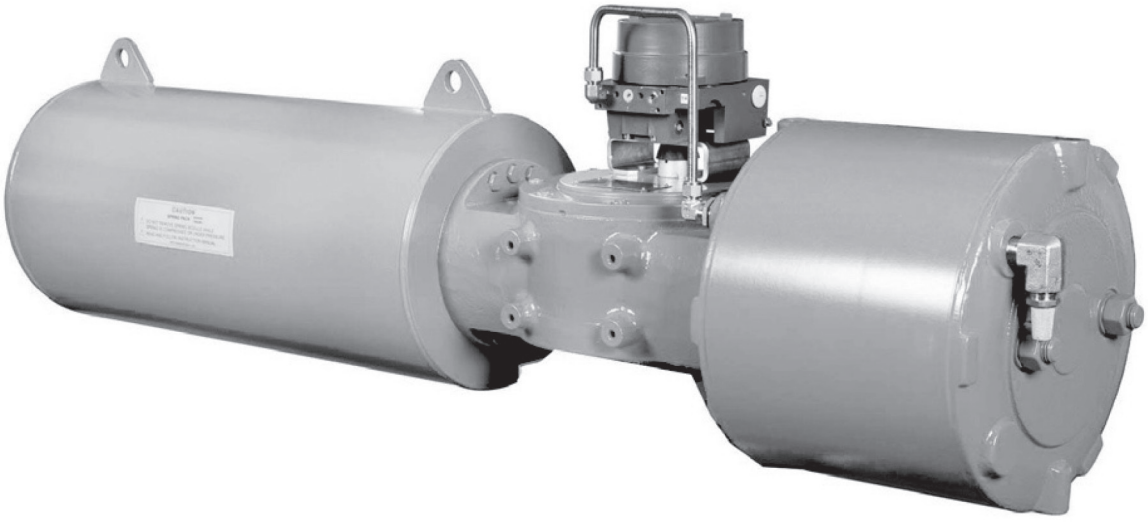
Neles™ high performance heavy duty scotch yoke actuator Series N1

Rev. 1.0

Safety Manual



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SIL Safety Manual for NELES N1-Series Actuators

1. Purpose

This safety manual provides information necessary to design, install, verify and maintain a Safety Instrumented Function (SIF) utilizing the NELES N1-Series Actuator.

2. Introduction

This safety manual provides information necessary to design, install, verify and maintain a Safety Instrumented Function (SIF) utilizing the NELES N1-Series Actuator. This manual provides necessary requirements for meeting the IEC 61508 or IEC 61511 functional safety standards.

2.1 Terms and Abbreviations

Safety: Freedom from unacceptable risk of harm.

Functional Safety: The ability of a system to carry out the actions necessary to achieve or to maintain a defined safe state for the equipment / machinery / plant / apparatus under control of the system.

Basic Safety: The equipment must be designed and manufactured such that it protects against risk of damage to persons by electrical shock and other hazards and against resulting fire and explosion. The protection must be effective under all conditions of the nominal operation and under single fault condition.

Safety Assessment: The investigation to arrive at a judgment - based on the facts - of the safety achieved by safety-related systems.

Fail-Safe State: State where valve actuator is de-energized and spring is extended.

Fail Safe: Failure that causes the valve to go to the defined fail-safe state without a demand from the process.

Fail Dangerous: Failure that does not respond to a demand from the process (i.e. being unable to go to the defined fail-safe state).

Fail Dangerous Undetected: Failure that is dangerous and that is not being diagnosed by automatic stroke testing.

Fail Dangerous Detected: Failure that is dangerous but is detected by automatic stroke testing.

Fail Annunciation Undetected: 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 Detected: 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 No Effect: Failure of a component that is part of the safety function but that has no effect on the safety function.

Low demand mode: Mode, where the frequency of demands for operation made on a safety-related system is no greater than twice the proof test frequency.

2.2 Acronyms

FMEDA: Failure Modes, Effects and Diagnostic Analysis

HFT: Hardware Fault Tolerance

MOC: Management of Change. These are specific procedures often done when performing any work activities in compliance with government regulatory authorities.

PFDAVG: Average Probability of Failure on Demand

SFF: Safe Failure Fraction, the fraction of the overall failure rate of a device that results in either a safe fault or a diagnosed unsafe fault.

SIF: Safety Instrumented Function, a set of equipment intended to reduce the risk due to a specific hazard (a safety loop).
Guidelines/References:

- Safety Integrity Level Selection - Systematic Methods Including Layer of Protection Analysis, ISBN 1-55617-777-1, ISA
- Control System Safety Evaluation and Reliability, 2nd Edition, ISBN 1-55617-638-8, ISA
- Safety Instrumented Systems Verification, Practical Probabilistic Calculations, ISBN 1-55617-909-9, ISA

2.3 Reference Standards

2.3.1 Functional Safety

- IEC 61508: 2010 Functional safety of electrical/electronic/ programmable electronic safety-related systems
- ANSI/ISA 84.00.01-2004 (IEC 61511 Mod.) Functional Safety - Safety Instrumented Systems for the Process Industry Sector

SIL: Safety Integrity Level, discrete level (one out of a possible four) for specifying the safety integrity requirements of the safety functions to be allocated to the E/E/PE safety-related systems where Safety Integrity Level 4 has the highest level of safety integrity and Safety Integrity Level 1 has the lowest.

SIS: Safety Instrumented System - Implementation of one or more Safety Instrumented Functions. A SIS is composed of any combination of sensor(s), logic solver(s), and final element(s).

2.3.2 Related Literature

Hardware Documents:
NELES N1-Series Actuator Technical Bulletin – 6N1 20 en – 8/2020
NELES N1-Series Actuator Installation, Maintenance and Operating Instructions – 6N1 70 en.8/2020

3. Device Description

The NELES N1-Series actuator is a Scotch-yoke type of actuator. This actuator is excellent for valves having break torque much higher than run torque. This is cost effective and does not require periodic servicing.

The N1-Series actuator can be installed on rotary-shaft valve bodies for throttling or on-off applications. The yoke is supported on life time lubricated ball bearings which have a very low coefficient of friction. The wear and tear of the yoke is reduced due to the right alignment and support provided by the bearings.

The NELES N1-Series actuator delivers several operations and maintenance advantages. It has an inherent failsafe position on loss of operating air. The N1-Series Actuator works on the scotch-yoke principle. This actuator makes use of Quad Seals which provide a longer service life and low wear and tear. They also have the grease retaining groove.

The Needle bearing, Flexi joint and the hardened thrust pin bearing are all incorporated into the actuator for longer life and smoother operation.

The N1-Series actuator is available in various sizes, upto maximum torque 600000 Nm.

The N1-Series actuator is used with a rotary valve to control process fluids that can be used in a wide variety of applications. They are typically used with other interface components (valve positioner or solenoid valve) to provide a final element subsystem for a Safety Instrumented Function (SIF). The N1-Series actuator provides ISO 5211 mounting for simplified valve mounting.

4. Designing a SIF Using a NELES N1-Series Actuator

4.1 Safety Function

When the N1-Series actuator is de-energized, the actuator and valve shall move to its fail-safe position in case of spring return actuator and stay put for double acting actuator. Depending on which configuration is specified fail-closed or fail-open or stay put, the actuator will rotate the valve disk to close off the flow path through the valve body or open the flow path through the valve body or stay put condition.

The N1-Series actuator is intended to be part of final element subsystem as defined per IEC 61508 and the achieved SIL level of the designed function must be verified by the designer.

4.2 Environmental limits

The designer of an SIF must check that the product is rated for use within the expected environmental limits. Refer to the NELES N1-Series Actuator catalogue and IOM for environmental limits.

4.3 Application limits

The N1-Series actuator materials of construction are specified in the catalogue. A range of materials are available for various applications. The name tag will indicate what the materials of construction are for a specific actuator. It is especially important that the designer check for material compatibility considering on-site chemical contaminants and air supply conditions. If the N1 actuator is used outside of the application limits or with incompatible materials, the reliability data provided becomes invalid.

4.4 Diagnostic Response Time

A N1-Series actuator does not perform any automatic diagnostic functions by itself and therefore it has no diagnostic response time of its own. However, automatic diagnostics of the final control subsystem may be performed such as Partial Valve Stroke Testing (PVST). This typically will exercise the actuator and valve over a small percentage of its normal travel without adversely affecting the flow through the valve. If any failures of this PVST are automatically detected and annunciated, the diagnostic response time will be the PVST interval time. The PVST must be performed 10 times more often than an expected demand in order for credit to be given for this test. Typically this test could be performed monthly or weekly.

4.5 Design Verification

A detailed Failure Mode, Effects, and Diagnostics Analysis (FMEDA) report is available from ValmetS. This report details all failure rates and failure modes as well as the expected lifetime.

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 architecture, proof test interval, proof test effectiveness, any automatic diagnostics, average repair time and the specific failure rates of all products included in the SIF. Each subsystem must be checked to assure compliance with minimum hardware fault tolerance (HFT) requirements. The exida tool is recommended for this purpose as it contains accurate models for the N1-Series actuator and its failure rates.

When using a N1-Series actuator 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 the FMEDA report is only valid for the useful lifetime of a N1-Series actuator. The failure rates will increase after this time period. Reliability calculations based on the data listed in the FMEDA report for mission times beyond the useful lifetime may yield results that are too optimistic, i.e. the calculated Safety Integrity Level will not be achieved.

4.6 SIL Capability Systematic Integrity

4.7 Connection of the NELES N1-Series Actuator to the SIS Logic-solver

The final element subsystem (consisting of a positioner, N1-Series actuator, and a rotary valve) is connected to the safety rated logic solver which is actively performing the Safety Function as well as any automatic diagnostics designed to diagnose potentially dangerous failures within the N1-Series actuator, valve and any other final element components (i.e. Partial Valve Stroke Test).

The product 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 level higher than stated without "prior use" justification by the end user or diverse technology redundancy in the design.

4.8 Random Integrity

The NELES N1-Series actuator is classified as Type A devices according to IEC 61508, having a hardware fault tolerance of 0. The complete final element subsystem, with a N1-Series actuator and rotary valve as the final control element, will need to be evaluated to determine the Safe Failure Fraction of the subsystem. If the SFF for the entire final element subsystem is between 60% and 90%, a design can meet SIL 2 @ HFT=0.

4.9 Safety Parameters

For detailed failure rate information refer to the Failure Modes, Effects and Diagnostic Analysis Report for the NELES N1-Series actuator.

4.10 General Requirements

The system's response time shall be less than process safety time. The final control element subsystem needs to be sized properly to assure that the response time is less than the required process safety time. The N1-Series actuator will move the valve to its safe state in less than the required SIF's safety time under the specified conditions.

All SIS components including the N1-Series actuator must be operational before process start-up.

The user shall verify that the N1-Series actuator is suitable for use in safety applications.

Personnel performing maintenance and testing on the N1-Series actuator and valve shall be competent to do so. Results from the proof tests shall be recorded and reviewed periodically.

The useful life of the N1-Series actuator is discussed in the Failure Modes, Effects and Diagnostic Analysis Report for the N1 actuator.

5. FMEDA Results

Table 1: Failure rates for Static Applications with Good Maintenance Assumption in FIT (SSI=2)

Device / Configuration	λSD	λSU	λDD	λDU	#	E
N1-Series actuator, Spring Return (Single Acting)	0	181	0	403	956	215
N1-Series Actuator, Double Acting	0	0	0	483	683	257
N1 Actuator, Spring Return (Single Acting) with PVST	179	2	264	139	956	215
N1-Series Actuator, Double Acting with PVST	0	0	324	159	683	257

Table 2: Failure rates for Dynamic Applications with Good Maintenance Assumption in FIT (SSI=2)

Device / Configuration	λSD	λSU	λDD	λDU	#	E
N1-Series actuator, Spring Return (Single Acting)	0	192	0	252	1036	232
N1-Series Actuator, Double Acting	0	0	0	371	738	273
N1-Series Actuator, Spring Return (Single Acting) with PVST	190	2	174	78	1036	232
N1-Series Actuator, Double Acting with PVST	0	0	258	113	738	273

6. Installation and Commissioning

6.1 Installation

The NELES N1-Series actuator must be installed per standard practices outlined in the instruction manual.

The environment must be checked to verify that environmental conditions do not exceed the ratings.

The N1-Series actuator must be accessible for physical inspection.

6.2 Physical Location and Placement

The N1-Series actuator shall be accessible with sufficient room for the valve, actuator, pneumatic connections, any other components of the final control element. Provisions shall be made to allow for manual proof testing.

Pneumatic piping to the actuator shall be kept as short and straight as possible to minimize the airflow restrictions and potential clogging. Long or kinked pneumatic tubes may also increase the valve closure time.

The N1-Series actuator shall be mounted in a low vibration environment. If excessive vibration can be expected special precautions shall be taken to ensure the integrity of pneumatic connectors or the vibration should be reduced using appropriate damping mounts.

6.3 Pneumatic Connections

Recommended piping for the inlet and outlet pneumatic connections to the N1-Series actuator is stainless steel or PVC tubing. The length of tubing between the N1-Series actuator and the control device, such as a solenoid valve, shall be kept as short as possible and free of kinks.

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 installation manual. The process air capacity shall be sufficient to move the valve within the required time.

7. Operation and Maintenance

7.1 Suggested Proof Test

The objective of proof testing is to detect failures within a N1-Series actuator that are not detected by any automatic diagnostics of the system. Of main concern are undetected failures that prevent the Safety Instrumented Function from performing its intended function.

The frequency of proof testing, or the proof test interval, is to be determined in reliability calculations for the Safety Instrumented Functions for which a N1-Series actuator is applied. The proof tests must be performed more frequently than or as frequently as specified in the calculation in order to maintain the required Safety Integrity of the Safety Instrumented Function.
The proof test shown in table 1 is recommended. The results of the proof test should be recorded and any failures that are detected and that compromise functional safety should be reported to Valmet. The suggested proof test consists of a full stroke of the N1-Series actuator.

Table 3: Suggested Proof Test

Step	Action
1.	Bypass the safety function and take appropriate action to avoid a false trip.
2.	Interrupt or change the air supply/input to the Actuator to force the Actuator and Valve to the Fail-Safe state and confirm that the Safe State was achieved and within the correct time. **Note:** This test for all failures that could prevent the functioning of the Control Valve as well as the rest of the final control elements.
3.	Inspect the Actuator and Valve for any leaks, visible damage or contamination.
4.	Re-store the air supply to the Actuator and inspect the Actuator for any leaks, visible damage or contamination and confirm that the normal operating state was achieved.
5.	Remove the bypass and otherwise restore normal operation

7.2 Proof Test Coverage

The Proof Test Coverage for the various product configurations is given in Table 4.

Table 4: Proof Test Result – N1-Series Valve Actuator – Static Application.

Device	λDUPT (FIT)	Proof Test Coverage	
		No PSVT	With PVST
N1-Series Valve Actuator - Spring Return	30	93%	78%
N1-Series Valve Actuator – Double Acting	38	92%	76%

Table 5: Proof Test Result – N1 Series Valve Actuator – Dynamic Application.

Device	λDUPT (FIT)	Proof Test Coverage	
		No PSVT	With PVST
N1-Series Valve Actuator - Spring Return	15	94%	81%
N1-Series Valve Actuator – Double Acting	27	93%	76%

7.3 Repair and replacement

Repair procedures in the N1-Series actuator instruction manual must be followed.

7.4 Useful Life

According to section 7.4.9.5 of IEC 61508-2, a useful lifetime, based on experience, should be assumed.

Although a constant failure rate is assumed by the probabilistic estimation method, this only applies provided that the useful lifetime of components is not exceeded. Beyond their useful lifetime the result of the probabilistic calculation method is therefore meaningless, as the probability of failure significantly increases with time. The useful lifetime is highly dependent on the subsystem itself and its operating conditions. This assumption of a constant failure rate is based on the bathtub curve. Therefore it is obvious that the PFDAVG calculation is only valid for components that have this constant domain and that the validity of the calculation is limited to the useful lifetime of each component.

It is the responsibility of the end user to maintain and operate the Valve Actuator per manufacturer's instructions. Furthermore regular inspection should show that all components are clean and free from damage. A major factor influencing the useful life is the air quality.

Based on general field failure data a useful life period of approximately 10 to 15 years is expected for the NELES N1-Series and ECF Series Valve Actuators.

When plant experience indicates a shorter useful lifetime than indicated, the number based on plant experience should be used.

7.5 Manufacturer Notification

Any failures that are detected and that compromise functional safety should be reported to Valmet.

The person(s) performing the proof test of a N1-Series actuator should be trained in SIS operations, including bypass procedures, valve maintenance and company Management of Change procedures. No special tools are required.

Note: Neither Valmet nor any of their affiliated entities assumes responsibility for the selection, use, or maintenance of any product. Responsibility for the selection, use, and maintenance of any product remains with the purchaser and end-user.

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