Operating Manual
V_9629 Rev. JH
October 2025

ASCO™ Solenoid Valves used in Safety Instrumented Systems

Operating Manual in accordance with IEC 61508

SIL
evaluated
IEC 61508



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Section 1: Introduction

This Operating Manual provides the necessary information to design, install, verify and maintain a Safety Instrumented Function (SIF) utilizing an ASCO Solenoid Valve. This manual provides necessary requirements for meeting the IEC 61508 or IEC 61511 functional safety standards.

1.1 Terms and Abbreviations

- **Process Valve** - Any valve that is used to control the flow of media being used in a process.

  For the purpose of this document, this is usually a 2-way valve whose movement is being controlled by an actuator and pilot valve.
- **Pilot Valve** - A 3-way or 4-way valve that is used to send or remove pressurized media to and from an actuator for the opening and closing of a process valve.
- **Direct Acting** - Refers to a solenoid valves main orifice that is opened and closed as a direct result of the solenoid valves electromagnetic movement when the coil is energized and de-energized.
- **Indirect Acting** - Refers to a solenoid valve's main orifice that is opened and closed as a result of fluid flow being directed from the electromagnetic 3-way solenoid pilot.
- **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 evidence-of the safety achieved by safety-related systems.
- **Fail-Safe State** - The state where the solenoid is de-energized and its return spring holds the pilot in the closed position.
- **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** - (DU) Failure that is dangerous and that is not being diagnosed by automatic stroke testing.
- **Fail Dangerous Detected** - (DD) Failure that is dangerous but is detected by automatic stroke testing.
- **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** - Way in which a safety function operates, 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 not greater than one per year.

1.2 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).

Section 2: Designing a Safety Instrumented Function (SIF) using an ASCO Solenoid Valve

2.1 Safety Function

When de-energized, the ASCO Solenoid Pilot Valve moves to its fail-safe position. Depending on the solenoid specified Normally Closed (NC) or Normally Open (NO), the valve will supply the fluid media or vent the fluid media depending on the piping of the installation. Please note that the solenoid pilot valve must be piped to the actuator in accordance with the manufacturer's recommendations and allowable desired function.

The 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.

2.2 Environmental limits

The environmental limits of each solenoid are specified in the products respective catalog and Installation & Maintenance Instructions. The designer of a SIF must check that the product is rated for use within the expected environmental limits.

2.3 Application limits

The application limits of an ASCO Solenoid are specified in the products respective catalog and Installation & Maintenance Instructions. It is especially important that the designer check for material compatibility considering on-site chemical contaminants and air supply conditions. If the solenoid valve is used outside of the application limits or with incompatible materials, the reliability data provided becomes invalid.

2.4 Design Verification

- A detailed Failure Mode, Effects, and Diagnostics Analysis (FMEDA) report is available from ASCO. This report details all failure rates and failure modes as well as the expected lifetime.
- 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 considering redundant architectures, 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 hardware fault tolerance (HFT) requirements. The Exida exSILentia tool is recommended for this work.
- When using an ASCO Solenoid in a redundant configuration, a common cause factor of 10% as defined by the end-user should be included in safety integrity calculations.

- The failure rate data listed the FMEDA report is only valid for the useful life time of an ASCO Solenoid.
  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 calculated Safety Integrity Level will not be achieved.

2.5 SIL Capability

2.5.1 Systematic Capability

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 end user or diverse technology redundancy in the design.

2.5.2 Random Integrity

The solenoid valve is a Type A Device. Therefore, when used the only component in a final element subassembly, a design can meet SIL 3 @ HFT=1 and SIL 2 @ HFT=0.

When the final element assembly consists of many components (solenoid valve, quick exhaust valve, actuator, isolation valve, etc.), 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.

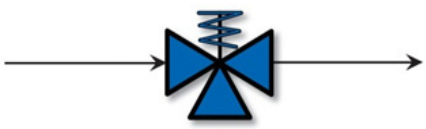
Section 3: Installation and Commissioning

3.1 Installation

- The ASCO Solenoid valve must be installed per standard installation practices outlined in the Installation Manual.
- The environment must be checked to verify that environmental conditions do not exceed the ratings.
- The ASCO Solenoid must be accessible for physical inspection.
- Instrument Air Filtration: These solenoids are intended for use on clean, dry air or inert gas filtered to 50 microns or better. To prevent freezing, the dew point of the media should be at least 18° F (10° C) below the minimum temperature to which any portion of the clean air or gas system could be exposed. Instrument air in compliance with ANSI/ ISA Standard S7.3-1975 (R1981) exceeds the above requirements and is, therefore, an acceptable medium for these valves.
- It is the operator's responsibility to only use design options such as latches, when it is safe to do so.
- Typical 3-way pilot valve piping configurations:

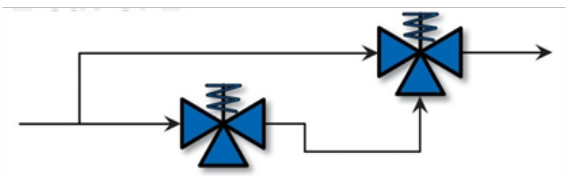
a. 1 out of 1 – This is the most common pilot valve configuration used.

Figure 3-1



b. 2 out of 2 – This is commonly used for high availability applications. In the case that one solenoid valve was to spuriously trip, the second solenoid still maintains the position of the actuator/process valve at its operating state. Both solenoids must close in order to shift the actuator/process valve to its non-operating state.

Figure 3-2



3.2 Response Time

The response time of a solenoid pilot valve will vary by design. The factors that affect response time are pilot valve orifice size, operating pressure, size of actuator, torque required to open and close process valve, and distance between pilot valve and actuator. It is the responsibility of the end user to use a pilot valve that delivers the correct opening and closing time of the process valve required for the application.

Section 4: Operation and Maintenance

4.1 Proof test without automatic testing

The objective of proof testing is to detect failures within an ASCO Solenoid 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 ASCO Solenoid 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 following proof test is recommended. Any failures that are detected and that compromise functional safety should be reported to ASCO.

Table 4-1

STEP	ACTION
1	Bypass the safety PLC or take other appropriate action to avoid a false trip, following company Management of Change (MOC) procedures
2	Inspect the external parts of the solenoid valve for dirty or clogged ports and other physical damage. Do not attempt disassembly of the valve.
3	De-energize the solenoid coil and observe that the actuator and valve move. Energize the solenoid after a small movement of the valve.
4	Inspect the solenoid for dirt, corrosion or excessive moisture. Clean if necessary and take corrective action to properly clean the air supply. This is done to avoid incipient failures due to dirty air.
5	Record any failures in your company's SIF inspection database. Restore the loop to full operation.
6	Remove the bypass from the safety PLC or otherwise restore normal operation

The percentage of possible DU failures detected in the solenoid (Proof Test Coverage) will vary by product line. See individual FMEDA reports for specific Proof Test Coverage.

The person(s) performing the proof test of an ASCO Solenoid should be trained in SIS operations, including bypass procedures, solenoid maintenance and company Management of Change procedures. No special tools are required.

4.2 Proof test with automatic partial valve stroke testing

4.2.1 Testing of the Product

An automatic partial valve stroke testing scheme that performs a full stroke of the solenoid valve and measures valve movement timing will detect most potentially dangerous failure modes.

4.2.2 Physical Inspection

It is recommended that a physical inspection (Step 2 from Table 4-1) be performed on a periodic basis. Maximum inspection interval may be up to five years depending on plant conditions, but an annual inspection is recommended.

4.3 Repair and replacement

According to section 7.4.7.4 of IEC 61508-2 a useful lifetime based on experience, should be assumed. General field knowledge suggests that most solenoid valves have a useful life of 3 to 10 years but may be longer depending on the valve series and other factors.

It is the responsibility of the end user to establish a preventative maintenance process to replace all solenoids before the end of the useful life.

4.4 ASCO Notification

Any failures that are detected and that compromise functional safety should be reported to ASCO Valve. Please contact ASCO customer service.

Section 5: ASCO Solenoid Pilot Valves Covered

Select ASCO valves from the following series have been evaluated per IEC 61508 parts 1 and 2 and covered under this document:

- 8314 Series - 3-Way Direct Acting Pilot Valves
- 8320 Series - 3-Way Direct Acting Pilot Valves
- 8316 Series - 3-Way Indirect Acting Pilot Valves
- 551, 552, 553 Series - 3 and 4-Way Indirect Acting Pilot Valves
- 8317, 8320, 8321 Series - 3-Way Harsh Environment Pilot Valves
- 327/8327 Series - 3-Way Direct Acting Pilot Valves.
- 126 Series - 3-Way Direct Acting Pilot Valves.
- 8317 Series – 3-Way Piloting Quick Exhaust valve
- 307 Series - 3-Way Direct Acting Pilot Valves
- 364 Series – 3-Way Spool Valves
- 362/562 Series – 3-Way and 4-Way Spool Valves
- 381 Series – 3-Way Poppet Valves
- 8800 Series – 3-Way High Flow Quick Exhaust Valves
- 8323 Series - 3-Way Redundant Coil Pilot Valve
- 330 Series - Volume Booster Valves
- 327C-STD - 3-Way Direct Acting Valves
- 327C-IS - 3-Way Direct Acting Valves, Intrinsically Safe
- X307573564 Series - 3-Way Direct Acting Pilot Valves

Section 6: Status of the document

6.1 Releases

Table 6-1

REVISION	ECN	DATE	CHANGE DESCRIPTION
JH	424385	10/2025	Section 4.1 - Updated contents below Table 4-1
JG	421115	06/2025	Added X307573564 Series to Section 5
JF	416650	12/2024	Added 327C-STD and 327C-IS to Section 5
JE	332609	04/2023	Added 330 Series to Section 5.
JD	328814	10/2022	Added Revision table in Section 6
JC	309245	12/2020	Section 2.4 - Common Cause Factor changed to 10% Section 4.2.2 - Text revised Section 5 - Added 8323 Series
JB	303145	04/2020	Specified "ASCO Valves" on page 1
JA	295072	06/2019	Format - Updated ASCO logo, footer, and Revision standard. Sections 1.1, 2.4, and 2.5.1 - Revised text
R9	288862	10/2018	Section 4.2 - Divided text into Section 4.2.1 and 4.2.2
R8	282229	03/2018	Section 5 - Added 8800 series
R7	267771	08/2016	Section 5 - Added 381 series
R6	264756	05/2016	Section 5 - Added 362/562 series.
R5	264139	04/2016	Page 7 - Added note
R4	256008	06/2015	Section 4.3 - Updated text
R3	251565	01/2015	Section 5- Added 307 series
R2	248275	09/2014	Section 5- Added 8317 series
R1	242234	01/2014	Section 5 - Added 126 series
R0	215464	02/2011	Initial Release