SAFETY MANUAL

SERIES 514 & 515

with NAMUR INTERFACE

PNEUMAX S.p.A.
Società unipersonale soggetta a direzione e coordinamento di PNEUMAX HOLDING S.p.A.
Sede operativa: Via Cascina Barbellina, 10 - 24050 Lurano (BG) - Italy
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Cap. Soc. € 2.700.000 I.V. - C.F. e P. Iva 02893330163 - Reg. Imprese MI n. 02893330163 - R.E.A. MI 1670562 - R.E.A. BG n. 331626 - N. Ident. IT 02893330163
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Revision			
Date	**Rev. no.**	**Section**	***Notes***
13/06/2025	00	N/A	First issue
31/10/2025	02	1.8 & 3.7	Added acronyms in Section 1.8 and added considerations in Section 3.7

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1 INTRODUCTION

1.1 Scope

The purpose of this Safety Manual is to document all the information specifically related to the safety aspect of the following products:

Series 514 & 515 Valves and Solenoid Valves with NAMUR interface:

- **Monostable pneumatic-differential valve**
- **Monostable pneumatic-spring valve**
- **Bistable double pneumatic valve**
- **Bistable double solenoid valve**
- **Monostable solenoid-differential valve**
- **Monostable solenoid-spring valve**
- **Universal Valve**

These valves are certified for use as component in Safety Instrumented Systems (SIS). This Safety Manual is required in order to enable the integration of the valves into a Safety Instrumented System with the objective to be in compliance with the requirements of IEC 61508-2, Annex D.

The information contained in this Safety Manual is valid for the models/series indicated in section 2.1 of this Safety Manual.

This Safety Manual defines, in particular:

- Environmental conditions in which the valves and solenoid valves can operate,
- Parameters related to Functional Safety,
- Tests, checks, and periodic maintenance.

For the purpose of its correct use, this Safety Manual shall be consulted in conjunction with:

- I081-IT-EN (General Instruction Manual for Series 514 & 515 Valves)
- TX082004-IST (ATEX Installation, use and maintenance instructions for valves and solenoid valves)
- CAT16 (Process Automation Technology Catalogue)

CAUTION: A copy of this Safety Manual must be stored by the User and used in conjunction with the product for all useful life of the product itself.

1.2 Disclaimer and warning

By using Series 514 & 515 Valves and Solenoid Valves with NAMUR interface, from now on referred also as valves in general, it hereby signifies that the User has read this disclaimer and warning carefully, and that understands and agrees to abide by the terms and conditions herein.
Integrating these valves into a Safety Instrumented System (SIS), the User agrees that they are solely responsible for their own conduct while using them, and for any consequences thereof.
The User agrees to use these products only for purposes that are proper and in accordance with all applicable laws, rules, and regulations, and all terms, safety prescriptions and precautions, practices, policies and all additional revisions or guidelines that PNEUMAX has made and may make available.

IMPORTANT: PNEUMAX won't be held liable for severe personal injuries, damage to property or environment caused by any of the followings:

- Unqualified personnel working on the valves.
- Override or bypassing of the Safety Function.
- Non-compliance with the instructions detailed in this Safety Manual.

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1.3 Skill level required

This manual is addressed to qualified personnel authorized for installation, operation, and maintenance of Series 514 & 515 Valves and Solenoid Valves with NAMUR interface. As required by IEC 61508-1 standard, an appropriate level of competence shall be taken into account considering all relevant factors including safety engineering knowledge appropriate to the technology, knowledge of safety regulatory framework and previous experience.

1.4 Product Support and Service

Please refer to Pneumax Quality, Technical and Customer Claim Offices.

1.5 Related Documents

Id.	Code	Title
[D1]	I081-IT-EN	General Instruction Manual for Series 514 & 515 Valves
[D2]	TX082004-IST	ATEX Installation, use and maintenance instructions for Series 514 & 515 valves and solenoid valves
[D3]	TX082004-DC	EU/UK Declaration of Conformity
[D4]	CAT16	Process Automation Technology Catalogue

Related document [D2] and [D3] are available only for products compliant to Directive 2014/34/EU.

1.6 Reference Standards

Id.	Code	Title
[S1]	IEC 61508:2010 Parts 1-2 and 4-7	Functional safety of electrical/electronic/programmable electronic safety-related systems
[S2]	IEC 654-1:1993	Industrial-process measurements and control equipment – Operating conditions - Part 1: Climatic conditions
[S3]	IEC 61511:2016 Part 1–3 + Part 1-A1:2017	Functional Safety – Safety Instrumented Systems for the process industry sector

1.7 Terms and abbreviations

For terms and definitions, reference is made to IEC 61508-4.

1.8 Acronyms

BPCS	Basic Process Control System
CCF	Common Cause Failure
DC	Diagnostic Coverage
DETT	De-energise to trip
EMC	Electromagnetic Compatibility
ETT	Energise to trip
FMEDA	Failure Modes, Effects and Diagnostics Analysis
HFT	Hardware Fault Tolerance
IOM	Installation, Operation, and Maintenance
MOC	Management Of Change
MRT	Mean Repair Time
PFD_{AVG}	Average Probability of dangerous Failure on Demand
PST	Partial Stroke Test
PTC	Proof Test Coverage

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PVST	Partial Valve Stroke Test
SC	Systematic Capability
SFF	Safe Failure Fraction
SIF	Safety Instrumented Function
SIL	Safety Integrity Level
SIS	Safety Instrumented System
SRS	Safety Requirements Specification
STR	Spurious Trip Rate

2 PRODUCT DESCRIPTION

2.1 Detailed models

Series	Ways / Position	Function
514	5/2	Pneumatic – Spring
		Pneumatic – Differential
		Pneumatic – Pneumatic
		Solenoid – Spring
		Solenoid – Differential
		Solenoid – Solenoid
	4/2	Pneumatic – Spring
		Pneumatic – Differential
		Pneumatic – Pneumatic
		Solenoid – Spring
		Solenoid – Differential
		Solenoid – Solenoid
	3/2	Pneumatic – Spring
		Pneumatic – Differential
		Pneumatic – Pneumatic
		Solenoid – Spring
		Solenoid – Differential
		Solenoid – Solenoid
515	5/2	Pneumatic – Spring
		Pneumatic – Differential
		Pneumatic – Pneumatic
		Solenoid – Spring
		Solenoid – Differential
		Solenoid – Solenoid

Check document [D4] for detailed product coding scheme.
Universal valve version, exclusive for Series 514, includes in the supply package dedicated plates for 3/2, 4/2 & 5/2 configurations according to the product code.

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2.2 Main Technical Data

Construction Features	
Body	Aluminium
Spacers	Technopolymer
Seals	Nitrile Rubber
Spring	Stainless Steel
Operators	Technopolymer
Spool	Stainless Steel
Screws	Zinc coated steel / Stainless Steel

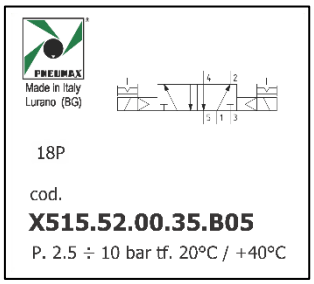
Functional Features	
Working fluid	Filtered air. No lubrication needed, if applied it shall be continuous.
Maximum working pressure (bar)	10 bar
Working Temperature (°C)	According to product version
Rated Voltage (V)	According to product version
Connection ports	G1/4" – 1/4 NPT

Check related documents in section 1.5 for further information.

2.3 Service condition limitations (Environmental limits)

Please refer to the information indicated on the product label and product documentation regarding pressure, temperature and other conditions of use. It is important to not use the product outside the indicated operating limits.

Check the following image for an example of a product label:



Models compliant to the Directive 2014/34/UE – ATEX shall have an additional label like the following example:

Check documents [D2] for specific conditions of use for ATEX valves.

IMPORTANT: The designer of the SIF must check that the product is rated for use within the expected environmental limits, maximum working pressure and temperature.

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IMPORTANT: The materials of construction of the devices are specified on the dedicated products catalogue (document [D4]). It is especially important that the designer of the SIF check for material compatibility considering on-site chemical contaminants and air (as appropriate) supply conditions. If the valves are used outside the application limits or with incompatible materials, the reliability data and predicted SIL capability becomes invalid.

3 RELIABILITY AND SAFETY CHARACTERISTICS

3.1 Safety Function(s)

The reliability parameters have been obtained with reference to the following Safety Function(s).

Id.	Safety Function	Safety Function Description
[SF1]	de-energised to trip (DETT)	The valve moves to the predefined safe state when de-energised.
[SF2]	energised to trip (ETT)	The valve moves to the predefined safe state when energised.

The following table summarizes the applicable safety function(s) for available versions.

Valve version	[SF1] (DETT)	[SF2] (ETT)
Pneumatic / Differential	YES	/
Solenoid / Differential		
Pneumatic / Spring	YES (fail safe)	YES
Solenoid / Spring		
Pneumatic / Pneumatic	/	YES
Solenoid / Solenoid		

3.2 Demand mode

Low Demand mode, as per IEC 61508 [S1], part 4, subclause 3.5.16 (i.e., the Safety Function is only performed on demand, with a frequency of demands no greater than once per year).

3.3 Product Classification

The valves are classified as Type A equipment, as per IEC 61508 [S1], part 2.

3.4 Useful Time

Based on general field failure data and a low demand mode of operation, for standard service conditions the expected useful life of the valves can be considered 10 years.

WARNING: The value indicated is valid only if prescriptions of this Safety Manual are fully respected.

3.5 Mean Repair Time (MRT)

The Mean Repair Time (MRT) is 2 hours.
This is an estimation for the valve replacement considering skilled personnel for maintenance, availability of spare parts and adequate tools on site. Contact the manufacturer for maintenance and repair of internal parts. Pneumax may not be hold accountable for any malfunctions related to reparations done by the end-user.

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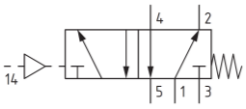
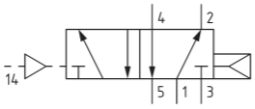
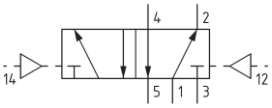
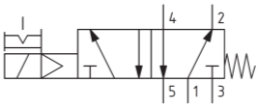
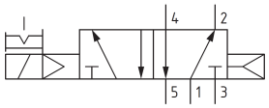
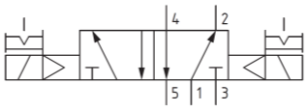
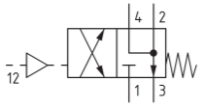
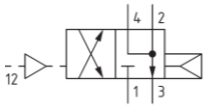
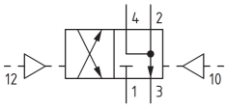
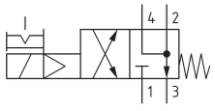
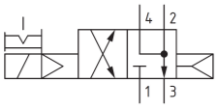
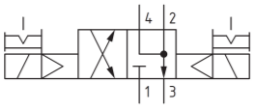
3.6 Failure Rates

With reference to the Safety Function(s) previously specified, a FMEDA has been carried out.
The following failure rates have been obtained.

Series	Ways / Positions	Function	Pneumatic Diagram	Operating Mode	λ_S	λ_{DU}	λ_{DD}
514	5/2	Pneumatic – Spring		DETT	89	122	-
				ETT	55	145	-
		Pneumatic – Differential		DETT	89	117	-
		Pneumatic – Pneumatic		ETT	55	132	-
		Solenoid – Spring		DETT	164	187	-
				ETT	65	270	-
		Solenoid – Differential		DETT	164	182	-
		Solenoid – Solenoid		ETT	65	322	-
	4/2	Pneumatic – Spring		DETT	122	66	-
				ETT	-	148	-
		Pneumatic – Differential		DETT	122	61	-
		Pneumatic – Pneumatic		ETT	88	77	-
		Solenoid – Spring		DETT	197	131	-
				ETT	10	273	-
		Solenoid – Differential		DETT	197	126	-
		Solenoid – Solenoid		ETT	99	266	-

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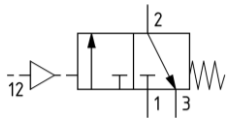
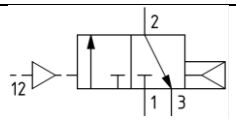
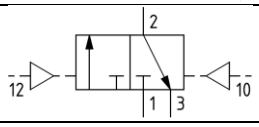
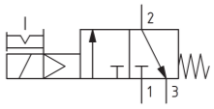
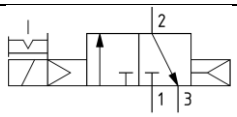
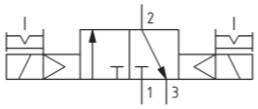
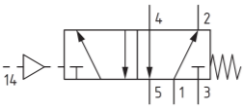
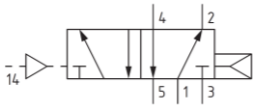
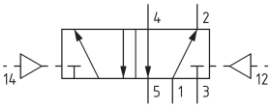
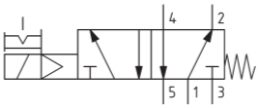
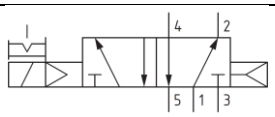
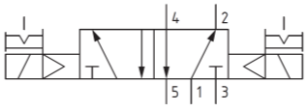
Series	Ways / Positions	Function	Pneumatic Diagram	Operating Mode	λ_S	λ_{DU}	λ_{DD}
	3/2	Pneumatic – Spring		DETT	122	66	-
				ETT	-	148	-
		Pneumatic – Differential		DETT	122	61	-
		Pneumatic – Pneumatic		ETT	88	77	-
		Solenoid – Spring		DETT	197	131	-
				ETT	10	273	-
		Solenoid – Differential		DETT	197	126	-
		Solenoid – Solenoid		ETT	99	266	-
515	5/2	Pneumatic – Spring		DETT	80	113	-
				ETT	46	137	-
		Pneumatic – Differential		DETT	80	108	-
		Pneumatic – Pneumatic		ETT	46	124	-
		Solenoid – Spring		DETT	156	178	-
				ETT	57	262	-
		Solenoid – Differential		DETT	156	173	-
		Solenoid – Solenoid		ETT	57	313	-

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All failure rates are in FIT (Failure In Time 1 FIT = 1 failure/10^9 hours).
The dangerous undetected failure rate λ_{DU} is due to faults that cause the failure of the Safety Function(s) and that are not detected by the diagnostic tests.
The dangerous detected failure rate λ_{DD} is due to faults causing the failure of the Safety Function(s) but that are detected by diagnostic tests.
The safe failure rate λ_S is due to faults that result in the spurious operation of the Safety Function or in the increase of the probability of spurious operation of the Safety Function.

The failure rates shall be used for PFD_{AVG} estimation, taking into consideration parameters such as redundancy, diagnostic capability (provided by external devices such as Partial Stroke Test devices, if any, or introduced by the whole Safety Instrumented System), Proof Test and its effectiveness, Mean Repair Time (MRT), up to the maintenance capability and its minimum characteristics.

The assumptions associated with these failure rates are as follows:

- Failure rates are constant over the expected lifetime specified in section 3.4 of this Safety Manual,
- Wear-out or infant mortality contributions are not included.

The above failure rates are valid:

- For the service conditions listed in section 2.3 of this Safety Manual,
- If periodic test and maintenance are properly carried out.

3.7 Hardware safety integrity (Architectural constraints)

In compliance with Route 1_H (see IEC 61508 [S1], part 2, subclause 7.4.4.2), the valves can be used in a single channel configuration (i.e., HFT = 0) up to SIL 1 or SIL 2 depending on the valve models and safety functions, and in consideration of SFF values.

In compliance with Route 2_H (see IEC 61508 [S1], part 2, subclause 7.4.4.3), the valves can be used in a single channel configuration (i.e., HFT = 0) up to SIL 2.

Faults detectable through a Partial Stroke Test (PST) can be considered substantially equivalent to those identified by a Full Stroke Test. Therefore, it can be assumed that the diagnostic coverage of the PST is close to the Proof Test Coverage (PTC) and, in any case, not less than 90%. It is a responsibility of the integrator or end user, for each specific project, to ensure that the PST has suitable characteristics in terms of automation and frequency, allowing it to be classified as a diagnostic test for the evaluation of Safe Failure Fraction (SFF) and for the use of this device with HFT=0 in SIL 3 systems, in accordance with Route 1H of IEC 51508-2.

Therefore, if the Integrator / End User has verified under their own responsibility the fulfilment of the conditions for considering PST as diagnostic test, the products can be used up to:

- SIL 2 without external diagnostic tests (HFT=0),
- SIL 3 with external diagnostic tests (HFT=0) and
- SIL 3 with HFT=1.

Check the systematic capability SC=3 of section 3.8 of this safety manual.

3.8 Systematic safety integrity (Systematic Capability)

The valves have met manufacturer design process requirements of SIL 3 (evaluated according to Route 1_S of IEC 61508-2 [S1]).
This Systematic Capability is guaranteed only if the User:

- Uses the product according to its instructions for use [D1], [D2] and to this Safety Manual,
- Uses the product in the appropriate environment, as per section 2.3 of this Safety Manual.

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WARNING: A Safety Instrumented Function (SIF) designed with this product must not be used at a SIL higher than that stated, unless diverse technology in the design of the SIF is used (see IEC 61508 [S1], part 2, subclause 7.4.3).

3.9 Common Cause Failures

The valve has a single channel configuration, i.e., HFT = 0.
When carrying out PFD_{AVG} calculations for redundant architectures, the following Common Cause factors should be used:

- $\beta = \beta_D = 10\%$

The above values are referred to 1oo2 architecture.
The values for other architectures shall be calculated according to IEC 61508 [S1], part 6, table D.5.
The above values are calculated in the hypothesis of redundancy without diversity.

4 INSTALLATION & COMMISSIONING

4.1 Installation

The valves must be installed as per standard practices outlined in the manual [D1], [D2] and product documentation [D4].
The environment must be checked to verify that environmental conditions do not exceed the ratings (see also section 2.3 of this Safety Manual).
The product must be accessible for physical inspection.

4.2 Physical location and placement

The valves shall be accessible with sufficient room for pneumatic connections.
They shall be mounted in a low vibration environment. If excessive vibration can be expected, then special precautions shall be taken to ensure the integrity of pneumatic connectors, or the vibration should be reduced using appropriate damping mounts.

IMPORTANT: Every form of tampering and unauthorized intervention on the product is strictly prohibited. Such actions will void the warranty of and the conformity of the product.

IMPORTANT: For valves with manual command, the valve state is maintained until another manual command occurs, operator intervention is needed. This action, when necessary, must be permitted only in case of authorized operations and when all appropriate safety measures are taken.

5 OPERATION & MAINTENANCE

5.1 Proof test

5.1.1 General

Purpose of the Proof Test is to reveal (all, or as close as possible to all) the failures not detected by the diagnostic tests (if any).

5.1.2 Disclaimer

The content of this chapter is relevant for reliability tests only.
Refer to manual [D1], [D2] or product catalogue [D4] for further information about the product maintenance, handling and storage. In case of any doubt, contact Pneumax S.p.A. offices.

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5.1.3 Suggested Proof Test Interval

The suggested Proof Test interval is 1 year. The choice of the Proof Test interval, anyway, is under User's responsibility and should take in account (at least) the followings:

- PFD_{AVG} target,
- Safety Function,
- Service conditions.

5.1.4 Execution of the test

The test is considered passed if the following conditions are satisfied:

Safety Function	Description
[SF1] DETT	De-energise the coil and check that the valve changes completely its state / position within 1s or 2s.
[SF2] ETT	Energise the coil and check that the valve changes completely its state / position within 1s or 2s.

5.1.5 Test set-up and test facilities

The test shall be carried out on the valve as installed.
It can be automated, if carried out by using a Logic Solver or a Partial Stroke Test device.
The procedure carried out without automated means might lead to a lower test coverage.

5.1.6 Proof Test Coverage

In case of Proof Test:

- automated, and
- supervised by trained and skilled operators, and
- carried out with calibrated measuring instruments,

the Proof Test Coverage (PTC) could be estimated in a value close to 100%.
Otherwise, the Proof Test Coverage (PTC) should be estimated by the User considering measurement inaccuracies as well as the reliability/competence of the operator.

5.1.7 Further Inspections

Proper inspection should be carried out on the valve to ensure that (as minimum):

- there are no external leakages,
- dust and dirt are removed from surfaces,
- the product is exempted from damages, even accidental.

Furthermore, for valves compliant to Directive 2014/34/EU, check the indications reported on document [D2].

5.1.8 Notification of failures

In case of detection of a failure, it is under User's responsibility to take action according to IEC 61508 [S1] and IEC 61511 [S3], if applicable.
PNEUMAX must be informed when the valves are required to be replaced due to failure. The occurred failure shall be documented and reported to PNEUMAX Quality & Technical representatives.

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6 DISPOSAL

The product must be disposed of in accordance with current regulations. It must not be dispersed into the environment.

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