Safety manual for Fisher™ ED, ES, ET, EW, EZ, or HP Valves with 657/667 Actuator

Purpose

This safety manual provides information necessary to design, install, verify and maintain a Safety Instrumented Function (SIF) utilizing the Fisher ED, ES, ET, EW, EZ, or HP valve with 657/667 actuator.

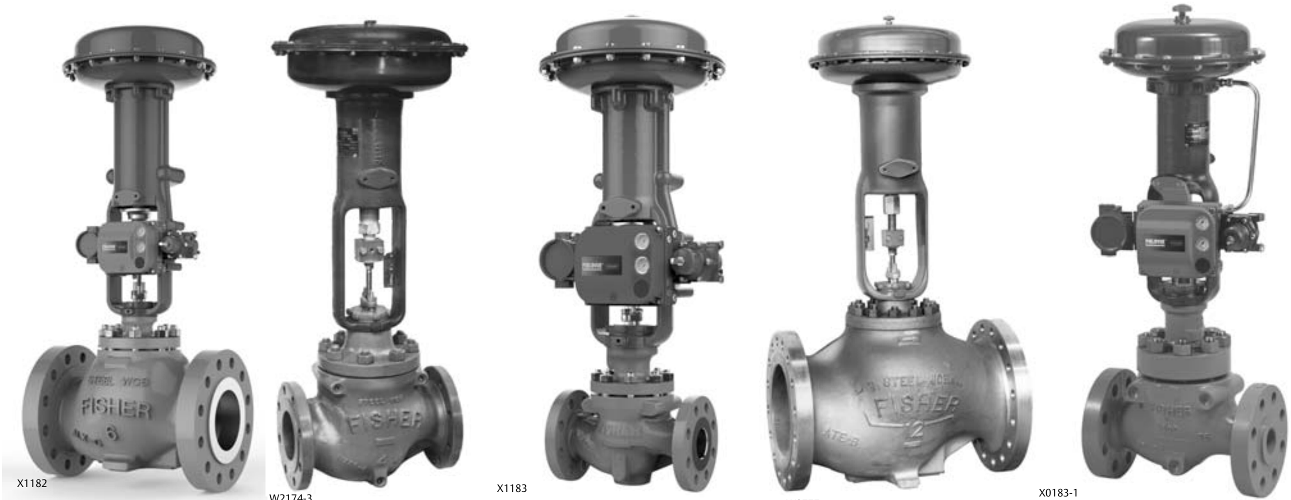
⚠ WARNING

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 ED and EAD easy-e™ Valves CL125 through CL600 Instruction Manual (D100390X012)
Fisher ES and EAS easy-e Valves CL125 through CL600 Instruction Manual (D100397X012)
Fisher ET and EAT easy-e Valves CL125 through CL600 Instruction Manual (D100398X012)
Fisher EZ easy-e Control Valve Instruction Manual (D100401X012)
Fisher EZ-C, ET-C, and EWT-C Cryogenic Control Valves Instruction Manual (D102175X012)
Fisher EWD, EWS, and EWT Valves through NPS 12x8 Instruction Manual (D100399X012)
Fisher Large ET/EWT and ED/EWD Valves NPS 12 through 30 Instruction Manual (D103553X012)
Fisher HP and HPA Control Valves Instruction Manual (D101634X012)
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 Process Management sales office.

Introduction

This manual provides information that is necessary for meeting the IEC 61508 or IEC 61511 functional safety standards.

Figure 1. Fisher Valve with 667 Actuator



ED or ET Valve | **ES Valve** | **EZ Valve with FIELDVUE™ DVC6200 Digital Valve Controller** | **EW Valve** | **HP Valve with FIELDVUE DVC6200 Digital Valve Controller**

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 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 proof test frequency is greater than twice the frequency of demand for operation made on the safety-related system.

β: Beta factor for common cause effects of failure.

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:

51.1:ED, Fisher ED, EAD, and EDR Sliding-Stem Control Valves Bulletin: D100017X012

Fisher ED and EAD easy-e Valves CL125 through CL600 Instruction Manual: D100390X012

51.1:ES, Fisher ES and EAS Sliding-Stem Control Valves Bulletin: D100021X012

Fisher ES and EAS easy-e Valves CL125 through CL600 Instruction Manual: D100397X012

51.1:ET, Fisher ET, EAT, and ETR Sliding-Stem Control Valves Bulletin: D100022X012

Fisher ET and EAT easy-e Valves CL125 through CL600 Instruction Manual: D100398X012

51.1:EZ, Fisher EZ Sliding-Stem Control Valve Bulletin: D100025X012

Fisher EZ easy-e Control Valve Instruction Manual: D100401X012

51.1:easy-e Cryogenic Fisher easy-e Cryogenic Sliding Stem Control Valves Bulletin: D102189X012

Fisher EZ-C, ET-C, and EWT-C Cryogenic Sliding-Stem Control Valves Instruction Manual: D102175X012

51.1:EW, Fisher EW Series (EWD/EWS/EWT) Sliding Stem Control Valves through NPS 12x8 Bulletin: D100023X012

Fisher EWD, EWS, and EWT Valves through NPS 12x8 Instruction Manual: D100399X012

51.1:ET/ED (Large): Fisher ED/EWD and ET/EWT Valves NPS 12 through 30 Bulletin: D103554X012

Fisher Large ET/EWT and ED/EWD Valves through NPS 12 through 30 Instruction Manual: D103553X012

51.2:HP, Fisher HP Series Control Valves Bulletin: D101635X012

Fisher HP and HPA Control Valves Instruction Manual: D101634X012

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 ED single-port control valves have balanced plugs and cage guided trim for all general applications with process temperatures up to 593°C (1100°F). They are available in sizes ranging from NPS 1 to 30 and pressure ratings up to CL600 in several different body configurations including ED and EAD:

- ED--Globe body sliding-stem valve with Push-Down-To-Close action
- EAD--Angle body sliding-stem valve with Push-Down-To-Close action.

In small to medium sizes these valves utilize a clamped trim design, meaning that the cage and seat ring are clamped into the body using compression from the valve bonnet. In large sizes the trim is hung in the valve body and the seat ring bolted into the valve body. These valves provide up to Class IV shutoff utilizing graphite piston rings, which seal between the plug and cage. For tighter shutoff applications, shutoff can be improved to Class V with the use of the optional C-seal or Bore seal.

Fisher ES single-port control valves have unbalanced plugs and cage guided trim for all general applications with process temperatures up to 566°C (1050°F). They are available in sizes ranging from NPS ½ to 8 and pressure ratings up to CL600 in several different body configurations including ES and EAS:

- ES--Globe body sliding-stem valve with Push-Down-To-Close action
- EAS--Angle body sliding-stem valve with Push-Down-To-Close action

These valves utilize a clamped trim design, meaning that the cage and seat ring are clamped into the body using compression from the valve bonnet. These valves provide up to Class V shutoff, for tighter shutoff applications, shutoff can be improved to Class VI.

Fisher ET single-port control valves have balanced plugs and cage guided trim for all general applications with process temperatures up to 316°C (600°F). They are available in sizes ranging from NPS 1 to 30 and pressure ratings up to CL600 in several different body configurations including ET and EAT:

- ET--Globe body sliding-stem valve with Push-Down-To-Close action
- EAT--Angle body sliding-stem valve with Push-Down-To-Close action

In small to medium sizes these valves utilize a clamped trim design, meaning that the cage and seat ring are clamped into the body using compression from the valve bonnet. In large sizes the trim is hung in the valve body and the seat ring screwed into the cage. These valves provide up to Class V shutoff utilizing a spring loaded PTFE seal ring, which seals between the plug and cage. For tighter shutoff applications, shutoff can be improved to Class VI in small to medium sizes.

Fisher Cryogenic single-port control valves have either balanced or unbalanced valve plugs and feature stainless steel materials, specialized seals and extension bonnets for cryogenic service applications with temperatures down to -193°C (-325°F). They are available in sizes ranging from NPS 1 to 30 and pressure ratings up to CL600 in several different globe body, sliding-stem configurations including ET-C, EWT-C, and EZ-C:

- ET-C--Balanced, cage guided, push-down-to-close valve
- EWT-C--Balanced, cage guided, push-down-to-close valve with expanded end connections
- EZ-C--Unbalanced, post guided, push-down-to-close valve

In small to medium sizes these valves utilize a clamped trim design, meaning that the cage (or seat ring retainer) and seat ring are clamped into the body using compression from the valve bonnet. In large sizes the trim is hung in the valve body and the seat ring bolted into the valve body. These valves tolerate the temperatures extremes of cryogenic applications by utilizing stainless steel materials, specialized seals, and extension bonnets that locate the sensitive packing parts away from the sub-zero temperatures. These valves provide up to Class V shutoff, however for tighter shutoff applications, shutoff can be improved to Class VI in small to medium sizes.

Fisher EZ single-port control valves have unbalanced valve plugs and post guided trim for viscous or other hard-to-handle applications with process temperatures up to 593°C (1100°F). They are available in sizes ranging from NPS ½ to 4 and pressure ratings up to CL600.

These valves utilize a clamped trim design, meaning that the seat ring and seat ring retainer are clamped into the body using compression from the valve bonnet. These valves provide up to Class V shutoff, for tighter shutoff applications, shutoff can be improved to Class VI.

Fisher EW single-port control valves have either balanced or unbalanced plugs, cage guided trim and feature large internal cavities with expanded end connections for all general applications with process temperatures up to 593°C (1100°F). The expanded end connections allow for installation into oversized piping without the need for piping reducers. They are available in sizes ranging from NPS 4x2 to 24x20, where size designations are “End Connection Size” x “Nominal Trim Size”. All sizes are available in pressure ratings up to CL600, with the NPS 8x6 and 12x8 sizes also available in CL900 ratings. Several different globe body, sliding-stem configurations are available including EWD and EWT:

- EWD--Balanced Push-Down-To-Close valve for applications with process temperatures up to 593°C (1100°F)
- EWT--Balanced Push-Down-To-Close valve for applications with process temperatures up to 316°C (600°F)

In small to medium sizes these valves utilize a clamped trim design, meaning that the cage and seat ring are clamped into the body using compression from the valve bonnet. In large sizes the trim is hung in the valve body and the seat ring bolted into the valve body (EWD constructions) or screwed into the cage (EWT constructions). EWD constructions provide up to Class IV shutoff, however for tighter shutoff applications, shutoff can be improved to Class V with the use of the optional C-seal or Bore seal. EWT constructions provide up to Class V shutoff, however for even tighter shutoff applications, shutoff can be improved to Class VI in small to medium sizes.

Fisher HP single-port control valves have either balanced or unbalanced plugs, cage guided trim, and Push-Down-To-Close action for all high pressure applications with process temperatures up to 566°C (1050°F). They are available in sizes ranging from NPS 1 to 8 and pressure ratings up to CL2500 in several different body configurations including HPD, HPAD, HPS, HPAS, HPT, and HPAT:

- HPD--Balanced, globe body sliding-stem valve for applications with process temperatures up to 566°C (1050°F)
- HPAD--Balanced, angle body sliding-stem valve for applications with process temperatures up to 566°C (1050°F)
- HPS--Unbalanced, globe body sliding-stem valve for applications with process temperatures up to 566°C (1050°F)
- HPAS--Unbalanced, angle body sliding-stem valve for applications with process temperatures up to 566°C (1050°F)
- HPT--Balanced, globe body sliding-stem valve for applications with process temperatures up to 316°C (600°F)
- HPAT--Balanced, angle body sliding-stem valve for applications with process temperatures up to 316°C (600°F)

These valves utilize a clamped trim design, meaning that the seat ring and cage are clamped into the body using compression from the valve bonnet. Up to Class V shutoff is available with these valves.

Designing a SIF Using Fisher ED, ES, ET, EW, EZ, or HP Valve

Safety Function

When the valve's actuator is 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 plug to close off the flow path through the valve body or open the flow path through the valve body.

The ED, ES, ET, EW, EZ, or HP valve 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.

Pressure and Temperature limits

The designer of a SIF must check that the product is rated for use within the expected pressure and temperature limits. Refer to the ED, ES, ET, EW, EZ, or HP valve product bulletin for pressure and temperature limits.

Application limits

The materials of construction of ED, ES, ET, EW, EZ, or HP valves are specified in the product bulletins. A range of materials are available for various applications. The serial card will indicate what the materials of construction are for a given valve. It is especially important that the designer check for material compatibility considering on-site chemical contaminants and environmental conditions. If the ED, ES, ET, EW, EZ, or HP valve is used outside of the application limits or with incompatible materials, the reliability data provided becomes invalid.

Diagnostic Response Time

The ED, ES, ET, EW, EZ, or HP valve 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 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 Process Management. 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 an ED, ES, ET, EW, EZ, or HP valve in a redundant configuration, a common cause factor of at least 5% should be included in the Safety Integrity calculations.

The failure rate data listed in the FMEDA report is only valid for the useful lifetime of an ED, ES, ET, EW, EZ, or HP valve. 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

Fisher ED, ES, ET, EW, EZ, or HP valves have met manufacturer design process requirements of IEC 61508 Safety Integrity Level 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 ED, ES, ET, EW, EZ, or HP valves are classified as Type A devices according to IEC 61508, having a hardware fault tolerance of 0. The complete final element subsystem, with a Fisher 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 ED, ES, ET, EW, EZ, or HP valve.

Connection of the Fisher ED, ES, ET, EW, EZ, HP Valve to the SIS Logic-solver

The final element subsystem (consisting of a positioner, actuator, and ED, ES, ET, EW, EZ, or HP 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 ED, ES, ET, EW, EZ, or HP valve, actuator 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 ED, ES, ET, EW, EZ, or HP valve will move to its safe state in less than the required SIF's safety time under the specified conditions.

All SIS components including the ED, ES, ET, EW, EZ, or HP valve must be operational before process start-up.

The user shall verify that the ED, ES, ET, EW, EZ, or HP valve is suitable for use in safety applications.

Personnel performing maintenance and testing on the ED, ES, ET, EW, EZ, or HP valve shall be competent to do so.

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

The useful life of the ED, ES, ET, EW, EZ, or HP valve is discussed in the Failure Modes, Effects and Diagnostic Analysis Report for the Fisher ED, ES, ET, EW, EZ, or HP valve.

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 ED, ES, ET, EW, EZ, or HP valve must be installed per standard practices outlined in the appropriate instruction manual.

The environment must be checked to verify that pressure and temperature conditions do not exceed the ratings.

The ED, ES, ET, EW, EZ, or HP valve must be accessible for physical inspection.

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 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 the ED, ES, ET, EW, EZ, or HP valve 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.

Physical Location and Placement

The Fisher ED, ES, ET, EW, EZ, or HP valve shall be accessible with sufficient room for the 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 ED, ES, ET, EW, EZ, or HP valve 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.

Operation and Maintenance

Suggested Proof Test

The objective of proof testing is to detect failures within an ED, ES, ET, EW, EZ, or HP valve 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 an ED, ES, ET, EW, EZ, or HP valve 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 Process Management. The suggested proof test consists of a full stroke of the ED, ES, ET, EW, EZ, or HP valve.

The person(s) performing the proof test of an ED, ES, ET, EW, EZ, or HP valve should be trained in SIS operations, including bypass procedures, valve maintenance and company Management of Change procedures. No special tools are required.

Repair and replacement

Repair procedures in the appropriate valve instruction manual must be followed.

Manufacturer Notification

Any failures that are detected and that compromise functional safety should be reported to Emerson Process Management. Please contact Emerson Process Management customer service or your local Emerson Process Management service representative.

Appendix A

Sample Startup Checklist

This appendix provides a Sample Start-up Checklist for a Fisher ED, ES, ET, EW, EZ, or HP valve. A start-up checklist will provide guidance during the final control element's employment.

Start-Up Checklist

The following checklist may be used as a guide to employ the ED, ES, ET, EW, EZ, or HP valve 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			

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