manual (D100310X012)
Fisher 667 Diaphragm Actuators Size 80 and 100 Instruction Manual (D100311X012)
Failure to use this instruction manual supplement in conjunction with the above referenced manual 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 657 and 667 Actuators



657 Size 40I　　**667 Size 40I**

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 injury 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 and is detected by another diagnostic.

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.

λ: Failure rate. λDD: dangerous detected; λDU: dangerous undetected; λSD: safe detected; λSU: safe undetected.

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:

Fisher 657 and 667 Size 30i through 76i Diaphragm Actuators Bulletin: D104018X012
Fisher 657 and 667 Diaphragm Actuators Bulletin: D100087X012

Instruction Manual:

Fisher 657 Diaphragm Actuators, Size 30/30i through 70/70i and 87 Instruction Manual: D100306X012
Fisher 657 Diaphragm Actuators Size 80 and 100 Instruction Manual: D100307X012
Fisher 667 Diaphragm Actuators, Size 30/30i through 76/76i and 87 Instruction Manual: D100310X012
Fisher 667 Diaphragm Actuators Size 80 and 100 Instruction Manual: D100311X012

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

The Fisher 657 and 667 are pneumatic spring and diaphragm sliding-stem actuators.

These are spring-opposed diaphragm actuators that position the valve plug in the valve, with response to varying controller or valve positioner pneumatic output signals, applied to the actuator diaphragm.

The 657 and 667 actuators can be installed on sliding-stem valve bodies for throttling or on-off applications. Zero setting of the actuator is determined by the compression of the actuator spring, and span is set by the actuator spring rate. The 657 actuator is direct-acting; the 667 is reverse-acting. These actuators are designed to provide dependable on-off or throttling operation of control valves.

The 657 and 667 actuators are used with sliding-stem valves to control process fluids that can be used in a wide variety of applications. They are typically used with other interface components (valve positioner or solenoid valve) to provide a final element subsystem for a SIF.

Designing a SIF Using a Fisher 657 and 667 Actuator

Safety Function

When the 657 and 667 actuators are de-energized, the actuator and valve shall move to its fail-safe position. Depending on which configuration is specified fail-closed or fail-open, the actuator will move the valve control element to close off the flow path through the valve body or open the flow path through the valve body.

The 657 and 667 actuators are 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 an SIF must check that the product is rated for use within the expected environmental limits. Refer to the appropriate Fisher 657 and 667 Diaphragm Actuator Bulletin (D100087X012) for size 30 through size 100 actuators or (D104018X012) for size 30i through 76i actuators for environmental limits.

Application limits

The 657 and 667 actuator materials of construction are specified in the product bulletin. A range of materials are available for various applications. The serial card will indicate what the materials of construction are for a specific actuator. It is especially important the designer check for material compatibility considering on-site chemical contaminants and air supply conditions. If the 657 or 667 actuator is used outside of the application limits or with incompatible materials, the reliability data provided becomes invalid.

Diagnostic Response Time

657 and 667 actuators do not perform any automatic diagnostic functions by themselves and therefore have no diagnostic response time of their 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

A detailed FMEDA report is available from Emerson Automation Solutions. This report details all failure rates and failure modes as well as the expected lifetime.

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 657 or 667 actuators in a redundant configuration, a common cause factor of at least 5% 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 the FMEDA report is only valid for the useful lifetime of a 657 or 667 actuator. The failure rates will increase after this time period. Reliability calculations based on the data listed in the FMEDA report 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

Figure 2. exida SIL 3 Capable

The product has met manufacturer design process requirements of SIL 3. 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 657 and 667 diaphragm sliding-stem actuators are classified as Type A devices according to IEC 61508, having a hardware fault tolerance of 0. The complete final element subsystem, with a 657 or 667 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 Failure Modes, Effects and Diagnostic Analysis Report for the Fisher 657 and 667 actuators.

Connection of the Fisher 657 and 667 Actuator to the SIS Logic-solver

The final element subsystem (consisting of a positioner, a 657 or 667 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 657 or 667 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 657 or 667 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 657 or 667 actuator must be operational before process start-up.

The user shall verify the 657 or 667 actuator is suitable for use in safety applications.

Personnel performing maintenance and testing on the 657 or 667 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 657 or 667 actuator is discussed in the Failure Modes, Effects and Diagnostic Analysis Report for the 657 and 667 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 657 or 667 diaphragm sliding-stem 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 657 or 667 actuator must be accessible for physical inspection.

Physical Location and Placement

The 657 or 667 actuator shall be accessible with sufficient room for the valve, actuator, pneumatic connections, 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 657 or 667 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 657 or 667 actuator is stainless steel tubing or other tubing material appropriate for the environmental and application conditions. The length of tubing between the 657 or 667 actuator and the control device, such as a solenoid valve, shall be kept as short as possible and free of kinks. For the 667 sizes 30i through 76i, a cast internal air passageway is available to be used instead of tubing and fittings when mounting a DVC2000 or DVC6200.

Only dry instrument air filtered to 50 micron level or better shall be used.

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 657 or 667 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 657 or 667 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 657 or 667 actuator.

The person(s) performing the proof test of a 657 or 667 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 657 or 667 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 657 or 667 actuator and confirm that the normal operating state was achieved.
4	Inspect the 657 or 667 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 procedures in the appropriate 657 or 667 actuator instruction manual 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.

Appendix A

Sample Startup Checklist

This appendix provides a sample Start-up Checklist for a 657 or 667 actuator. A Start-up Checklist will provide guidance during the final control elements employment.

Start-Up Checklist

The following checklist may be used as a guide to employ the 657 or 667 actuator in a safety critical SIF compliant to IEC61508.

#	Activity	Result	Verified	
			By	Date
	Design			
	Target Safety Integrity Level and PFD_{AVG} determined			
	Correct valve mode chosen (Fail-closed, Fail-open)			
	Design decision documented			
	Pneumatic compatibility and suitability verified			
	SIS logic solver requirements for valve tests defined and documented			
	Routing of pneumatic connections determined			
	SIS logic solver requirements for partial stroke tests defined and documented			
	Design formally reviewed and suitability formally assessed			
	Implementation			
	Physical location appropriate			
	Pneumatic connections appropriate and according to applicable codes			
	SIS logic solver valve actuation test implemented			
	Maintenance instructions for proof test released			
	Verification and test plan released			
	Implementation formally reviewed and suitability formally assessed			
	Verification and Testing			
	Electrical connections verified and tested			
	Pneumatic connection verified and tested			
	SIS logic solver valve actuation test verified			
	Safety loop function verified			
	Safety loop timing measured			
	Bypass function tested			
	Verification and test results formally reviewed and suitability formally assessed			
	Maintenance			
	Tubing blockage / partial blockage tested			
	Safety loop function tested			

Emerson Automation Solutions
Marshalltown, Iowa 50158 USA
Sorocaba, 18087 Brazil
Cernay, 68700 France
Dubai, United Arab Emirates
Singapore 128461 Singapore

www.Fisher.com