Jamesbury™ Valv-Powr™ compact rack and pinion pneumatic actuator Series VPVL model D

Rev. 4.0

Safety manual

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1. Introduction

This safety manual provides the functional safety related information required to integrate and use Valv-Powr Series VPVL pneumatic rack and pinion actuators 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 Jamesbury Valv-Powr Series VPVL actuators.

The Valv-Powr Series VPVL is a quarter turn rack and pinion actuator, which is used in automated on/off and control process applications. In on/off service, the actuator is either fully closed or fully open. The Valv-Powr Series VPVL actuator is commonly part of an automated on/off (block) valve assembly, which consists of a valve, actuator, accessories, and linkage parts. Only the actuator component of the automated on/off valve assembly is considered in this document. The valve part of the assembly can be a quarter turn valve such as a ball or disc type. 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 pneumatic rack and pinion actuator

2.1 Components and description of use

See IMO-553en or the documentation available for the actuator for a detailed technical description of the actuator.

2.2 Permitted actuator types

The information in this manual pertaining to functional safety applies to all Valv-Powr Series VPVL Model D actuator sizes and variants mentioned in the actuator type coding in the IMO. This manual applies to double acting (DA) and spring return (SR) versions. The actuator can be used in valve fail-open or valve fail-closed actions, depending on actuator installation.

2.3 Supplementary actuator documentation

1. Installation, Maintenance and Operating Instructions IMO-553en.
2. Technical Bulletin A111-5en.

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

3. Using the pneumatic rack and pinion 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 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 bare shaft actuator is a quarter turn rotation. The spring in the single acting version (VPVL SR) forces the actuator to reach its safety position. The secure instrument air (SIA) buffer vessel is commonly used together with a double acting actuator (VPVL DA) to provide a safety function. The 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 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 actuator is selected correctly for the service and that 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 functional safety reliability estimations is typically 10 – 15 years for the Valv-Powr Series VPVL actuator, 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 actuator is higher, and should not be confused with "useful lifetime" used in these reliability evaluations.

3.4 Connecting the pneumatic rack and pinion actuator 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 actuator cannot be connected to the safety system directly.

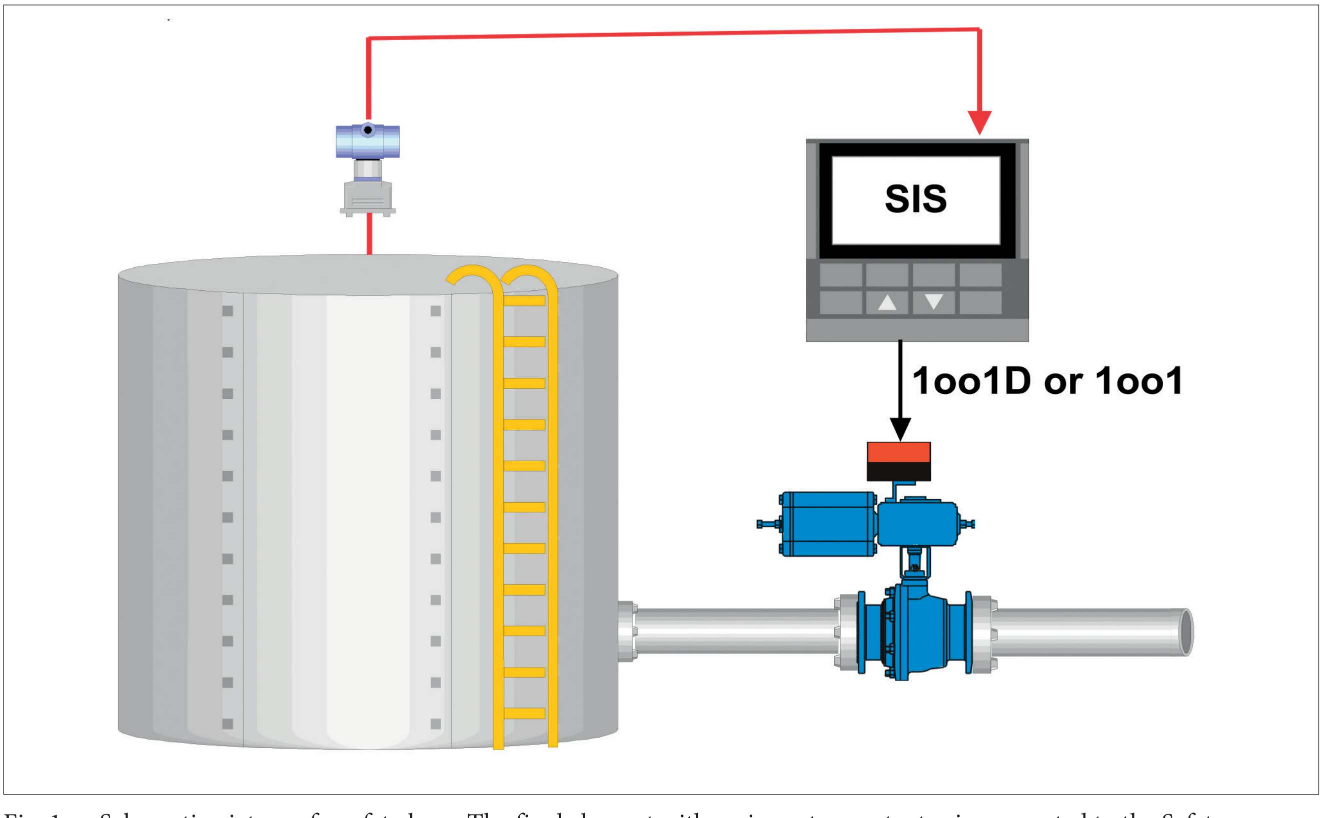

Fig. 1. Schematic picture of a safety loop. The final element with spring return actuator is connected to the Safety Instrumented System (SIS) via a solenoid or safety valve controller (partial stroke device). This shows a single channel final element subsystem with voting, either 1oo1D or 1oo1.

3.5 Random hardware integrity

The tables below show the "full" reliability numbers based on the Safety Certification for Valv-Powr Series VPVL actuator. The data represent the bare shaft actuator, which is one part of the final element.

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.

Table 1 VPVL failure rate data with automatic partial stroke test

		VPVL_SR	VPVL_DA
Diagnostic coverage*	DC [%]	58 %	51 %
Dangerous failures	λD (failures/hour)	1,86E-07	2,24E-07
Dangerous undetected failures	λDU (failures/hour)	7,81E-08	1,10E-07
Dangerous detected failures, PST	λDD (failures/hour)	1,08E-07	1,14E-07
Safe failures	λS (failures/hour)	0	0
Safe failure fraction	SFF	N/A**	N/A**

Table 2 VPVL failure rate data without automatic partial stroke test

		VPVL_SR	VPVL_DA
Diagnostic coverage*	DC [%]	58 %	51 %
Dangerous failures	λD (failures/hour)	1,86E-07	2,24E-07
Dangerous undetected failures	λDU (failures/hour)	7,81E-08	1,10E-07
Dangerous detected failures, PST	λDD (failures/hour)	1,08E-07	1,14E-07
Safe failures	λS (failures/hour)	0	0
Safe failure fraction	SFF	N/A**	N/A**

* Diagnostic coverage represents common valve - actuator assemblies equipped with an intelligent partial stroke devices such as the Neles ValveGuard. The DC values has been used to calcatule λDU and λDD.
** 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 Integrity 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. Valv-Powr Series VPVL actuators 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 Jamesbury Valv-Powr Series VPVL actuator must be installed on the valve 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 actuator (not supplied as an assembly by Valmet) is to be installed in a valve assembly, 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 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% of full travel starting from fully open in shutdown service and from 3 to 5 % starting from fully closed in blowdown (vent) service.

Note, that in some valve types such as butterfly valves which have small valve dead angle values, a small amount of flow might occur during a partial stroke in blowdown service. In typical 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 the Jamesbury Valv-Powr Series VPVL actuator must be carried out by Valmet or competent personnel. Maintenance procedures are given in the IMO.

After the maintenance is completed, verify the functionality of the actuator 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 553 (Mod D)
[2] Technical bulletin A111-5 (Mod D)
[3] SIL certificate TUV 968/V 1215.00/21
[4] IEC 61508 – Part 1 to 7 (2010)
[5] Neles ValvGuard 7VG9H70, 7VG9F70, 7LCP9H70 and 7RCI9H270

Appendix 1. 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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