SAFETY MANUAL

V SERIES FLOW SWITCH

REVISION HISTORY			
REV	DESCRIPTION	AUTHOR	DATE
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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 V Series Flow Switch. The manual provides necessary requirements for meeting the IEC61508, IEC 61511, or ISO13849 functional safety standards.

1.1. 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 evidence – of the safety achieved by safety-related systems
Fail-Safe State	State where the switch is de-energized and spring is extended
Fail Safe	Failure that causes the switch 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 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 of 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

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
PFDavg	Average Probability of Failure on Demand
SFF	Safe Failure Faction, 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).

1.3. Product Support

Product support can be obtained from:

Precision Sensors Division, United Electric Controls, 340 Woodmont Road, Milford CT 06460

www.precisionsensors.com

(1)(203) 877-2795

1.4. Related Literature

Hardware documents

- V Series Flow Switch Installation and Maintenance Instructions

Guidelines/References

- Safety Integrity Level Selection – Systematic Method Including Layer of Protection Analysis, ISBN 1-55617-777-1, ISA
- Control System Safety Evaluation and Reliability, 2nd Edition, ISBN 1-55671-638-8, ISA
- Safety Instrumented Systems, Verification, Practical Probilistic Calculations, ISBN 1-55617-909-9, ISA

1.5. Reference Standards

Functional Safety

- IEC 61508: 2000 Functional safety of electrical/electronic/programmable electronic safety-related systems
- ANSI/ISA 84.00.01-2004 (IEC61511 Mod.) Functional Safety – Safety Instrumented Systems for the Process Industry Sector

2. DEVICE DESCRIPTION

The V Series Flow Switch is a flow through electromechanical flow switch designed to signal an electrical circuit based on media velocity through the device. The V series switches utilize a welded piston, or float, to interface with the sensed media and are installed via integral port fittings and are available in gaseous and liquid versions. Liquid flow settings are factory set and can be set from 0.01 gallons per minute to 15 gallons per minute (exact ranges are dependent upon fluid properties such as density and viscosity. Gaseous media settings start at 0.5 SLPM and extend up to approximately 100 SLPM (exact ranges are dependent upon media properties, temperature, and pressure).

Pressure connections are available in a variety of industry standard configurations. Electrical connections are available as standard free leads or factory installed crimp type connectors. Contact arrangements are available in NO (normally open), NC (normally closed), and SPDT (single pole double throw) arrangements. Electrical ratings up to 1.5 Amps are available.

Detailed information for each product is contained on a product envelope drawing that defines the relevant flow, pressure, media, physical and electrical interfaces, and applicable temperature and electrical ratings. Detailed installation instructions can be found in the V Series Installation Manual.

3. DESIGNING A SIF USING THE V SERIES SWITCH

3.1. Safety Function

Each V Series switch is configured for a specific operating flow and electrical arrangement as required to perform it's intended safety instrumented function. The configuration is listed on the applicable V Series product envelope drawing.

The V Series switch is intended to be part of a safety instrumented function and the achieved SIL level of the design 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 V Series product envelope drawing and V Series Brochure for environmental limits.

The V Series Flow switch contains a magnet and a reed switch. The unit should not be used in any locations where external magnetic fields are present.

3.3. Application Limits

The wetted materials for each V Series switch are listed on the applicable V Series product envelope drawing. It is especially important that the designer check for material compatibility considering on-site chemical contaminants and sensed media supply conditions. If the V Series Flow Switches are used outside of the application limits or with incompatible materials the reliability data becomes invalid.

The V series switches respond to fluid flow through the unit. As such, the fluid must be clean filtered fluid. A filtration level of 10 microns or better is preferable. Lack of filtering can lead to product failure.

3.4. Design Verification

A detailed Failure Mode, Effects, and Diagnostics Analysis (FMEDA) report is available from Precision Sensors. The 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 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 hardware fault tolerance (HFT) requirements. The exida exSILentia® tool is recommended for this purpose as it contain accurate models for the V Series Flow Switch and their failure rates.

When using the V Series Flow Switch in a redundant configuration, a common cause factor of at least 5% should be included in safety integrity calculations.

The failure rate data listed in the FMEDA report is only valid for the useful lifetime of a V Series Flow Switch. 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.

3.5. SIL Capability

3.5.1. Systematic Integrity

The product has met manufacturer design process requirements of a 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) design with this product must not be used at a SIL higher than the statement without “prior use” justification by end user or diverse technology redundancy in the design.

3.5.2. Random Integrity

According to IEC 61508 the architectural constraints of an element must be determined. This can be done by following the 1_H approach according to 7.4.4.2 of IEC 61508-2 or the 2_H approach according to 7.4.4.3 of IEC 61508-2 (see Section 5.2).

The 1_H approach involves calculating the Safe Failure Fraction for the entire element.

The 2_H approach involves assessment of the reliability data for the entire element according to 7.4.4.3.3 of IEC 61508-2.

The failure rate data used for this analysis meets the *exida* criteria for Route 2_H. Therefore, the V Series Flow Switch meets the hardware architectural constraints for up to SIL 2 at HFT=0 (or SIL 3 @ HFT=1) when the listed failure rates are used.

If Route 2_H is not applicable for all devices that constitute the entire element, the architectural constraints will need to be evaluated per Route 1_H.

The architectural constraint type for the V Series Flow Switch is A. The hardware fault tolerance of the device is 0. The SIS designer is responsible for meeting other requirements of applicable standards for any given SIL.

3.5.3. Safety Parameters

For detailed failure rate information refer to the Failure Modes, Effects and Diagnostic Analysis Report for the V Series Flow Switch.

3.6. Connection of the V Series Switch to the SIS Logic Solver

The V Series Flow Switch is connected to the safety rated logic solver which is actively performing the safety function as well as automatic diagnostics designed to diagnose potentially dangerous failures within the V Series Flow Switch, ie flow tests.

3.7. General Requirements

The system's response time shall be less than process safety time. The V Series Flow Switch will move to its safe state in less than three (3) seconds under specified conditions.

All SIS components including the V Series Flow Switch must be operational before process start-up.

User shall verify that the V Series Flow Switch is suitable for use in safety application by confirming the V Series Flow Switch nameplates are properly marked.

Personnel performing maintenance and testing on the SIS shall be competent to do so.

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

The useful life of the V Series Flow Switch is discussed in the Failure Modes, Effects and Diagnostic Analysis Report for the V Series Flow Switch.

4. INSTALLATION AND COMMISSIONING

4.1. Installation

The V Series Flow Switch must be installed per standard practices outlined in the V Series installation manual.

The environment must be checked to verify that environmental conditions do not exceed the parameters listed on the V Series product envelope drawing.

The V Series Flow Switch must be accessible for physical inspection.

4.2. Physical Location and Placement

The V Series Flow Switch shall be accessible with sufficient room for media and electrical connections and shall allow manual proof testing.

Media connections to the switch shall be kept as straight as possible to minimize restrictions and potential clogging. Obstructed or otherwise compromised connections may reduce switch sensitivity.

The V Series Flow Switch shall be mounted in a low vibration environment. If excessive vibration can be expected special precautions shall be taken to ensure the integrity of media and electrical connections or vibration should be reduced using appropriate damping mounts.

The V Series Flow switch contains a magnet and a reed switch. The unit should not be used in any locations where external magnetic fields are present.

4.3. Process Connections

The SIF designer shall ensure that the process connections used when installing the switch are rated for the operating temperatures and pressures of the system, do not restrict sensed flow to the V Series switch and are compatible with the operating media.

5. OPERATIONS AND MAINTENANCE

5.1. Proof test without Automatic Testing

The object of proof testing is to detect failures within a switch 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 switch 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. The results of the proof test should be recorded and any failures that are detected and that compromise functional safety should be reported to Precision Sensors.

TABLE 1: Recommended Proof Test

Step	Action
1	Bypass the safety function or take other appropriate action to avoid a false trip.
2	Connect a fluid supply line to the inlet port and a fluid return line to the outlet port.
3	Perform a calibration cycle to confirm that the V Series Flow Switch switches at the specified flow.
4	Inspect the V Series Flow Switch for any visible damage, contamination, or other damage.
5	Record any failures in your company's SIF inspection database.
6	Remove the bypass and otherwise restore normal operation.

The proof test will detect >92% of possible DU failures in the V Series switch for low trip safety functions and >97% of possible DU failures in the V Series switch for high trip safety functions.

The person(s) performing the proof test of a V Series Flow Switch should be trained in SIS operations, including bypass procedures, system maintenance, and company Management of Change procedures.

5.2. Repair and Replacement

The V Series Flow Switch is factory set and is not repairable. If a failure has occurred the switch must be replaced. The person(s) replacing a V Series Flow Switch should be trained in SIS operations, including bypass procedures, system maintenance, and company Management of Change procedures.

5.3. Useful Life

The useful life for a V Series flow switch is 10 years.

5.4. Manufacturer Notification

Any failures that are detected and that compromise functional safety should be reported to Precision Sensors Division of United Electric Controls. Contact technical support at (1)(203)877-2795 or via www.precisionsensors.com

6. STARTUP CHECKLIST

The following checklist may be used as a guide the employ the V Series Flow Switch in a safety critical SIF compliant to IEC61508.

#	Activity	Result	Verified	
			By	Date
	Design			
	Target Safety Integrity Level and PFD_{avg} determined.			
	Correct Switch Function (Normally Open, Normally Closed, SPDT)			
	Correct Flow Setting and Direction Chosen (value on rising or falling flow)			
	Design Decision Documented			
	Media Compatibility and Suitability Verified			
	SIS logic solver requirements for switch tests defined and documented			
	Routing of process and electrical connections determined			
	Design formally reviewed and suitability formally assessed.			
	Implementation			
	Physical location and environment appropriate			
	Process connections appropriate and according to applicable codes.			
	Electrical connections appropriate and according to applicable codes.			
	SIS logic solver automatic switch tests implemented.			
	Maintenance instructions for proof test released			
	Verification and test plan released			
	Implementation formally reviewed and suitability formally assessed.			
	Verification and Testing			
	Process Connections Verified and Tested			
	Electrical Connections Verified and Tested			
	SIS logic solved automatic test verified			
	Safety loop function verified			
	Safety loop timing measured			
	Bypass function tested			
	Verification and test results formally reviewed and suitability formally assessed.			
	Maintenance			
	Process connection or tubing blockage / partial blockage tested			
	Safety loop function tested			