FLOWSERVE

SIL SAFETY MANUAL

NAF Trunnball DL Ball Valves

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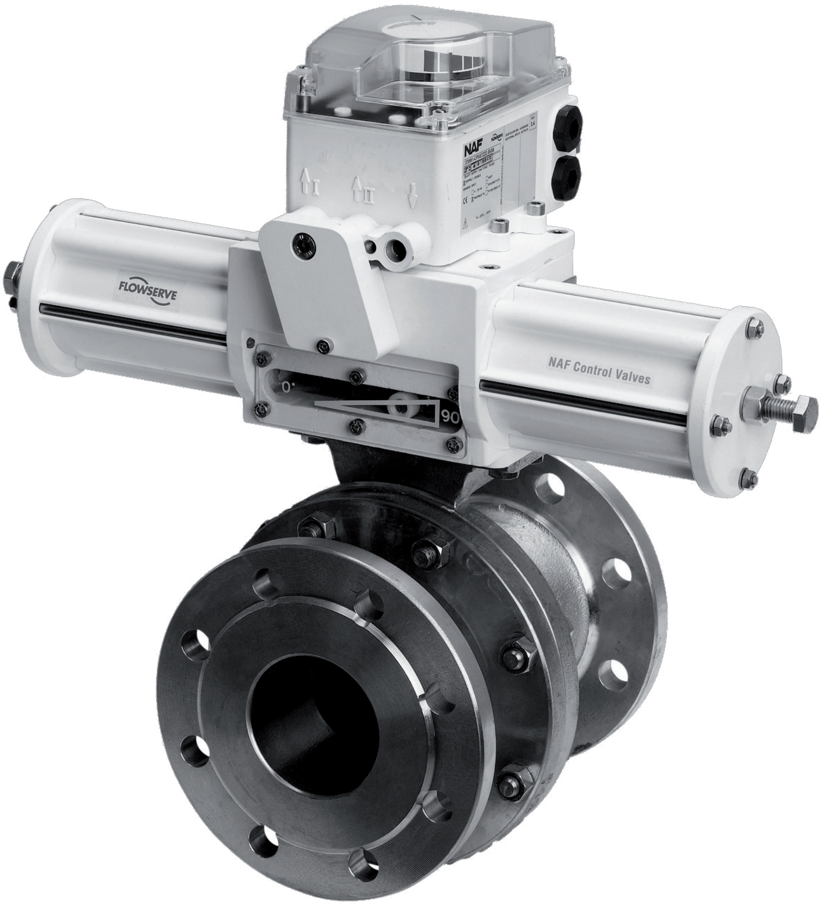

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Contents

1 Introduction

1.1 Scope and purpose of the Safety Manual

This safety manual provides the information necessary to design, install, verify and maintain a Safety Instrumented Function (SIF) utilizing the Trunnball DL Ball Valve. This manual provides necessary requirements to enable the integration of the Trunnball DL Ball Valve when showing compliance with the IEC 61508 or IEC 61511 functional safety standards.
This Safety Manual indicates all assumptions that have been made on the usage of the Trunnball DL Ball Valve. If these assumptions cannot be met by the application, the SIL capability of the Trunnball DL Ball Valve may be adversely affected.

1.2 Skill level required

System design, installation and commissioning, and repair and maintenance shall be carried out by suitably qualified personnel.

1.3 Terms, abbreviations and acronyms

Basic Safety	Freedom from unacceptable risk of harm.
BPCS	Basic Process Control System - a system which responds to input signals from the process, its associated equipment, other programmable systems and/or an operator and generates output signals causing the process and its associated equipment to operate in the desired manner but which does not perform any safety instrumented functions with a claimed SIL ≥ 1.
Fail-safe State	State where solenoid valve is de-energized and spring is extended.
Fail Annunciation Detected	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 Undetected	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 Dangerous	Failure that does not respond to a demand from the process (i.e. being unable to go to the fail-safe state).
Fail Dangerous Detected	Failure that is dangerous but is detected as part of partial valve stroke testing.
Fail Dangerous Undetected	Failure that is dangerous and that is not detected as part of partial valve 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.
Fail Safe	Failure that causes the valve to go to the defined fail-safe state without a demand from the process.
FMEDA	Failure Modes, Effects and Diagnostics Analysis.
Functional safety	Part of the overall safety relating to the process and the BPCS which depends on the correct functioning of the SIS and other protection layers.
HFT	Hardware Fault Tolerance.
Low demand	Mode of operation, where the frequency of demands for operation made on a safety-related system is no greater than twice the proof test frequency.
MOC	Management Of Change - specific procedures often done when performing any work activities in compliance with government regulatory authorities.
PFDAVG	Average Probability of Failure on Demand.

PVST	Partial Valve Stroke Test.
SFF	Safe Failure Fraction - fraction of the overall random failure rate of a device that results in either a safe failure or a detected dangerous failure.
SIF	Safety Instrumented Function - safety function with a specified SIL which is necessary to achieve functional safety. Typically a set of equipment intended to reduce the risk due to a specified hazard (a safety loop).
SIL	Safety Integrity Level - discrete level (one out of four) for specifying the safety integrity requirements of the safety instrumented functions to be allocated to the safety instrumented systems. SIL 4 has the highest level of safety integrity; SIL 1 has the lowest.
SIS	Safety Instrumented System - instrumented system used to implement on or more safety instrumented functions. An SIS is composed of any combination of sensor(s), logic solver(s), and final element(s).

1.4 Product Support & Service

Please refer to the contact information on the back cover of this document.

1.5 Related Documents

Hardware documents:
FCD NFENTB4168, Trunnball DL Ball Valve Datasheet
NFENIM4168, Trunnball DL Maintenance and installation instructions

Guidelines/References:

FMEDA report - NAF 10/06-013 R001

16 Reference standards

IEC 61508-2: 2010, Functional Safety of Electrical/Electronic/Programmable Electronic Safety-Related Systems
IEC 60654-1:1993-02, second edition, Industrial-process measurement and control equipment – Operating conditions – Part 1: Climatic condition.

2 Trunnball DL Ball Valve Description

The NAF Trunnball DL is a full-bore trunnion-mounted ball valve, developed using NAF's more than 80 years of experience manufacturing ball valves. The ball is supported by two large, low friction trunnion bearings for consistent low torque even at high differential pressures. Due to its bidirectional tightness, low friction and high controllability, it is an excellent choice for isolation, on/off and modulating control applications.
NAF Trunnball DL is supplied as standard in stainless steel or carbon steel but is also available in other materials e.g. Duplex, titanium, etc.

The valve has:

- A spring loaded stem seal packing that provides long, maintenance-free and safe operation in automated on/off and control service.
- Direct actuator mounting capabilities of the NAF Turnex actuator which provides a high performance, vibration resistant, compact valve package.
- A sturdy, blowout-proof stem providing high torque transmission with a minimum mechanical backlash for optimum controllability.
- A trunnion-mounted ball providing bidirectional tightness.
- Low friction bearings for low torque and smooth operation.
- The unique Z-trim option that minimizes cavitation and noise and has an excellent control characteristic.
- An extensive size range, DN 150–800, size 6" to 32".

- An easy-to-service arrangement, due to the off-center joint face of the valve body, which allows for easy replacement of the ball and seals without the need for removing the stem and actuator.
- Metal seats with a rigid welded overlay of Alloy 6 or alternatively, metal supported, reinforced PTFE seats.

3 Designing a SIF Using the Trunnball DL Ball Valve

3.1 Safety Function

The safety function for the valve and the additional components in the subsystem is to move the valve to the safe position (which can be either open or closed as required by the application) within the specified safety time when the system is tripped.

3.2 Environmental limits

The designer of the SIF must check that the product is rated for use within the expected environmental limits, maximum working pressure and temperature. Refer to the Trunnball DL Ball Valve datasheet for this information.

3.3 Application limits

The materials of construction of a Trunnball DL Ball Valve are specified in the Trunnball DL Ball Valve datasheet. It is especially important that the designer of the SIF checks for material compatibility considering on-site chemical contaminants and air/hydraulic (as appropriate) supply conditions. If the Trunnball DL Ball Valve is used outside the application limits or with incompatible materials, the reliability data and predicted SIL capability becomes invalid.

3.4 Design Verification

A detailed Failure Modes, Effects and Diagnostics Analysis (FMEDA) report is available from NAF AB for this product. This report details all failure rates and failure modes as well as expected lifetime of the product.
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 the architecture, proof test interval, proof test effectiveness, any automatic diagnostics, average repair time and the specific failures rates of all equipment 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 Trunnball DL Ball Valve and its failure rates.
When using the Trunnball DL Ball 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 the Trunnball DL Ball Valve. The failure rates will increase after this useful lifetime period has expired. 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 SIL will not be achieved.

3.5 SIL Capability

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3.5.1 Systematic Integrity

The Trunnball DL Ball Valve 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 higher than the statement without “prior use” justification by the end user, or verification of diverse technology 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 1H approach according to 7.4.4.2 of IEC 61508 or the 2H approach according to 7.4.4.3 of IEC 61508.
The 1H approach involves calculating the SFF for the entire element.

The 2H approach involves assessment of the reliability data for the entire element according to 7.4.4.3.3 of IEC 61508.
The Trunnball DL Valve is classified as a device that is part of a Type A element according to IEC 61508, having a hardware fault tolerance of 0.
The Trunnball DL Valve can be classified as a 2H device when the failure rates listed in the FMEDA report are used for the Design Verification calculations. When 2H data is used for all of the devices in an element, then the element meets the hardware architectural constraints up to SIL 2 at HFT=0 (or SIL 3 @ HFT=1) per Route 2H. If Route 2H is not applicable for the entire final element, the architectural constraints will need to be evaluated per Route 1H.

When the final element assembly consists of several components additional to Trunnball DL Ball Valve, the SIL must be verified for the entire assembly using the failure rates of all components. This analysis must account for architectural constraints by comparing both SFF and HFT with IEC61508-2, Table 2 if following Route 1H

3.5.3 **Safety Parameters**
For detailed failure rate information refer to the FMEDA report for the Trunnball DL Ball Valve.

3.6 Connection of the Trunnball DL Ball Valve to the SIS Logic Solver

The Trunnball DL Valve should be assembled with an actuator and logic solver where all components are safety rated.
The safety rated logic solver shall actively perform the safety function as well as automatic diagnostics (if any) designed to diagnose potentially dangerous failures within the Trunnball DL Ball Valve, (i.e. partial valve stroke test).

3.7 General Requirements

The system and function response time shall be less than the process safety time. The Trunnball DL Ball Valve will move to its defined safe state in less than this time with relation to the specific hazard scenario.
All SIS components including the Trunnball DL Ball Valve must be operational before process start-up.
The User shall verify that the Trunnball DL Ball Valve is suitable for use in safety applications by confirming the Trunnball DL Ball Valve nameplate and model number is properly marked.
Personnel performing maintenance and testing on the Trunnball DL Ball Valve shall first be assessed as being competent to do so.
Results from periodic proof tests and partial valve stroke tests (if any) shall be recorded and periodically reviewed.
The Trunnball DL Ball Valve shall not be operated beyond the useful lifetime as listed in paragraph 5.3 without undergoing overhaul or replacement.

4 Installation & Commissioning

4.1 Installation

The Trunnball DL Ball Valve must be installed per the standard practices outlined in the Maintenance and Installation Instructions.
The environment must be checked to verify that environmental conditions do not exceed the ratings.
The Trunnball DL Ball Valve must be accessible for physical inspection.

4.2 Physical location and placement

The Trunnball DL Ball Valve shall be accessible with sufficient room for pneumatic connections to the actuator and shall allow for manual proof testing to take place.
The Trunnball DL Ball Valve shall be mounted in a low vibration environment. If excessive vibration can be expected then 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

Pneumatic piping to the valve actuator shall be kept as short and straight as possible to minimize airflow restrictions and potential clogging. Long or kinked pneumatic tubes may also increase valve closure time.
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 actuator installation manual.
The process air capacity shall be sufficient to move the valve within the required time.

5 Operation & Maintenance

5.1 Proof Test requirement

During operation, a low demand mode SIF must be proof tested. The objective of proof testing is to detect failures within the equipment in the SIF that are not detected by any automatic diagnostics of the system. Of main concern are undetected failures that prevent the SIF from performing its function.
Periodic proof tests shall take place at the frequency (or interval) defined by a SIL verification calculation. The proof tests must be performed more frequently than (or as frequently as) specified in the SIL verification calculation in order to maintain the required safety integrity of the overall SIF. Results from periodic proof tests and partial valve stroke tests (if any) shall be recorded and periodically reviewed.
For detailed Proof Test information refer to the FMEDA report for the Trunnball DL Ball Valve.

5.2 Repair and replacement

Repair procedures outlined in the Maintenance and Installation Instructions must be followed.

5.3 Useful life

Based on general field failure data and a low demand mode of operation, a useful life period of approximately 10 to 15 years is expected for the Trunnball DL Ball Valve.
For high demand mode applications, the useful lifetime of the mechanical parts is limited by the number of cycles. The useful lifetime of the mechanical parts is > 10,000 full scale cycles or 8 to 10 years, whichever results in the shortest lifetime.

5.4 Notification of failures

In case of malfunction of the system or SIF, the Trunnball DL Ball Valve shall be put out of operation and the process shall be kept in a safe state by other measures.

NAF AB must be informed when the Trunnball DL Ball Valve is required to be replaced due to failure. The occurred failure shall be documented and reported to Flowserve NAF representative or directly to NAF AB using the contact details on the back cover of this safety manual.

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