

 PNEUMAX	SAFETY MANUAL for SERIES 1700 STEEL LINE REGULATORS & FILTER REGULATORS		N.	TF232003-FRV-MA
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SAFETY MANUAL **SERIES 1700 STEEL LINE** **REGULATORS &** **FILTER REGULATORS**

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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 1700 STEEL LINE SERIES REGULATORS & FILTER REGULATORS

These products are certified for use as component in Safety Instrumented Systems (SIS). This Safety Manual is required to enable the integration of the regulators and filter regulators 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 document.

This Safety Manual defines, in particular:

- Environmental conditions in which regulators and filter regulators can operate,
- Parameters related to Functional Safety,
- Tests, checks, and periodic maintenance.

For its correct use, this Safety Manual shall be consulted in conjunction with the documents indicated in section 1.5.

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 these regulators and filter regulators, 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 products into a Safety Instrumented System (SIS), the User agrees that is 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 regulators or filter regulators,
- Override or bypassing of the Safety Function,
- Non-compliance with the instructions detailed in this Safety Manual.

1.3. Skill level required

This manual is addressed to qualified personnel authorized for installation, operation, and maintenance of Regulators & Filter Regulators series Steel Line. 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.

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1.5. Related Documents

Id.	Code	Title
[D1]	TF232003-IST	Installation, use and maintenance instructions for stainless steel air service units series
[D2]	I038IT-GB	IOM for Steel Line Series Air Service Units
[D3]	CAT16	Process Automation Technology Catalogue

Related document D1 is 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
EUC	Equipment under control
FMEDA	Failure Modes, Effects and Diagnostics Analysis
FST	Full Stroke Test
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
PFH	Probability of Failure per Hour
PST	Partial Stroke Test
SAT	Site Acceptance 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

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2. PRODUCT DESCRIPTION

2.1. Detailed models

Product Code	Description
#SS172#R### - #SF172#R### #SS173#R### - #SF173#R### #SS174#R### - #SF174#R###	Regulators
#SS172#E##### - #SF172#E##### - #SM172#E##### #SS173#E##### - #SF173#E##### - #SM173#E##### #SS174#E##### - #SF174#E##### - #SM174#E#####	Filter Regulators

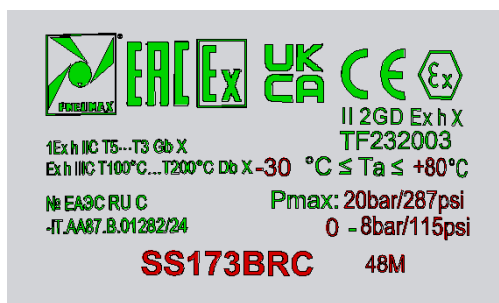
2.2. Main Technical Data

Feature	Description
Size	3 sizes available with connections from ¼" to 1"
Body, bowl and regulation mechanism	AISI 316L
Caseback regulator	AISI 316L
Adjustment screw, locking nut and fastening screws	AISI 316L
Internal Components	AISI 316L
Spring	AISI 316L
Seals	According to the product version: NBR NBR for Low temperature FPM – HNBR for high temperature EFDM Silicone - PU

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 product label lay-out:



The information indicated on the lay-out will be indicated on the product through lasering. Specific information related to the product version such as product code, temperature and pressure varies.

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 [3]). 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 device is used outside the application limits or with incompatible materials, the reliability data and predicted SIL capability becomes invalid.

IMPORTANT: Every form of tampering or unauthorised intervention on the product is strictly forbidden. Such actions may void the warranty and the product conformity. In particular, the setting of the regulation screw must be modified only in case of authorised operation and when all suitable safety measures were taken.

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.	Demand Mode of Operation	Safety Function Description
[SF1]	High demand / Continuous mode	To guarantee a controlled pressure downstream to pressurize the chamber of an actuator.
[SF2]	Low demand mode	When part of emergency systems operating in DETT mode, not to hinder the emergency manoeuvre.

3.2. Demand mode

As per IEC 61508 [S1], part 4, subclause 3.5.16, according to the safety function(s):

- Low demand mode (i.e., the Safety Function is only performed on demand, with a frequency of demands no greater than once per year),
- High demand mode (i.e. the safety function is performed on demand with a frequency of demands greater than one per year),
- Continuous mode (i.e. the safety function retains the EUC in a safe state as part of normal operation).

3.3. Product Classification

Air service units regulators and filter regulators series 1700 Steel Line are classified as Type A equipment, as per IEC 61508 [S1], part 2.

3.4. Useful Time

Based on general field failure data for standard service conditions the expected useful life of the devices can be considered an average of 20 years.

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

3.5. Mean Repair Time (MRT)

The Mean Repair Time (MRT) is 2h.

This is an estimation for an air service unit 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.

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.

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Models	Description	Safety Function	λ_s	λ_{DU}	λ_{DD}
#SS172#R### - #SF172#R###	Regulator	SF1	-	493.1	-
#SS173#R### - #SF173#R###		SF2	327.9	2.0	-
#SS174#R### - #SF174#R###					
#SS172#E#### - #SF172#E#### - #SM172#E####	Filter Regulator	SF1	-	508.7	-
#SS173#E#### - #SF173#E#### - #SM173#E####		SF2	327.9	2.0	-
#SS174#E#### - #SF174#E#### - #SM174#E####					

All failure rates are in FIT (Failure In Time 1 FIT = 1 failure/10⁹ 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/PFH 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 device can be used in a single channel configuration (i.e., HFT = 0) up to SIL 3 for SF2 and up to SIL 1 for SF1.

In compliance with Route 2_H (see IEC 61508 [S1], part 2, subclause 7.4.4.3), the device can be used in a single channel configuration (i.e., HFT = 0) up to SIL 3 for SF2 and up to SIL 1 for SF1.

Therefore, regulators and filter regulators can be used up to SIL 3 with HFT=0. Check the systematic capability SC=3 of section 3.8 of this safety manual.

3.8. Systematic safety integrity (Systematic Capability)

Regulators and filter regulators have met manufacturer design process requirements of SIL 3 (evaluated according to Route 1S 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], [D3] and to this Safety Manual,
- Uses the product in the appropriate environment, as per section 2.3 of this Safety Manual.

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).

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3.9. Common Cause Failures

The device has a single channel configuration, i.e., HFT = 0.

When carrying out PFD/PFH 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

Series 1700 Steel Line air service units must be installed per the standard practices outlined in the manuals [D1], [D2] and product documentation [D3].

The environment must be checked to verify that environmental conditions do not exceed the ratings (see also section 2.3 of this Safety Manual).

Regulators and filter regulators must be accessible for physical inspection.

4.2. Physical location and placement

Regulators and filter regulators shall be accessible with sufficient room for pneumatic connections.

These devices 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.

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.

Functional test must be executed before using the device.

Refer to manuals [D1] and [D2] or product catalogue [D3] for further information about the product maintenance, handling and storage. In case of any doubt, contact Pneumax SpA offices.

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} / PFH target,
- Safety Function,
- Service conditions.

The following parameters can be verified through a Proof test:

- Proper functionality
- Pressure regulation downstream if suitable means are available

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5.1.4. Execution of the test

A proof test can be performed by installing a pressure gauge downstream of the regulator / filter regulator. The test is considered passed if the following conditions are satisfied:

Safety Function	Description
[SF1]	<ul style="list-style-type: none"> The correct regulated output pressure is maintained throughout the entire test. Output pressure corresponds to the desired set pressure.
[SF2]	<ul style="list-style-type: none"> No anomaly detected during a PST or proof test of an emergency system.

IMPORTANT: A partial stroke test on the assembly results in full stroke test on the regulator / filter regulator. So, a partial stroke test done with manual or automatic procedure with PST device, gives as a result on the air service unit the same test coverage reached with the FST.

IMPORTANT: Pneumatic pressure monitoring is requested by IEC 61511-1 par. 11.2.11 for subsystems which do not fail to the safe state upon loss of power. It can be classified as "line monitoring". This test method can be used to detect failures such as breakage or restrictions. Diagnostic coverage of the method depends on the effectiveness of the test equipment.

5.1.5. Test set-up and test facilities

The test shall be carried out on the regulator / filter regulator as installed.
The test 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 solenoid valve to ensure that (as minimum):

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

Furthermore, for solenoid valves compliant to Directive 2014/34/EU, check the indications reported on document [D1] TF231011-IST.

5.2. 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 solenoid valves are required to be replaced due to failure. The occurred failure shall be documented and reported to PNEUMAX Quality & Technical representatives.