Flanged Jamesbury™ ball valves Series 5000, 6000, 7000, 9000 Soft seated trunnion and seat supported

Rev. 3.0

Safety manual

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1. Introduction

This safety manual provides the functional safety related information required to integrate and use Jamesbury Series 5000, 6000, 7000, 9000 flanged ball valves in safety systems in compliance with the IEC 61508 standard. This safety manual shall be used together with the Installation, Maintenance, and Operation manual for Series 5000, 6000, 7000, 9000 flanged ball valves.

The Series 5000, 6000, 7000, 9000 flanged ball valve is a quarter turn valve, which is used in automated on/off and control process applications. In on/off service, the valve is either fully closed or fully open. The Series 5000, 6000, 7000, 9000 flanged ball valves is commonly part of an automated on/off (block) valve assembly, which consists of a valve, actuator, accessories, and linkage parts. Only the valve component of the automated on/off valve assembly is considered in this document. The actuator part of the assembly can be one of several quarter turn pneumatic types such as a rack and pinion, piston, etc. Actuators may also be electrically or hydraulically powered. Accessory parts of the automated on/off valve assembly may include a partial stroke test device, such as a Neles ValvGuard or solenoid valves. Instruments such as quick exhaust valves, boosters and/or limit switches may be present.

In safety applications, the automated on/off valve assembly is part of safety instrumented function (SIF), The SIF purpose is to protect plant, environment and personnel against a hazard. In safety systems, the valve assembly is commonly called a final element subsystem. The primary function of the final element is to either isolate (block) the process, or to release or vent (blowdown) energy such as pressure, from the vessel.

2. Structure of the flanged ball valve

2.1 Components and description of use

See the appropriate IMO (214, 225, 226, 227, 228, 259, 270, 271, 277, 278, 280, 281, or 299) or the documentation available for the valve for a detailed technical description.

2.2 Permitted valve types

The information in this manual pertaining to functional safety applies to many different valve sizes, pressure classes, ball support types, and variants mentioned in the type coding in the Technical Bulletin's. The valve can be used in valve fail-open or valve fail-closed actions, depending on actuator installation and selection.

2.3 Supplementary valve documentation

1. Installation, Maintenance and Operating Instructions IMO - 214, 225, 226, 227, 228, 259, 270, 271, 277, 278, 280, 281, or 299.
2. Technical Bulletin B107-1, B107-2, B107-3, or B107-4

These are available from a Valmet contact, or for download from www.valmet.com/flowcontrol/documents.
Note that the IMO is not always shipped with the product.

3. Using the flanged ball valve in safety systems

3.1 Safety function

When de-energised, the complete valve assembly goes to its fail safe position. The safety position of the valve can correspond to either valve fully closed or fully open. The safety action within the assembly is normally initiated by a solenoid valve or intelligent partial stroke device. This releases actuator power, causing the actuator to reach its safety position. Hence, the safety function of valve and actuator is a quarter turn (full stroke) rotation either to close the fluid flow through the valve or open the fluid flow through the valve.

The spring in a single acting pneumatic actuator forces the actuator and valve to reach its safety position. The secure instrument air (SIA) buffer vessel is commonly used together with a double acting pneumatic actuator to provide a safety function. The SIA is not considered in this document.

3.2 Environmental and application restrictions

Ensure that the valve is selected and specified correctly for the application and that the process conditions and atmospheric conditions are taken into account. Environmental limits for which the product is designed and general instructions for applications are given in the product IMO and technical bulletin. Please contact Valmet in case more details are needed. Proper specification of application, process and environmental conditions is the user responsibility.

The reliability values given in Paragraph 3.5 assume the valve is selected correctly for the service and that all the environmental and application restrictions are considered. If the valve is used outside of its application or environmental limits, or with incompatible materials, the reliability information shown in Paragraph 3.5 may not be valid.

3.3 Useful lifetime

The useful lifetime needed for functional safety reliability estimations is typically 10 – 15 years for the Series 5000, 6000, 7000, 9000 flanged ball valves, if Proof test (5.1), Partial Stroke test (5.2), Maintenance (5.3), have been considered accordingly. The “useful lifetime” is the time period after burn-in and before wear-out, when the failure rate of a simple item is more or less constant. Note that the design life of the valve is higher, and should not be confused with “useful lifetime” used in these reliability evaluations.

3.4 Connecting the flanged ball valve to a safety system

The complete final element (valve-actuator-accessories assembly) is connected to the safety system through an electrical connection, which commonly operates an intelligent partial stroke device or a solenoid valve (see Fig 1).

A single final element installation provides hardware fault tolerance (HFT) equal to 0. If HFT equal to one is required, then two final elements installed in series (block) or parallel (vent) must be used.

Note, that the single final element may contain internal redundancy of some accessories, e.g. where 1oo2 or 2oo2 solenoid valves are required.

Note that the bare shaft valve cannot be connected to the safety system directly.

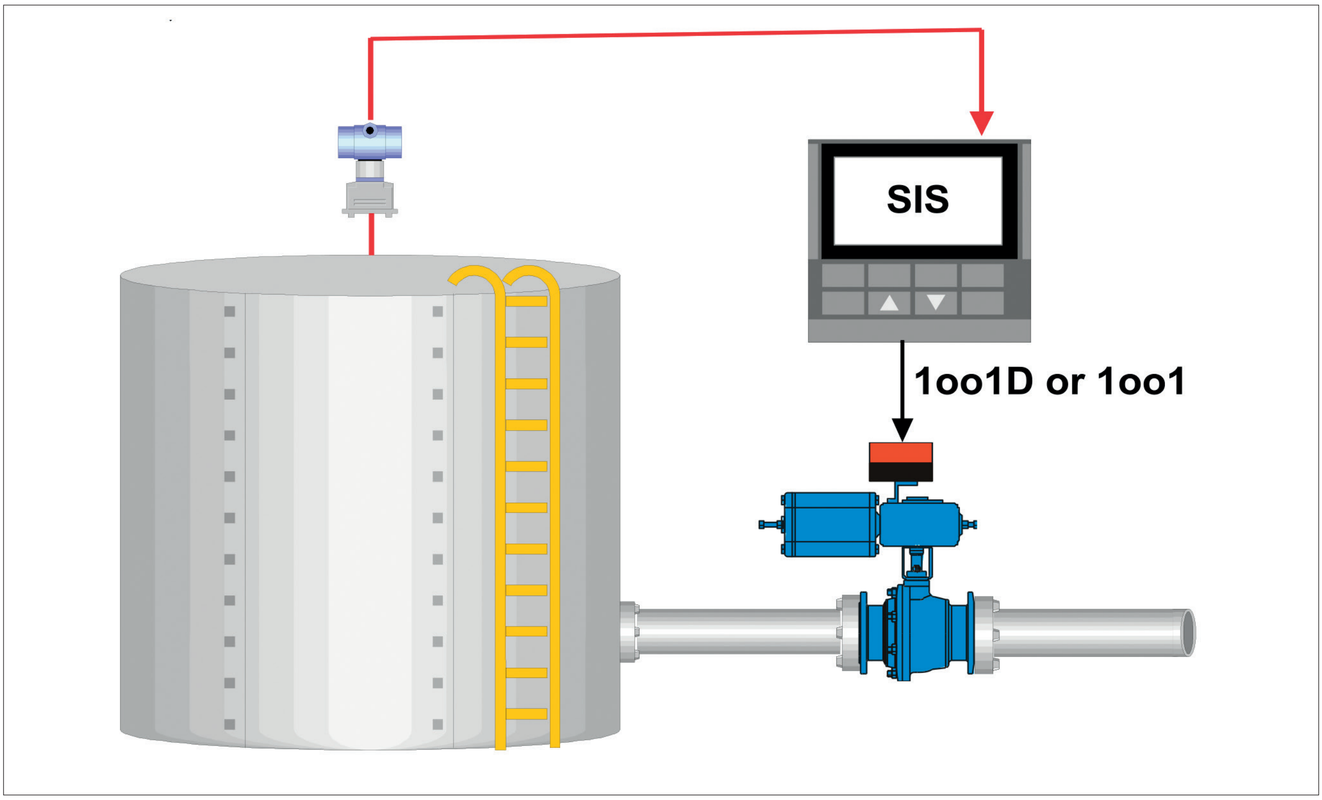

Fig. 1. Schematic picture of a safety loop. The final element with spring return actuator is connected to the Safety Instrumented System (SIS) via a solenoid or safety valve controller (partial stroke device). This shows a single channel final element subsystem with voting, either 1oo1D or 1oo1.

3.5 Random hardware integrity

The tables below show the "full" reliability numbers based on the Safety Certification for Series 5000, 6000, 7000, 9000 flanged ball valves in clean fluid services. The data represent the bare shaft valve, which is one part of the final element.

Using the Nelprof™ tool, example calculations of the average probability of dangerous failure on demand (PFD) are shown in Appendix 1.

Note that all the other safety related components of the final element should be included when the reliability of the final element subsystem is estimated. The analysis must also account for the hardware fault tolerance and architecture constraints for the complete final element subsystem.

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Table 1 Close on demand and external tightness failure rate data with automatic partial stroke test.

Sub system type		A
Diagnostic coverage*	DC[%]	38
Safe Failure Fraction	SFF	N/A**
Dangerous failures	λ_D [failures / hour]	2.51E-7
Dangerous undetected failures*	λ_{DU} [failures / hour]	1.56E-7
Dangerous detected failures, PST*	λ_{DD} [failures / hour]	9.54E-8

Table 2 Close on demand and external tightness failure rate data without partial stroke test.

Sub system type		A
Diagnostic coverage*	DC[%]	0
Safe Failure Fraction	SFF	N/A**
Dangerous failures	λ_D [failures / hour]	2.51E-7
Dangerous undetected failures	λ_{DU} [failures / hour]	2.51E-7
Dangerous detected failures, PST	λ_{DD} [failures / hour]	0

Table 3 Open on demand and external tightness failure rate data with partial stroke test.

Sub system type		A
Diagnostic coverage*	DC[%]	38
Safe Failure Fraction	SFF	N/A**
Dangerous failures	λ_D [failures / hour]	2.00E-07
Dangerous undetected failures*	λ_{DU} [failures / hour]	1.24E-07
Dangerous detected failures, PST*	λ_{DD} [failures / hour]	7.60E-08

Table 4 Open on demand and external tightness failure rate data without partial stroke test.

Sub system type		A
Diagnostic coverage*	DC[%]	0
Safe Failure Fraction	SFF	N/A**
Dangerous failures	λ_D [failures / hour]	2.00E-07
Dangerous undetected failures*	λ_{DU} [failures / hour]	2.00E-07
Dangerous detected failures, PST*	λ_{DD} [failures / hour]	0

* Diagnostic coverage represents common valve – actuator assemblies equipped with an intelligent part stroke device such as the Neles ValvGuard, The DC value has been used to calculate λ_{DU} and λ_{DD}.
**Safe failure fraction must be assessed for the complete final element assembly.

3.6 Systematic integrity

Systematic integrity requirements according IEC 61508 up to and including Safety Integrety level (SIL) 3 are fulfilled. These requirements include adequate integrity against systematic errors in the product design, and controlling systematic failures in the selection and manufacturing process. Series 5000, 6000, 7000, 9000 flanged ball valves must not be used in safety integrity functions with higher than the stated SIL level without a proven in use statement or, in some cases, redundant designs.

3.7 Additional information

Personnel doing the maintenance and testing must be competent to perform the required actions.

All final element components and components shall be operational before startup.

Proof testing should be recorded and documented according to IEC 61508 and maintenance actions done according to Part 5.

Unless the procedures above are properly followed, the reliability data shown in Paragraph 3.5 might not be valid.

4. Installation

The Series 5000, 6000, 7000, 9000 flanged ball valves must be installed into the pipeline according to Valmet instructions given in the Installation, Maintenance and Operation manual. Possible standards relevant to applications, local requirements, etc should be also considered. Installation must be done by competent persons. In case a bare shaft valve (not supplied as an assembly by Valmet) is to be used in a valve assembly, by adding the actuator and other components, the installer is responsible to verify the suitability of all linkage parts (see more details in IMO). It is particularly important to confirm that all components are working properly together.

Incorrect installation may jeopardize the validity of the reliability data given in Paragraph 3.5.

In cases where the complete valve assembly is supplied and shipped by Valmet, the complete valve assembly is tested and configured according to Valmet internal procedures, except where project specific procedures are used.

5. Operation

5.1 Recommended proof test

The purpose of proof testing is to detect failures of the complete final element subsystem. Valmet recommends the following proof test procedure:

- Conduct an initial visual inspection. Check that there are no unauthorized modifications to the SIS valve assembly. Verify that there is no observable deterioration in the SIS valve such as pneumatic leaks, visible damage, or impurities on the SIS valve.
- Bypass the SIS valve if full stroke could cause an unnecessary process shutdown.
- Perform the safety action (full stroke), preferably using the system. Verify that the SIS valve achieves safe position within the required time specified by the application. Verify also the shutoff tightness for tightness critical applications. Note that a tightness measurement might require removing the valve from the pipeline. If the valve must be removed from the pipeline, verify proper full stroke operation after re-installation.
- Restore the SIS valve to it's normal position.
- Conduct a final visual inspection. Check that the SIS valve is in the normal position, and verify that all accessories are operating according the specification for the SIS valve normal operation. Inspect visually that there is no observable deterioration of the SIS valve.
- Record all results and observations into the corresponding database with necessary audit trail information.
- Remove the SIS valve bypassing, if used.

5.2 Recommended partial stroke test

A partial stroke test is a verified movement of an emergency valve from the normal operating position toward the safe state. Partial stroke testing can be done in most cases while the process is on-stream without disturbing the process. The purpose is to provide early detection of automated block / vent valve failure modes, and to reduce the probability of failure on demand.

Valmet recommends using the testing capability available with intelligent partial stroke devices such as the Neles ValvGuard. In order to obtain the full benefit of diagnostics provided by partial stroke devices, ensure first that the device is calibrated and configured correctly according to the manufacturer's guidelines.
Before initiating the partial stroke, ensure that the partial stroke will not cause a process hazard. If needed, the possible pressure disturbance can be further estimated by using Nelprof™ valve sizing software.

The required partial stroke test interval may depend on application and targeted SIL level, but test intervals from 1 month to 6 month are generally recommended. Partial stroke size is typically from 10 to 20% of full travel starting from fully open, in shutdown service and from 3 to 5 % starting from fully closed in blowdown (vent) service. In these flanged ball valves, the partial stroke test can be done within the valve's dead angle value, thus maintaining tightness in blowdown service.

A partial stroke test can be initiated either manually or automatically. The test interval is set by the user. The user can be reminded by a partial stroke scheduler system in manual mode, and the test interval is controlled by the intelligent partial stroke test device in the automatic mode. Contact the partial stroke test device manufacturer for more details on how to select and set parameters to control the partial stroke size and frequency.

5.3 Maintenance

Any repair of Series 5000, 6000, 7000, 9000 flanged ball valves must be carried out by Valmet or competent personnel. Maintenance procedures are given in the IMO.

After the maintenance is completed, do a shell test and verify seat tightness, if necessary for the application, according to relevant tightness standards. Verify the functionality of the valve including the assembly regarding the safety function in question. Note that all maintenance actions should be recorded.

Valmet Service provides the recommended spare part kits defined in the Bills of Material contained in every Instructions, Maintenance and Operation (IMO) manual. The need for parts replacement increases with the number of valve operations done during it's lifetime and with the severity of service. Only authorized Valmet replacement parts should be used.

Soft sealing materials especially are affected by aging, and useful lifetime depends strongly on the application. Therefore, the condition of those components should be checked carefully during proof testing. In optimum operating conditions, the maintenance interval may be extended up to 10 years. The estimated typical time for spare parts change is 0 to 2 times during the valve useful lifetime. Possible problems must be resolved in any case of failure, or doubt observed in proof testing.

6. References

[1] IMO – 214, 225, 226, 227, 228, 259, 270, 271, 277, 278, 280, 281, or 299
[2] Technical bulletin B107-1, B107-2, B107-3,and B107-4
[3] SIL certificate TUV 968/V 1213.00/21
[4] IEC 61508 – Part 1 to 7 (2010)
[5] Neles ValvGuard IMO 7VG9H70, 7VG9F70, and 7LCP9H70

Appendix 1. Examples of reliability (PFD) calculations for complete final elements.

Series 9000 flanged ball valve with B Series actuator, equipped with Neles ValvGuard for partial stroke and safety action. The diagnostic factor 38% is used for the complete valve assembly.

FINAL ELEMENT SETUP

FINAL ELEMENT SETUP	SELECTION
Safety position	Close
Diagnostic coverage (DC)	Valve + Actuator + ValvGuard PST

TEST INTERVALS

TEST INTERVALS	UNIT	VALUE
Full stroke test (TIFST)	Months	24
Partial stroke test (TIPST)	Months	3
Pneumatic test (TIPNEUMATIC)	Days	7

VALVE AND ACTUATOR

DEVICES	ARCHITECTURE	NAME	λD [1/h]	DC	MTTR [h]	PFD
Valve	1oo1D	JB 7000/9000-SEF	2.51e-7	0.38	24	1.474e-3
Actuator	1oo1D	B1J-SERIES (SPR	1.14e-7	0.27	24	7.654e-4

ACCESSORIES

DEVICES	ARCHITECTURE	NAME	λD [1/h]	DC	MTTR [h]	PFD
Intelligent PST	1oo1D	VG9000F/H			4	5.271e-4
Instrument 1	1oo1	RCI9H2 FOR VG9(	1.9e-9	0	4	1.665e-5
Instrument 2	None					
Instrument 3	None					
Instrument 4	None					

RESULT

RESULT	VALUE
PFD total	2.783e-3
SIL	2
Note	Final element is suitable for use in safety systems up to and including SIL 2

Series 9000 flanged ball valve with B Series actuator, equipped with solenoid valve control for safety action.

FINAL ELEMENT SETUP

FINAL ELEMENT SETUP	SELECTION
Safety position	Close
Diagnostic coverage (DC)	No diagnostics test

TEST INTERVALS

TEST INTERVALS	UNIT	VALUE
Full stroke test (TIFST)	Months	48

VALVE AND ACTUATOR

DEVICES	ARCHITECTURE	NAME	ΛD [1/h]	DC	MTTR [h]	PFD
Valve	1oo1	JB 7000/9000-SEF	2.51e-7	0	24	4.404e-3
Actuator	1oo1	B1J-SERIES (SPR	1.14e-7	0	24	2e-3

ACCESSORIES

DEVICES	ARCHITECTURE	NAME	ΛD [1/h]	DC	MTTR [h]	PFD
Instrument 1	1oo1	SOV GENERIC 3-\	5.85e-7	0	4	1.025e-2
Instrument 2	None					
Instrument 3	None					
Instrument 4	None					

RESULT

RESULT	VALUE
PFD total	1.666e-2
SIL	1
Note	Final element is suitable for use in safety systems up to and including SIL 1

Appendix 2. Equations to calculate PFD for 1oo1 and 1oo1D final elements.

These equations correspond to IEC 61508 and ISA TR-96.05.01.

An average value of probability of failure on demand for 1oo1D architecture with diagnostics is given by the equation

$$PFD_{AVG} = DC * \lambda_D * TI_{PST}/2 + (1\text{-}DC) * \lambda_D * TI_{FST}/2 + \lambda_D * MTTR$$

where DC is diagnostic coverage (fraction), λ_D is dangerous failure rate (failures / hour), TI_{FST} is full stroke test interval (hours), TI_{PST} is partial stroke test interval (hours) and MTTR is mean time to repair (hours).

Diagnostic coverage provided by a typical partial stroke device is applicable to the valve, actuator, quick exhaust valves and volume boosters. Diagnostic coverage for a solenoid or air operated valve is not available.

The Neles ValvGuard device itself uses diagnostic coverage provided by the internal pneumatic diagnostic test, and / or the partial stroke test.

The PFD equation for 1oo1 voting without diagnostic testing is similar to 1oo1D except that the diagnostic coverage is equal to 0. Thus the general equation becomes:

$$PFD_{AVG} = \lambda_D * TI_{FST}/2 + \lambda_D * MTTR$$

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