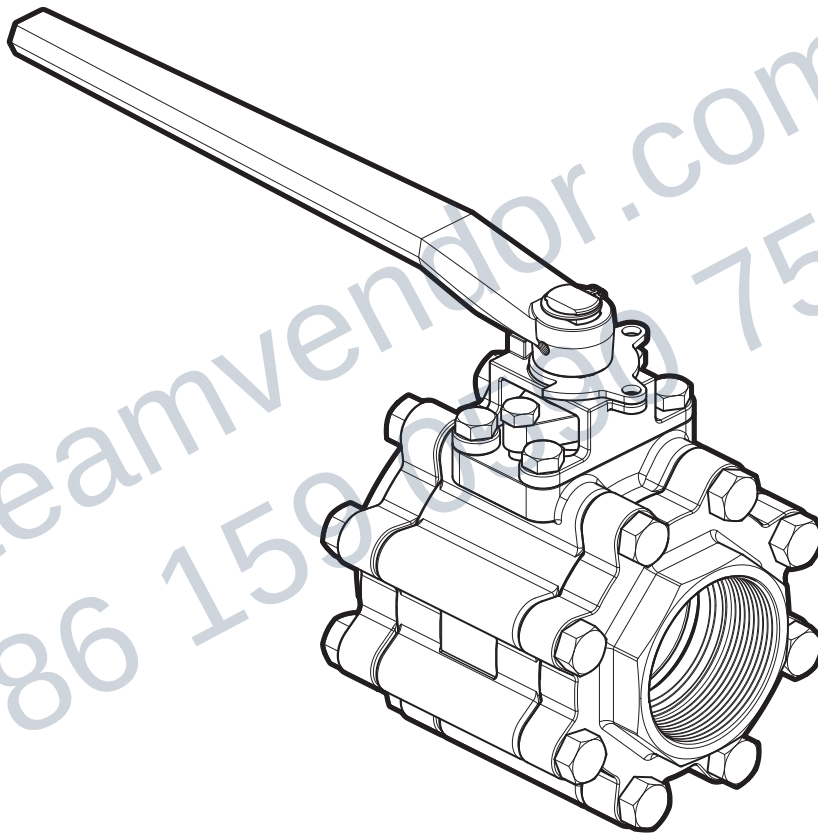


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**TRIAD SERIES**  
**QUARTER TURN FLANGED FLOATING BALL VALVES**  
**FUNCTIONAL SAFETY MANUAL**

Per IEC 61508 and IEC 61511 Standards



### CONTENTS

|     |                                                                    |   |
|-----|--------------------------------------------------------------------|---|
| 1.0 | INTRODUCTION . . . . .                                             | 3 |
| 1.1 | TERMS AND ABBREVIATIONS. . . . .                                   | 3 |
| 1.2 | ACRONYMS . . . . .                                                 | 3 |
| 1.3 | PRODUCT SUPPORT . . . . .                                          | 4 |
| 1.4 | RELATED LITERATURE . . . . .                                       | 4 |
| 1.5 | REFERENCE STANDARDS . . . . .                                      | 4 |
| 2.0 | DEVICE DESCRIPTION . . . . .                                       | 4 |
| 3.0 | DESIGNING A SIF USING A MANUFACTURER PRODUCT. . . . .              | 4 |
| 3.1 | SAFETY FUNCTION . . . . .                                          | 4 |
| 3.2 | ENVIRONMENTAL LIMITS . . . . .                                     | 4 |
| 3.3 | APPLICATION LIMITS . . . . .                                       | 5 |
| 3.4 | DESIGN VERIFICATION. . . . .                                       | 5 |
| 3.5 | SIL CAPABILITY . . . . .                                           | 5 |
| 3.6 | CONNECTION OF THE BRAY BALL VALVE TO THE SIS LOGIC-SOLVER. . . . . | 5 |
| 3.7 | GENERAL REQUIREMENTS . . . . .                                     | 5 |
| 4.0 | INSTALLATION AND COMMISSIONING . . . . .                           | 6 |
| 4.1 | INSTALLATION. . . . .                                              | 6 |
| 4.2 | PHYSICAL LOCATION AND PLACEMENT. . . . .                           | 6 |
| 4.3 | PNEUMATIC CONNECTIONS. . . . .                                     | 6 |
| 5.0 | OPERATION AND MAINTENANCE. . . . .                                 | 6 |
| 5.1 | PROOF TEST WITHOUT AUTOMATIC TESTING . . . . .                     | 6 |
| 5.2 | PROOF TEST WITH AUTOMATIC PARTIAL VALVE STROKE TESTING . . . . .   | 7 |
| 5.3 | REPAIR AND REPLACEMENT . . . . .                                   | 7 |
| 5.4 | USEFUL LIFE. . . . .                                               | 7 |
| 5.5 | MANUFACTURER NOTIFICATION . . . . .                                | 7 |
| 5.6 | PRODUCT REGISTRATION . . . . .                                     | 7 |
| 6.0 | START-UP CHECKLIST . . . . .                                       | 8 |

### 1.0 INTRODUCTION

This Safety Manual provides information necessary to design, install, verify and maintain a Safety Instrumented Function (SIF) utilizing Bray floating ball valves Triad Series. This manual provides necessary requirements for meeting the IEC 61508 or IEC 61511 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 solenoid valve 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 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 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.

**PFD<sub>AVG</sub>** - 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 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:

**Bray Controls Inc.**

13333 Westland East Blvd.

Houston, TX 77041 - USA.

Phone: 281-894-5454

bray.com

### 1.4 RELATED LITERATURE

**Hardware Documents:**

Triad Series Installation, Operation and Maintenance Manual

**Guidelines/References:**

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

### 1.5 REFERENCE STANDARDS

**Functional Safety**

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

### 2.0 DEVICE DESCRIPTION

The floating ball valves Triad Series are a  $\frac{1}{4}$  turn ball valve used to control process fluids. The TRIAD valves are available in sizes from  $\frac{1}{4}$ " to 2" in full port design and  $\frac{3}{4}$ " to 2 $\frac{1}{2}$ ". They are available in following end connection configurations:

1. threaded end
2. socket weld end
3. butt weld end
4. flanged end class 600 extended socket weld end
5. extended butt weld end

All valves Triad Series are provided with 3 piece body design and locking device. All above products are designed to meet international standards for pressure and temperature ratings, shell thickness, and bore diameters. All of them are provided with ISO 5211 mounting pad for standardized and simple actuator mounting. Valves Triad Series are made in both stainless steel and carbon steel materials (with special alloys available upon request) and include multiple stem seals.

### 3.0 DESIGNING A SIF USING A MANUFACTURER PRODUCT

#### 3.1 SAFETY FUNCTION

When de-energized, the Bray ball valves Triad Series move to its fail-safe position. Depending on the version specified Fail – Closed or Fail – Open, these valves will rotate the valve closing element-ball to close off the flow path through the valve body or open the flow path through the valve body.

The Triad ball 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.

#### 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 Bray Control Valve Brochure for environmental limits.

### 3.3 APPLICATION LIMITS

The materials of construction of Triad Series ball valves are specified in the Bray 3 Piece Ball Valves Triad Series Brochure. It is especially important that the designer check for material compatibility considering on-site chemical contaminants and air supply conditions. If Bray Triad Series valves are used outside of the application limits or with incompatible materials, the reliability data provided becomes invalid.

### 3.4 DESIGN VERIFICATION

The achieved Safety Integrity Level (SIL) of an entire Safety Instrumented Function (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 hardware fault tolerance (HFT) requirements. The Exida exSILentia® tool is recommended for this purpose as it contains accurate models for the Bray Triad Series valves and its failure rates.

When using a TRIAD valves in a redundant configuration, a common cause factor of at least 5% should be included in safety integrity calculations.

The failure rate data listed the FMEDA report is only valid for the useful life time of a Bray Triad Series valve. 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.

The FMEDA report is available from Bray product support group.

### 3.5 SIL Capability

#### 3.5.1 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.

#### 3.5.2 Random Integrity

The Bray floating ball valve Triad Series is a Type A Device.

When the final element assembly consists of many components (Bray Triad Series, actuator, solenoid, quick exhaust 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.

#### 3.5.3 Safety Parameters

For detailed failure rate information refer to the Failure Modes, Effects and Diagnostic Analysis Report for the Bray floating ball valve.

### 3.6 CONNECTION OF THE BRAY BALL VALVE TO THE SIS LOGIC-SOLVER

The Triad Series valve 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 Bray floating ball valve Triad Series group, (i.e. partial valve stroke test).

### 3.7 GENERAL REQUIREMENTS

1. The system's response time shall be less than process safety time. The Triad valve will move to its safe state in less than 3 S under specified conditions.
2. All SIS components including the Bray Triad valves must be operational before process start-up.
3. User shall verify that the Bray floating ball valves Triad Series are suitable for use in safety applications by confirming the valves nameplate is properly marked.
4. Personnel performing maintenance and test on the Bray ball valves shall be competent to do so.
5. Results from the proof tests shall be recorded and reviewed periodically.
6. The useful life of the Triad Series ball valves is discussed in the Failure Modes, Effects and Diagnostic Analysis Report for the Bray floating ball valves.

## 4.0 INSTALLATION AND COMMISSIONING

### 4.1 INSTALLATION

The Bray ball valves must be installed per standard practices outlined in the Installation, Operation and Maintenance Manual.

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

All Bray ball valves must be accessible for physical inspection.

### 4.2 PHYSICAL LOCATION AND PLACEMENT

The Bray floating ball valves shall be accessible with sufficient room for pneumatic 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 valves 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.

### 4.3 PNEUMATIC CONNECTIONS

Recommended piping for the inlet and outlet pneumatic connections to the automated ball valve is ½" stainless steel or PVC tubing. The length of tubing between the valve and the control device, such as a solenoid valve, shall be kept as short as possible and free of kinks.

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.

## 5.0 OPERATION AND MAINTENANCE

### 5.1 PROOF TEST WITHOUT AUTOMATIC TESTING

The objective of proof testing is to detect failures 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 solenoid is applied. The proof tests must be performed more 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. The suggested proof test consists of a full stroke of the ball valve.

**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 valve for any visible damage or contamination.                                                  |
| 4    | Record any failures in your company's SIF inspection database.                                              |
| 5    | Remove the bypass and otherwise restore normal operation.                                                   |

This test will detect >54% of possible DU failures in the valve for the full stroke options. (For the tight shutoff and open to trip options the proof test coverage is >19%, and >77% respectively).

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

## **5.2 PROOF TEST WITH AUTOMATIC PARTIAL VALVE STROKE TESTING**

An automatic partial valve stroke testing scheme that performs a full stroke of the isolation valves 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.

## **5.3 REPAIR AND REPLACEMENT**

Repair procedures in the Bray Installation, Operation and Maintenance Manual must be followed.

## **5.4 USEFUL LIFE**

The useful life of the valve is 10 to 15 years, or 10,000 cycles.

## **5.5 MANUFACTURER NOTIFICATION**

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

## **5.6 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 Customer Service.

### 6.0 START-UP CHECKLIST

The following checklist may be used as a guide to employ the Bray Triad Series ball valves in a safety critical SIF compliant to IEC 61508.

| 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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