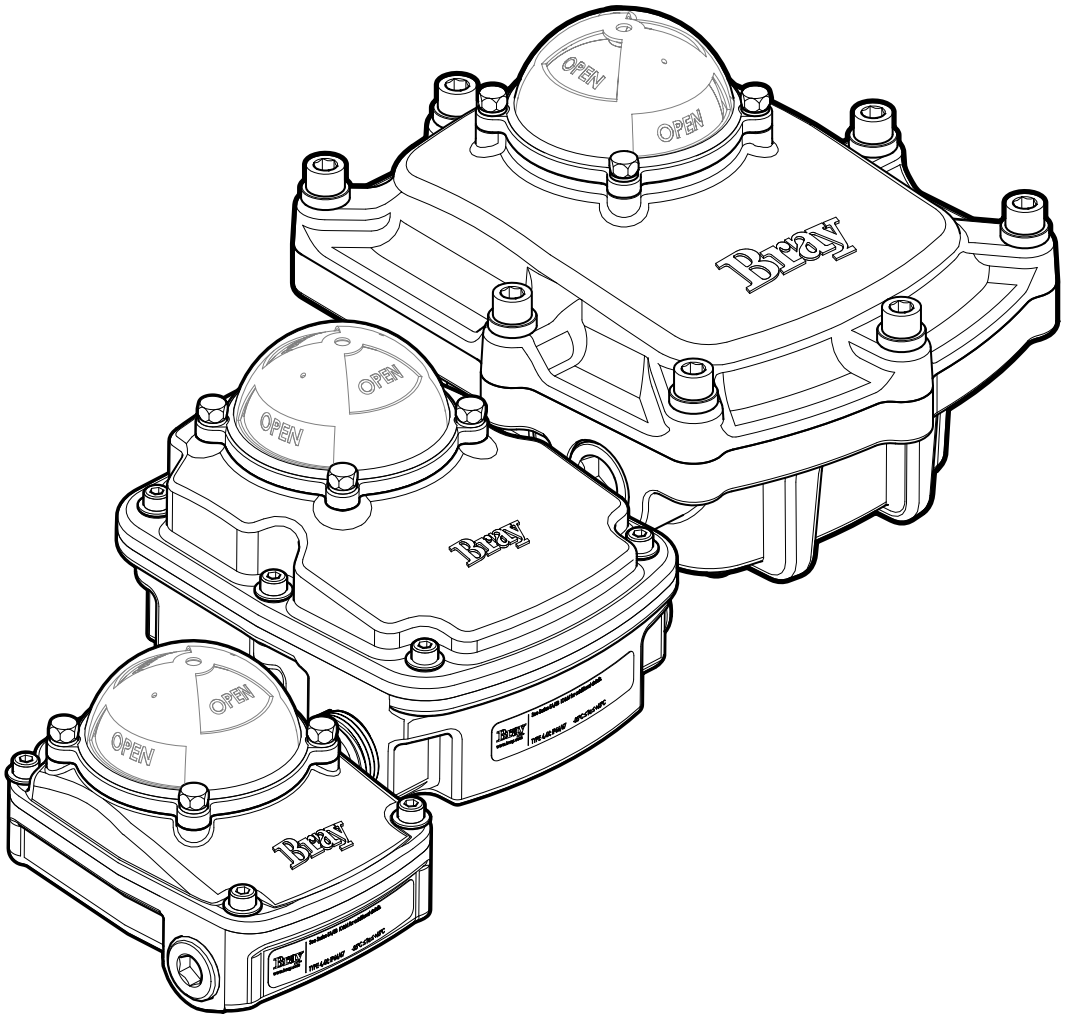
Series 5A, 5B, AND 5C

VALVE STATUS MONITORS

SIL SAFETY MANUAL



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READ AND FOLLOW THESE INSTRUCTIONS CAREFULLY. SAVE THIS MANUAL FOR FUTURE USE.

1.0 Definition of Terms

1.1 All information within this manual is relevant to the safe operation and proper care of your Bray product. Please understand the following examples of information used throughout this manual.

1.2 Notes are indicated by the following symbols in these instructions. Failure to follow these procedures and observe these notes, cautions and warnings could lead to hazards and/or affect product warranty.

DANGER
Indicates a potentially hazardous situation which, if not avoided, will result in death or serious injury.

WARNING
Indicates a potentially hazardous situation which, if not avoided, could result in death or serious injury.

CAUTION
Indicates a potentially hazardous situation which, if not avoided, could result in minor or moderate injury.

NOTICE
Used without the safety alert symbol, indicates a potential situation which, if not avoided, may result in an undesirable result or state, including property damage.

2.0 INTRODUCTION

This Safety Manual provides information necessary to design, install, verify and maintain a Safety Instrumented Function (SIF) utilizing the Bray Series 5A, 5B, and 5C Valve Status Monitors (VSM). This manual provides necessary requirements for meeting the IEC 61508 or IEC 61511 functional safety standards.

2.1 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 solenoid valves de-energize and springs are 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 - Where the frequency of demands for operation made on a safety-related system is no greater than twice the proof test frequency.

2.2 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 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. An SIS is composed of any combination of sensor(s), logic solver(s), and final element(s).

2.3 Product Support

Product support can be obtained from:

Bray Controls Inc.
13333 Westland Blvd. East Houston, TX, 77041, USA.
Phone: 281 894 5454
www.braycontrols.com

2.4 Related Literature

Hardware Documents:

- Switchbox Series 5A, 5B, and 5C Product Brochure
- Series 5A and Series 5B Switch Boxes Installation, Operation and Maintenance Manual
- Switchbox Series 5C Technical Manual
- Series 5C Explosion-Proof Switch Box Installation, Operation and Maintenance Manual

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

2.5 Reference Standards

Functional Safety:

- IEC 61508: 2000 Functional safety of electrical/electronic/programmable electronic safety-related systems
- ANSI/ISA 84.00.01-2004 (IEC 61511 Mod.) Functional Safety Instrumented Systems for the Process Industry Sector

3.0 DEVICE DESCRIPTION

The Bray Series 5A, 5B, and 5C Valve Status Monitors (VSM), available in resin and aluminum body types, provide reliable visual and electrical position indication on any VDI/VDE 3845-compliant quarter-turn device. Series 5A offers lightweight, compact housing to fit the tightest spots. Series 5B features a larger body to accommodate up to 20 terminal points and six switches for increased customization. Our explosion-proof Series 5C provides unparalleled protection and reliability during service in the harshest environments. Our solutions enable end users to better monitor their process, no matter the conditions.

Bray Series 5A and 5B VSMs are comprised of a NEMA Type 4/4X housing with external position indicator and two conduit entries, cam shaft with self-locking cams, elevated terminal block, internal grounding screw, and mounting bracket. The VSM is coupled to the quarter turn device via the indicator shaft. Rotation of the indicator shaft, in turn, drives the cams and activates the switch. The angular position in which the switches activate can be adjusted through the self-locking cams. Mechanical or proximity activation of switches provides electrical feedback of achieved position through field wiring to a control network.

Bray Series 5C VSMs are comprised of a hazardous location housing with NEMA Type 4, 4x and IP 66/67/68 (1 meter for 1 hour) ratings, external position indicator, three conduit entries, cam shaft with self-locking cams, elevated terminal block(s), internal grounding screw, ATEX/IECEx required external grounding screw, and mounting bracket.

4.0 DESIGNING A SIF USING A MANUFACTURED PRODUCT

4.1 Safety Function

When used with a de-energized to trip final element subsystem, the Series 5A, 5B, and 5C VSMs will not interfere with the ability of the logic solver to bring the final element to its safe state.

The Series 5A, 5B, and 5C VSMs are intended to be part of a final element subsystem as defined per IEC 61508 and the achieved SIL level of the designed function must be verified by the designer.

4.2 Environmental Limits

The designer of a SIF must check that the product is rated for use within the expected environmental limits. Refer to the Bray Series 5A, 5B, and 5C VSM product brochures for environmental limits.

4.3 Application Limits

The materials of construction of the Series 5A, 5B, and 5C VSMs are specified in the Bray Series 5A, 5B, and 5C VSM product brochures. It is important that the designer check for material suitability considering on-site conditions. If the Series 5A, 5B, and 5C VSM is used outside of the application limits or with incompatible materials, the reliability data provided becomes invalid.

4.4 Design Verification

A detailed Failure Mode, Effects, and Diagnostics Analysis (FMEDA) report is available from Bray Controls. 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 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 failure rate data listed the FMEDA report is only valid for the useful life time of the Series 5A, 5B, and 5C VSMs. 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.

4.5 SIL Capability

Systematic Integrity - 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.

Random Integrity - The Series 5A, 5B, and 5C VSM is one of many components that can be used in a final element assembly. The final element assembly consists of many components, i.e. S92/93 Pneumatic Actuator, solenoid, quick exhaust valve, etc.) and 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

For detailed failure rate information refer to the Failure Modes, Effects and Diagnostic Analysis Report for the Series 5A, 5B, and 5C VSMs.

4.6 Connection of the S92/93 Pneumatic Actuator to the SIS Logic-solver

The Series 5A, 5B, and 5C VSMs are 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 Series 5A, 5B, and 5C VSMs, (i.e. partial stroke test).

4.7 General Requirements

The systems response time shall be less than process safety time. The Series 5A, 5B, and 5C VSM are only one part of the final element of a SIS. All elements of the SIF must be chosen to meet the safety response time.

All SIS components, including the Series 5A, 5B, and 5C VSM must be operational before process start-up.

User shall verify that the Series 5A, 5B, and 5C VSM is suitable for use in safety applications by confirming the Series 5A, 5B, and 5C VSM's nameplate is properly marked.

Personnel performing maintenance and testing on the Series 5A, 5B, and 5C VSM shall be competent to do so.

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

The useful life of the Series 5A, 5B, and 5C VSM is discussed in the Failure Modes, Effects and Diagnostic Analysis Report for the Series 5A, 5B, and 5C VSMs.

5.0 INSTALLATION AND COMMISSIONING

5.1 Installation

The Series 5A, 5B, and 5C VSM must be installed per standard practices outlined in the Installation Manual.

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

The Series 5A, 5B, and 5C VSM must be accessible for physical inspection.

5.2 Physical Locatation and Placement

The Series 5A, 5B, and 5C VSM shall be accessible with sufficient room for connections and shall allow manual proof testing.

Pneumatic piping to the valve 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 Series 5A, 5B, and 5C VSM 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.

5.3 Proof Test Without Automatic Testing

The objective of proof testing is to detect failures within the Series 5A, 5B, and 5C VSM that are not detected by 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 proof test interval, is to be determined in reliability calculations for the safety instrumented functions for which Bray Series 5A, 5B, and 5C VSM is applied. The proof tests must be performed at least as frequently as specified in the calculation in order to maintain the required safety integrity of the safety instrumented function.

6.0 OPERATING AND MAINTENANCE

6.1 Proof test without automatic testing

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 Bray Controls.

TABLE 1: RECOMMENDED PROOF TEST

STEP	ACTION
1	Bypass the safety function and take appropriate action to avoid a false trip.
2	Send a signal to the final element configuration to perform a full stroke and verify that this is achieved.
3	Inspect the Series 5A, 5B, and 5C VSM for any visible damage or contamination.
4	Record any failures in your company's SIF inspection database.
5	Restore normal operation.

The proof test coverage for Series 5A, 5B, and 5C VSM are listed in the FMEDA report which is available from Bray Controls.

The person(s) performing the proof test of Series 5A, 5B, and 5C VSM should be trained in SIS operations, including bypass procedures, valve maintenance and company Management of Change procedures.

6.2 Proof test with automatic partial operational stroke testing

An automatic partial valve stroke testing scheme that also performs a periodic full stroke of the Series 5A, 5B, and 5C VSM and measures valve movement timing will detect most potentially dangerous failure modes. It is recommended that a physical inspection (Step 2 from Table 1) be performed on a periodic basis with the time interval determined by plant conditions. A maximum inspection interval of five years is recommended.

6.3 Repair and Replacement

Repair procedures in the Series 5A, 5B, and 5C VSM Installation, Operation and Maintenance Manual must be followed.

6.4 Useful Life

The useful life of the Series 5A, 5B, and 5C VSM is 10 years.

6.5 Manufacturer Notification

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

6.6 Product Registration

If the product is being used in a safety application and there is a desire to receive notices regarding the product, register the product with Bray Controls customer service.

7.0 FAILURE RATES

Using reliability data extracted from the *exida* Electrical and Mechanical Component Reliability Handbook the following failure rates resulted from the Series 5A, 5B, and 5C VSM FMEDA.

Table 3 and Table 4 list the failure rates for the Series 5A, 5B, and 5C VSM with a Site Safety Index (SSI) of 2 (good site maintenance practices). These failure rates may be used for either Normally Open or Normally Closed switch configurations for the Safe State.

7.1 Table 3 Failure rates for Static Applications[3] with Good Maintenance Assumptions in FIT @ SSI=2

Application/Device/Configuration	λ_{SD}	λ_{SU}[4]	λ_{DD}	λ_{DU}	#
Series 5A, 5B, and 5C with: A*, B*, K*, or S* Switch Types with external Current Limiting / Protection or H Inductive Sensor	0	16	0	103	48

7.2 Table 4 Failure rates for Dynamic Applications[5] with Good Maintenance Assumptions in FIT @ SSI=2

Application/Device/Configuration	λ_{SD}	λ_{SU}[6]	λ_{DD}	λ_{DU}	#
Series 5A, 5B, and 5C with: A*, B*, K*, or S* Switch Types with external Current Limiting / Protection or H Inductive Sensor	0	16	0	83	32

[3]Static Application failure rates are applicable if the device is static for a period of more than 200 hours.

[4]It is important to realize that the No Effect failures are no longer included in the Safe Undetected failure category according to IEC 61508, ed2, 2010.

[5]Dynamic Application failure rates may be used if the device moves at least once every 200 hours.

[6]It is important to realize that the No Effect failures are no longer included in the Safe Undetected failure category according to IEC 61508, ed2, 2010

8.0 START-UP CHECKLIST

The following checklist may be used as a guide to employ the Series 5A, 5B, and 5C VSM in a safety critical SIF compliant to IEC 61508

Activity	Result	Verified	
		By	Date
Design			
Target Safety Integrity Level and PFDavg determined			
Correct operating mode chosen (Fail-closed, Fail-open)			
Design decision documented			
Pneumatic compatibility and suitability verified			
SIS logic solver requirements for Series 5A, 5B, and 5C VSM 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 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 actuation test verified			
Safety loop function verified			
Safety loop timing measured			
Bypass function tested (manual override)			
Verification and test results formally reviewed and suitability formally assessed			
Maintenance			
Tubing blockage / partial blockage tested			
Safety loop function tested			

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