Pneumatic cylinder actuator Series VBC/VBD/VBR

Rev. 0

Safety Manual

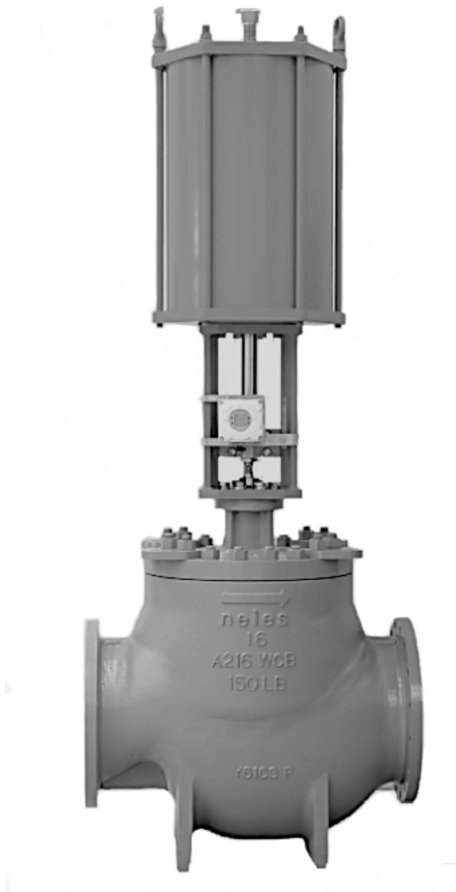


Table of Contents

1. Introduction

This safety manual provides the functional safety related information required to integrate and use VB-series pneumatic cylinder actuator in safety systems in compliance with IEC 61508 standard. The safety manual shall be used together with Installation, Manufacturer and Operation manual of Neles series VBC/VBD/VBR actuator.

Neles series VBC/VBD/VBR actuator is a linear operating pneumatic cylinder actuator which is used in automated on/off and control process applications. In on/off service actuator is either fully closed or open. Neles series VBC/VBD/VBR actuator is commonly part of automated on/off (block) valve assembly which consist of valve, actuator, accessories and linkage parts. Actuator part of the automated on/off valve assembly is considered in this document. Valve part of the assembly can be a linear operating valve such as globe. 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/or 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 (SIS) final element subsystem. The primary function of final element is to either isolate the process or release (blowdown) energy for instance pressure from the vessel.

2. Structure of the diaphragm actuator

2.1 Components and description of use

See the IMO (6VBC70, 6VBJ70 – Chapter 1 and 10) or the documentation delivered with the actuator for the detailed technical description of the actuator

2.2 Permitted actuator types

The information in this manual pertaining to functional safety applies to all actuator sizes and variants mentioned in the actuator type coding in the IMO.

2.3 Supplementary actuator documentation

1. 6VBC70, 6VBJ70 Installation, Maintenance and Operating Instructions (IMO).
2. 6VB20 Technical Bulletin

These are available from Neles or for download from from https://valveproducts.neles.com/.
Note, that IMO is always shipped with product.

3. Using pneumatic diaphragm actuator 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 bare shaft actuator can be either 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 resulting actuator to reach its safety position. Hence the safety function of bare shaft actuator is a linear action. The spring in the single acting (VBD/VBR) forces actuator to reach its safety position. The SIA buffer vessel (secure Instrument air) is commonly used together with double acting actuator (VBC) to provide a safety function. SIA is not considered in this document.

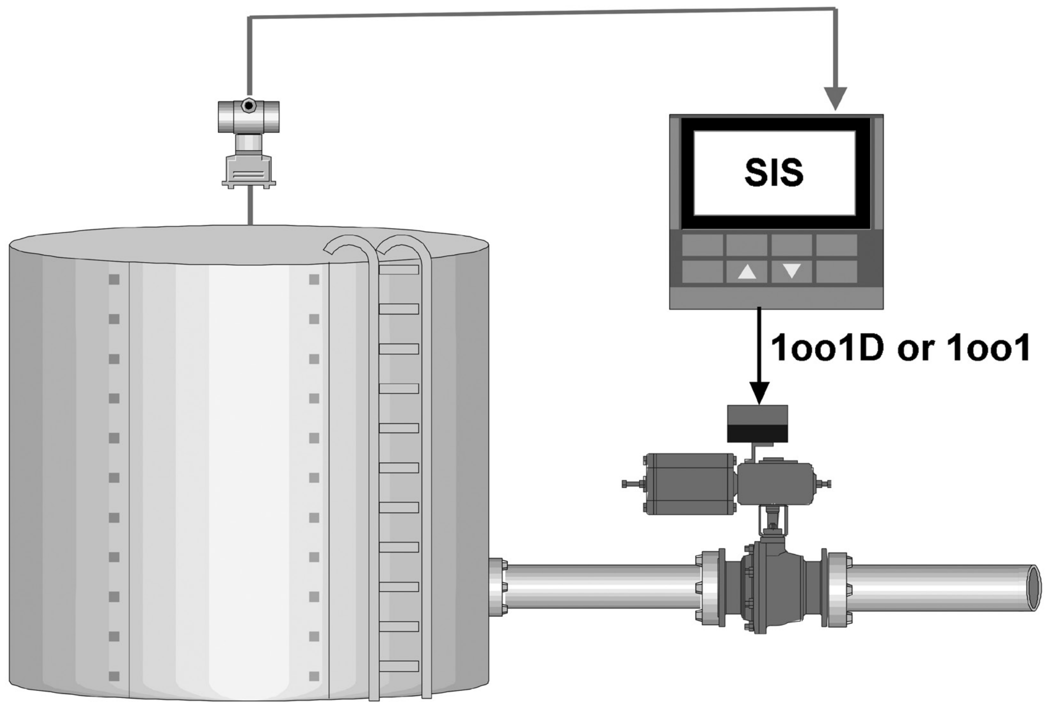
3.2 Environmental and application restrictions

Ensure that the actuator is selected and specified correctly for the application and that the process conditions and atmospheric conditions are taken into account. Environmental limits for which product is designed and general instructions for applications are given in the product IMO and technical bulletin. Please, contact Neles in case more details are needed.

The reliability values given in paragraph 3.5 assume the actuator is selected correctly for the service and all the environmental and application restrictions are considered. If the actuator 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 reliability estimations is typically 10 – 15 years for VB series actuator if Proof test (5.1), Partial Stroke test (5.2) and 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 actuator is higher and should not be mixed to useful lifetime used in reliability evaluations.



3.4 Connecting a pneumatic cylinder actuator to the safety system

The complete final element (valve-actuator-accessories assembly) is connected to the safety system through an electrical connection which is 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.
Note, that the single final element may contain internal redundancy in the accessories part, in some cases e.g. 1oo2 or 2oo2 solenoid valves are required.
Note, that bare shaft actuator can not be connected to the safety system directly

Figure 1. Schematical picture of safety loop. Final element is connected to safety system (SIS) via solenoid or safety valve controller (partial stroke device). This shows 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 calculations for VB series actuator. The data represent the bare shaft actuator which is one part of the final element.
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.
Neles recommends multiplying failure rate values shown in table 1 and 2 by factor 5,0 to assure conservative, reliable estimation of failures with high confidence for all applications including severe service, for all sizes and variants for VBC/VBD/VBR-actuator. An example calculation of an average probability of failure on demand (PFD) is shown in appendix 1.

Table 1 VBD/VBR Failure rate data with automatic partial stroke test.

Architecture type		A
Diagnostic coverage, DC [%] *	DC[%]	83
Safe Failure Fraction	SFF	N/A**
Dangerous failures	λD [failures / hour]	1.73E-8
Dangerous undetected failures*	λDU [failures / hour]	2.94E-9
Dangerous detected failures, PST*	λDD [failures / hour]	1.44E-8
Safe failures	λS [failures / hour]	3.93E-9

Table 2 VBD/VBR Failure rate data without partial stroke test.

Architecture type		A
Diagnostic coverage, DC [%]*	DC[%]	0
Safe Failure Fraction	SFF	N/A**
Dangerous failures	λD [failures / hour]	1.73E-8
Dangerous undetected failures*	λDU [failures / hour]	1.73E-8
Dangerous detected failures, PST*	λDD [failures / hour]	0
Safe failures	λS [failures / hour]	3.93E-9

Table 3 VBC Failure rate data with automatic partial stroke test.

Architecture type		A
Diagnostic coverage, DC [%] *	DC[%]	84
Safe Failure Fraction	SFF	N/A**
Dangerous failures	λD [failures / hour]	1.67E-8
Dangerous undetected failures*	λDU [failures / hour]	2.67E-9
Dangerous detected failures, PST*	λDD [failures / hour]	1.40E-8
Safe failures	λS [failures / hour]	0

Table 4 VBC Failure rate data without partial stroke test.

Architecture type		A
Diagnostic coverage, DC [%]*	DC[%]	0
Safe Failure Fraction	SFF	N/A**
Dangerous failures	λD [failures / hour]	1.67E-8
Dangerous undetected failures*	λDU [failures / hour]	1.67E-8
Dangerous detected failures, PST*	λDD [failures / hour]	0
Safe failures	λS [failures / hour]	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 λDU and λDD.
**Safe failure fraction must be assessed for complete final element assembly.

3.6 Systematic integrity

Systematic integrity requirements according IEC 61508 up to and including SIL2 are fulfilled. These requirements include adequate integrity against systematic errors in the product design, and controlling systematic failures in the selection and manufacturing process. VB-series actuators 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.
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 Paragraph 5.
Unless the procedures above are no properly followed, the reliability data shown in 3.5 may not be valid.

4. Installation

The Neles series VBC/VBD/VBR actuator must be installed into the valve according to Neles 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 of bare shaft actuator is installed to valve 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 cases where the complete valve assembly is shipped by Neles, the complete valve assembly is tested and configured according Neles 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. Neles recommends the following proof test procedure:

- Visual inspection. Check that there are no unauthorized modifications in SIS valve. Verify that there is no observable deterioration in the SIS valve such as pneumatic leakages, visible damage or impurities on the SIS valve.
- Bypass the SIS valve if full stroke may cause unnecessary process shutdown.
- Perform safety action (full stroke) preferably using the system. Verify the SIS valve achieve 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 do full stroke test after re-installation.
- Restore the SIS valve into normal position.
- Visual inspection. Check the SIS valve is in normal position and verify all accessories are according the specification for the SIS valve normal operation. Inspect visually there is no observable deterioration in SIS valve.
- Record all results and observations into corresponding database with necessary audit trail information.
- Remove the SIS valve 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.

Neles 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 % in blowdown service.

Note, that in some valves such as globe valves a small amount flow may be resulted through during partial stroke in blowdown 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 Series VBC/VBD/VBR-actuator must be carried out by Neles or competent personnel. Maintenance procedures are given in IMO.

Neles Service provides recommended spare part kits defined in the Bill of Material of every Instructions, Maintenance and Operation (IMO) manual. The need for 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

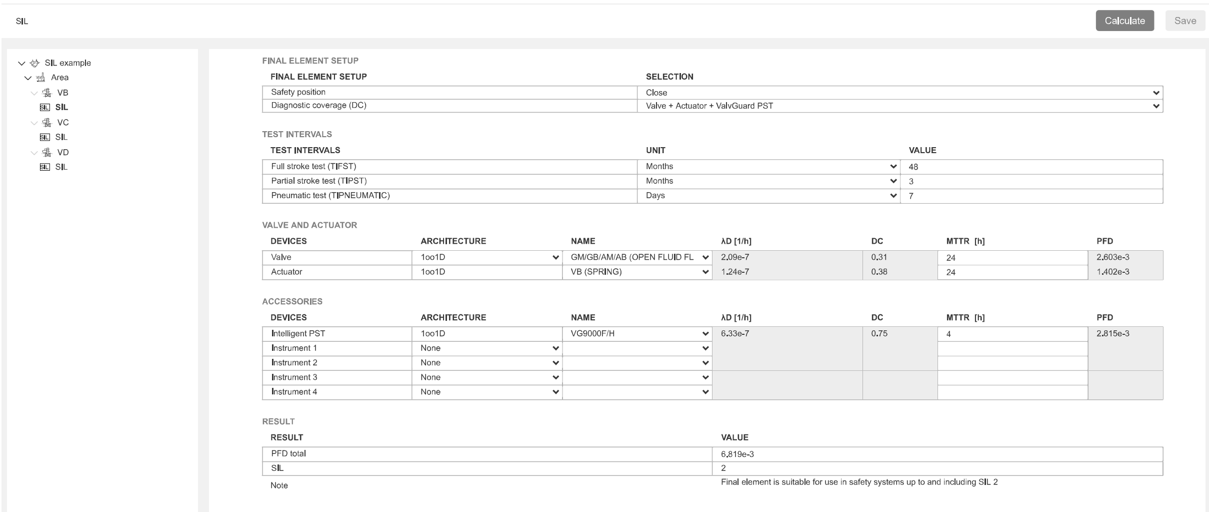
[1] IMO 6VBC70 and 6VBJ70

[2] IEC 61508 – Part 1 to 7 (2010)

[3] Technical bulletin 6VB20

Appendix 1. An example of reliability (PFD) calculation for complete final element

VB-series actuator and Neles Globe - valve equipped with Neles ValvGuard for partial stroke and safety action.
Note, that failure rate values are multiplied by factors as given in Paragraph 3.5. Diagnostic factor 74 % used for complete valve assembly.



SIL

Calculate Save

SIL example / Area / VB / SIL / VC / SIL / VD / SIL

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	48
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	GM/GB/AM/AB (OPEN FLUID FL	2,09e-7	0,31	24	2,603e-3
Actuator	1oo1D	VB (SPRING)	1,24e-7	0,38	24	1,402e-3

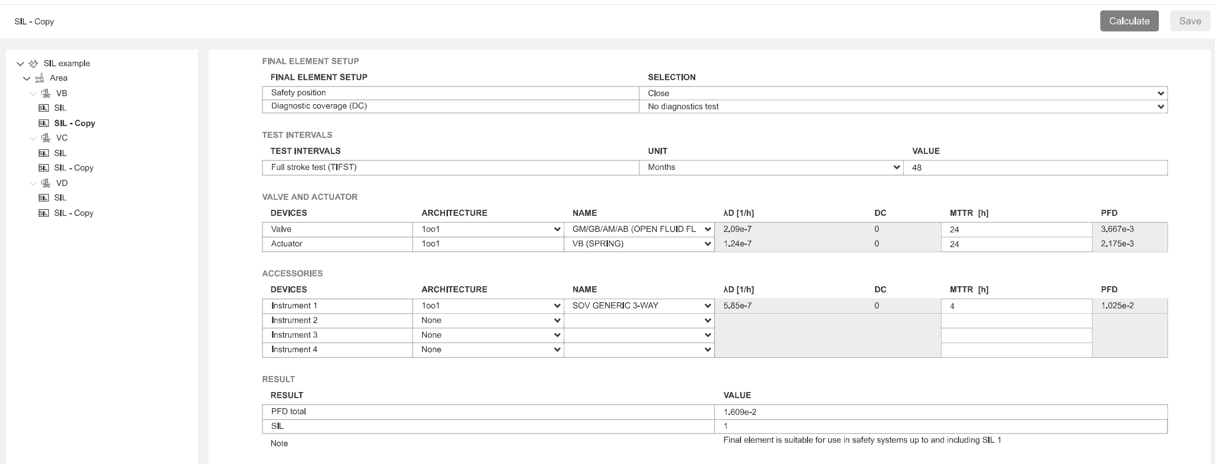
ACCESSORIES

DEVICES	ARCHITECTURE	NAME	λD [1/h]	DC	MTTR [h]	PFD
Intelligent PST	1oo1D	VG9000F/H	6,33e-7	0,75	4	2,815e-3
Instrument 1	None					
Instrument 2	None					
Instrument 3	None					
Instrument 4	None					

RESULT

RESULT	VALUE
PFD total	6,819e-3
SIL	2
Note	Final element is suitable for use in safety systems up to and including SIL 2

VB-series actuator and Neles Globe- valve equipped with solenoid valve control for safety action.



SIL - Copy

Calculate Save

SIL example / Area / VB / SIL / SIL - Copy / VC / SIL / SIL - Copy / VD / SIL / SIL - Copy

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	GM/GB/AM/AB (OPEN FLUID FL	2,09e-7	0	24	3,667e-3
Actuator	1oo1	VB (SPRING)	1,24e-7	0	24	2,175e-3

ACCESSORIES

DEVICES	ARCHITECTURE	NAME	λD [1/h]	DC	MTTR [h]	PFD
Instrument 1	1oo1	SOV GENERIC 3-WAY	5,85e-7	0	4	1,025e-2
Instrument 2	None					
Instrument 3	None					
Instrument 4	None					

RESULT

RESULT	VALUE
PFD total	1,609e-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.

An average value of probability of failure on demand for 1oo1D architecture with diagnostic is given by equation PFDAVG = DC * λD * TIPST/2 + (1-DC) * λD * TIFST/2 + λD * MTTR where DC is diagnostic coverage, λD 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.
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. PFD equation for 1oo1 voting without diagnostic test is similar to 1oo1D except diagnostic coverage is equal to 0. The equation corresponds IEC 61508 and ISA TR-96.05.02.

Valmet Flow Control Oy
Vanha Porvoontie 229, 01380 Vantaa, Finland.
Tel. +358 10 417 5000.
www.valmet.com/flowcontrol