

Neles™ high pressure ball valve

Series XH, T2, S6 and XU
Rev. Original



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1. Introduction

This safety manual provides the functional safety related information required to integrate and use XH, T2, S6 and XU series trunnion mounted or seat supported ball valve in safety systems in compliance with IEC 61508/61511 standard. The safety manual shall be used together with Installation, Maintenance and Operating Instructions manual (IMO) of Neles XH, T2, S6 and XU series ball valve.

Neles high pressure XH, T2, S6 and XU series ball valve is a quarter turn valve which is used in automated on/off and control process applications. In on/off service valve is either fully closed or open. XH, T2, S6 and XU series ball valve is commonly part or automated on/off (block) valve assembly which consist of valve, actuator, accessories and linkage parts. Valve part of the automated on/off valve assembly consist of valve body which is considered in this document. Actuator part of the automated on/off valve assembly can be pneumatically, electrically or hydraulically powered. Accessory part of the automated on/off valve assembly may consist of partial stroke test device such as Neles ValvGuard or solenoid valves as well as additional instruments such as quick exhaust valve, booster and limit switch.

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

2. Structure of the XH, T2, S6 and XU series high pressure ball valve

2.1 Components and description of use

See the IMO for the detailed technical description of the valve. See paragraph 1 “General” and paragraph 12 “Type code” in IMO.

2.2 Permitted valve types

The information in this manual pertaining to functional safety applies to all valve sizes and variants covered by the IMO.

2.3 Supplementary valve documentation

1. 1XH70 ; Installation, Maintenance and Operating Instructions (IMO)

These are available from Valmet or for download from www.neles.com/products.

Note, that IMO is always shipped together with the product

3. Using Valmet high pressure 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 be either fully close or fully open. The safety action within the assembly is normally initiated by solenoid valve or intelligent partial stroke device. This releases actuator power resulting in the valve reaching its safety position. Hence the safety function of bare shaft valve is quarter turn action (full stroke) either to close the fluid flow through valve or open the fluid flow through valve.

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 where 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.

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

3.3 Useful lifetime

The useful lifetime needed for reliability estimations is typically 10 – 15 years for Valmet high pressure valve, 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 design life of the valve is higher and should not be mixed to useful lifetime used in reliability evaluations.

3.4 Connecting High Pressure XH, T2, S6 and XU series ball valve to safety system

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

A single final element installation provides hardware tolerance (HFT) equal to 0. In case HFT equal to one is required then two final elements installed in series or parallel must be used depending on the safety position.

Note, that the single final element may contain internal redundancy in the accessories part in cases required e.g. 1oo2 solenoid valves are required.

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

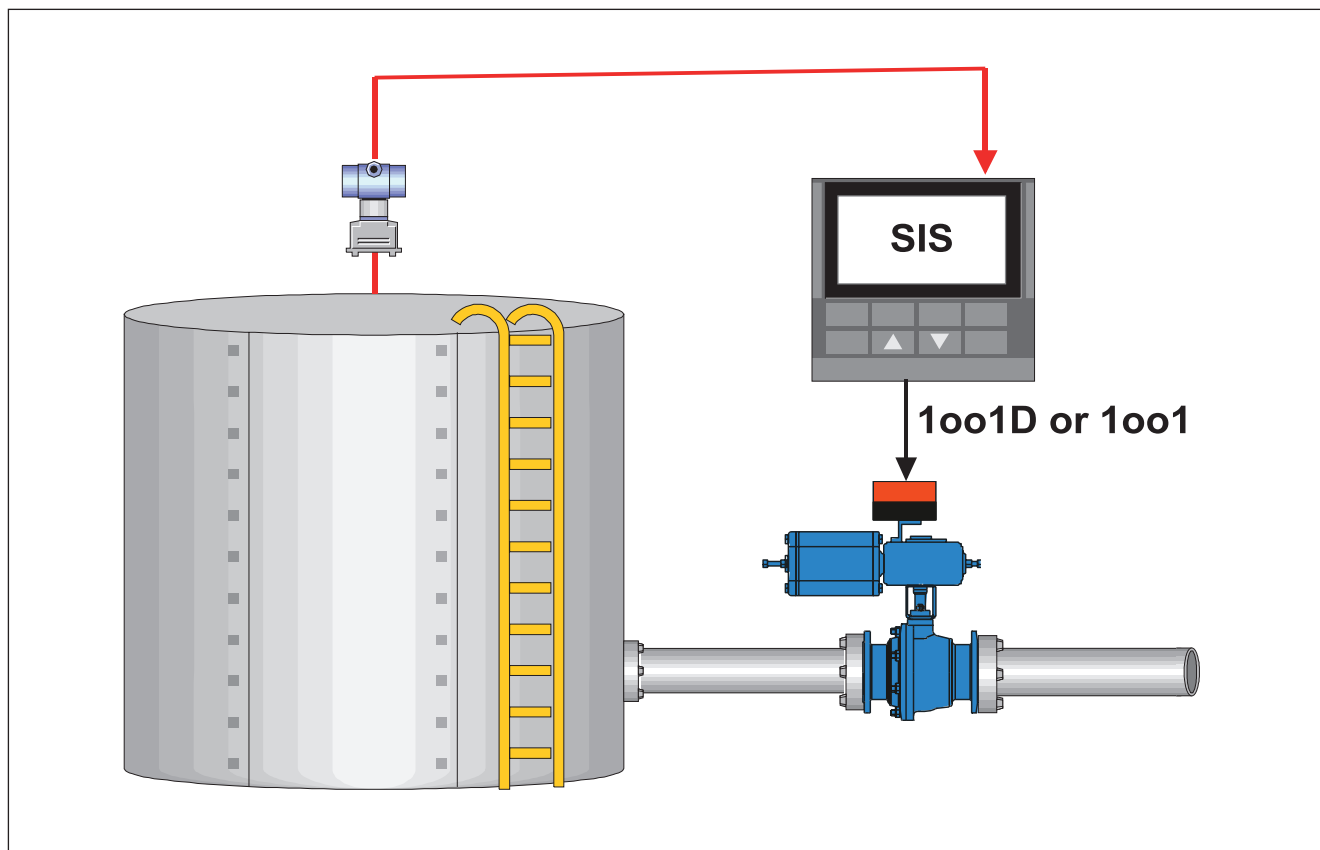


Fig. 1. Schematic picture of safety loop. Final element is connected to safety (SIS) logic solver via solenoid or safety valve controller (partial stroke device). Here shown single channel final element subsystem with voting 1oo1D or 1oo1.

3.5 Random hardware integrity

The table below shows the information to be used in reliability calculation for XH, T2, S6 and XU series valve. The data represent the bare shaft valve which is part of the final element.

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

An example calculation of an average probability of failure on demand (PFD) is shown in appendix 1.

Table 1. Failure rate data with automatic partial stroke test		Safety Function	
		Open on demand	Close on demand
Diagnostic coverage, DC [%]	DC [%]	83*	82*
Safe failure fraction	SFF	N/A**	N/A**
Dangerous failures	λ_D [failures/hour]	2,86E-07	2,90E-07
Dangerous undetected failures	λ_{DU} [failures/hour]	4,86E-08	5,22E-08
Dangerous detected failures, PST	λ_{DD} [failures/hour]	2,37E-07	2,38E-07
Safe failures	λ_S [failures/hour]	0	0

Table 2. Failure rate data without automatic partial stroke test		Safety Function	
		Open on demand	Close on demand
Diagnostic coverage, DC [%]	DC [%]	0	0
Safe failure fraction	SFF	N/A**	N/A**
Dangerous failures	λ_D [failures/hour]	2,86E-07	2,90E-07
Dangerous undetected failures	λ_{DU} [failures/hour]	2,86E-07	2,90E-07
Dangerous detected failures, PST	λ_{DD} [failures/hour]	0	0
Safe failures	λ_S [failures/hour]	0	0

* Diagnostic coverage represent common valve – actuator -assembly equipped with intelligent part stroke device such as Neles ValvGuard, The DC value have been used to calculate λ_{DU} and λ_{DD} .

** Safe failure fraction must be assessed for complete final element assembly.

3.6 Systematic integrity

Systematic integrity requirements to according IEC 61508 (2010) up to and including SIL3 are fulfilled. These requirements include adequate integrity against systematic errors in the product design, and controlling systematic failures in selection and manufacturing process. XH, T2, S6 and XU series valves must not be used in safety integrity functions with higher than stated SIL level without prior in use statement or redundant designs.

3.7 Additional information

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

Verify final element is operational before startup.

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

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

4. Installation

Neles XH, T2, S6 and XU series valve must be installed into pipeline according to Valmet instructions given in the IMO. Possible standards relevant to applications, local requirements, etc should be also considered. Installation must be done by competent persons. In case of bare shaft valve is installed to actuator assembly, 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 reliability data given in paragraph 3.5.

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

5. Operation

5.1 Recommended proof test

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

- Visual inspection. Check there is no unauthorized modifications in SIS final element. Check that the SIS final element is in the normal position and verify that all accessories are according to the specification for the SIS valve normal operation. Verify that there is no observable deterioration in SIS valve such as pneumatic leakages, visible damages or impurities on the SIS valve.
- Bypass the SIS final element, if full stroke may cause unnecessary process shutdown.
- Perform safety action (full stroke) preferably using the safety system. Verify that the SIS valve achieves safe position within required time specified by the application. Verify also the tightness for tightness critical applications. Note, that tightness measurement might need removing valve from the pipeline. If valve is removed from the pipeline repeat full stroke test after re-installation.
- Restore the SIS valve into normal position.
- Visual inspection. Check the SIS final element is in normal position and verify all accessories are according to the specification for the SIS valve normal operation. Inspect visually there is no observable deterioration in SIS final element.
- Record all results and observations into corresponding database with necessary audit trail information.
- Remove the SIS final element by bypassing.

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 while the process is on-stream without disturbing the process to provide early detection of automated block valve failure modes and to improve probability of failure on demand.

Valmet recommends using testing capability available with intelligent partial stroke devices such as 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 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 Neles 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% in shutdown service and from 3 to 5 % within the valve's dead angle value to maintain the valve tightness in blow-down service.

Partial stroke test can be initiated either manually or automatically. The test interval is set by the user. The user can be reminded by partial stroke scheduler system in manual mode and the test interval is controlled by 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 partial stroke size and frequency.

5.3 Maintenance

Any repair for the Neles XH, T2, S6 and XU series valves must be carried out by Valmet or competent personnel. All repairs must be done according to Valmet maintenance procedures given in the corresponding IMO. After the maintenance, do shell test and verify seat tightness if necessary 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 recommended spare part kits defined in the Bill of Material of every Instructions, Maintenance and Operation Manual (IMO). The need for spare parts replacement is directly comparable to the amount of operations done by the valve unit during its lifetime and the severity of service.

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 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 failures must be overhauled in case of failure or doubt observed in proof testing.

6. References

- [1] IMO: 1XH70, 1T70en, 1S670en and 1X73en
- [2] SIL certification No.: 968/V 1037.01/23
- [3] IEC 61508 – Part 1 to 7 (2010)
- [4] Neles ValvGuard Safety manual: VG9000H SAFETY_MANUAL, VG9000F SAFETY_MANUAL, 10SM_VG9000Hen
- [5] Neles ValvGuard IMO: 7VG9H70, 7VG9F70, 7LCP9H

Appendix 1. An example of reliability (PFD) calculation for complete final element.
High Pressure ball valve and B-series actuator equipped with Neles ValvGuard for partial stroke and safety action.

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	AD [1/h]	DC	MTTR [h]	PFD
Valve	1001D	XHG-SERIES Close on demand	2.9e-7	0.82	24	7.246e-4
Actuator	1001D	B1J-SERIES (SPRING)	1.14e-7	0.27	24	7.654e-4

ACCESSORIES

DEVICES	ARCHITECTURE	NAME	AD [1/h]	DC	MTTR [h]	PFD
Intelligent PST	1001D	VG9000F-H				1.426e-3
Instrument 1	None					
Instrument 2	None					
Instrument 3	None					
Instrument 4	None					

RESULT

RESULT	VALUE
PFD total	2.916e-3
SIL	2
Note	Final element is suitable for use in safety systems up to and including SIL 2

High Pressure ball valve and B-series actuator equipped with solenoid valve controller 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	24

VALVE AND ACTUATOR

DEVICES	ARCHITECTURE	NAME	AD [1/h]	DC	MTTR [h]	PFD
Valve	1001	XHG-SERIES Close on demand	2.9e-7	0	24	2.547e-3
Actuator	1001	B1J-SERIES (SPRING)	1.14e-7	0	24	1.001e-3

ACCESSORIES

DEVICES	ARCHITECTURE	NAME	AD [1/h]	DC	MTTR [h]	PFD
Instrument 1	1001	SOV GENERIC 3-WAY	5.85e-7	0	4	5.127e-3
Instrument 2	None					
Instrument 3	None					
Instrument 4	None					

RESULT

RESULT	VALUE
PFD total	8.676e-3
SIL	2
Note	Final element is suitable for use in safety systems up to and including SIL 2

Appendix 2.

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

$$PFD_{AVG1oo1D} = DC * \lambda_D * TI_{PST}/2 + (1-DC) * \lambda_D * TI_{FST}/2 + \lambda_D * MTTR$$

where DC is diagnostic coverage, λ_D is dangerous failure rate, TI_{FST} is full stroke test interval, TI_{PST} is partial stroke test interval and MTTR is mean time to repair. The equation is based on ISA TR96.05.01-2008.

Diagnostic coverage provided by partial stroke is utilized for valve, actuator, quick exhaust valve and volume booster. Diagnostic test for solenoid or air operated valve is not available.

ValvGuard is using diagnostic coverage provided by internal pneumatic diagnostic test or partial stroke test.

An average value of probability of failure on demand for 1oo1 architecture without diagnostic is given by equation

$$PFD_{AVG1oo1D} = \lambda_{du} * TI_{FST}/2 + MRT$$

where λ_{du} is dangerous undetected failure rate, TI_{FST} is full stroke test interval and MRT is mean repair time (MRT is assumed to be equal to MTTR). The equation is based on IEC 61508-6, Edition 2, 2010.

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