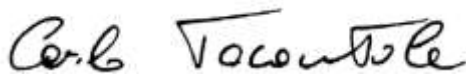


Sede legale:Via del Commercio, 6/A
60030 Monte Roberto (AN)
T: +39 0731 22781
F: +39 0731 227806
E: info@tuvaustritalia.com
tuvaustritalia@legalmail.it
www.tuvaustritalia.com
Codice Sdl M5UXCR1**Sede operativa:**Via dell'Industria, 14
25030 Erbusco (BS)
T: +39 030 9821049
F: +39 030 9822253
info.bs@tuvaustritalia.com**Sede operativa:**Via Pasquale Romano, 25
72100 Brindisi (BR)
T: +39 347 5970825
F: +39 030 9822253
info.br@tuvaustritalia.com**Sede operativa:**Via Fellini, 25
65010 Spoltore (PE)
T: +39 085 8427172
info.pe@tuvaustritalia.com**Sede operativa:**Via Paolo Belizzi, 16/18
29122 Piacenza (PC)
T: +39 0523 1860091
info.pc@tuvaustritalia.com**Sede operativa:**C.so R. Montevecchio, 45
10129 Torino (TO)
T: +39 011 8174896
F: +39 011 5692074
info.to@tuvaustritalia.com**Sede operativa:**Via Enrico Fermi, 23
35136 Padova (PD)
T: +39 049 8725897
F: +39 178 6076741
info.pd@tuvaustritalia.com

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Report no.: TAI-FS-R-22-0083 Rev. 01

SIL SUMMARY REPORT**IEC 61508-1/7:2010****Pneumatic / hydraulic compact scotch-
yoke spring return and double acting
actuator****Series RC****Rotork Sweden AB
Kontrollvägen, 15
791 22 Falun
Sweden**Date: **2023-03-20**Author
Carlo Tarantola

Signature

This document is only valid in its entirety, without any change.

0 STATUS OF THE DOCUMENT

| | | | |
|-----------------|--------------------|---|------------------|
| History: | R 01: | General revision to: <ul style="list-style-type: none">• Better detail the external diagnostic test as on-line monitoring• Correct some typo errors Main modifications in respect to Rev. 00 are in green colour. | Date: 2023-03-20 |
| | R 00: | Initial release | Date: 2022-09-09 |
| Release status: | Released to client | | |
| Author(s): | Carlo Tarantola | | |

1 INTRODUCTION

This report is related to the assessment according to standards:

IEC 61508-1/7:2010

for the following products:

pneumatic / hydraulic compact scotch-yoke spring return and double acting actuator series RC

NOTES:

- The results of this report can be used for the assessment of a complete Safety Instrumented System.

2 ASSESSMENT AND RESULTS

| Product identification | | |
|--|--|---|
| Device | Pneumatic / hydraulic compact scotch-yoke spring return and double acting actuator | |
| Series | RC | |
| Models / configurations | RC - No on-line monitoring RC - With on-line monitoring RC88 - No on-line monitoring RC88 - With on-line monitoring | |
| Safety function(s) | | |
| 1. | <u>Spring return actuators:</u> Delivery of a full stroke ($90^\circ \pm$ tolerance) driven by the spring, with power fluid exhausted from the cylinder through the control system. NOTE: considering the functioning of the actuator to perform the safety function(s), the safety functions "close" and "open" can be considered equivalent. The safety function is in both cases driven by the spring. | |
| 1. | <u>Double acting actuators:</u> Delivery of a full stroke ($90^\circ \pm$ tolerance) driven by the piston of cylinder, powered by the specified medium working pressure. NOTE: considering the functioning of the actuator to perform the safety function(s), the safety functions "close" and "open" can be considered equivalent. | |
| Mode of operation of the safety function(s) | High demand mode | |
| Reference standards | | |
| General functional safety standard | IEC 61508-1/7:2010 | |
| Product specific functional safety standard | None | |
| Assessment phases | | |
| Management of functional safety / functional safety planning | Assessed | A functional safety audit of the management systems and of the functional safety planning is conducted to document and highlight that the development of the product under consideration is compliant with IEC 61508. |
| Safety requirements specification | Assessed | The Safety requirements specification is assessed with respect to its consistency and completeness in a comparison with the applicable requirements of IEC 61508. |

| | | |
|-----------------------------|----------|--|
| Design | Assessed | The assessment of the design included the following aspects: <ul style="list-style-type: none"> Quantifiable aspects: random failure rates, DC, SFF, PFH, β factors, MRT, PTC, architectural constraints Non-quantifiable aspects: behaviour of the safety function under fault conditions, safety-related software (not applicable to the product under consideration), systematic failures, behaviour under environmental conditions See below for the results. |
| Verification and Validation | Assessed | The verification and validation activities performed by the manufacturer include review, analysis and tests. |
| Information for use | Assessed | The assessment covers: <ul style="list-style-type: none"> the installation, operation and maintenance instructions (IOM Manual) the particular instructions required by Annex D of IEC 61508 Part 2 (Safety Manual) |
| Modification | Assessed | Procedures for modification activity are described in specific documents, referenced in the safety planning. |

Results

| | |
|----------------------------|---|
| Selected assessment routes | <ul style="list-style-type: none"> For architectural constraints: Routes 1_H and 2_H For Systematic Capability: Route 1_s Furthermore, the requirements in paragraphs 7.4.10.1–7.4.10.7 of IEC 61508 Part 2 are assessed and considered fulfilled, as: <ul style="list-style-type: none"> the product has a restricted and specified functionality and is designed to perform specified safety functions the product has an adequate documentary evidence (including extensive operating experience and results of suitability analysis and testing), sufficient to claim the declared failure rates the manufacturer has an effective system for reporting failures |
| Element type (A or B) | Type A |
| HFT | The product has a single channel configuration, HFT=0. |
| Random failure rates | The determination of random failure rates is performed with a FMEDA, integrated with field feedback, according to IEC 61508 Part 2 Par. 7.4.4.3.3, using the Bayesian approach. |

| Configuration | Safety function | λ_{DU} [1/h] | λ_{DD} [1/h] | λ_S [1/h] |
|--|-----------------|----------------------|----------------------|-------------------|
| RC spring return - No on-line monitoring | 1 | 8,52E-08 | 0,00E+00 | 0,00E+00 |
| RC spring return - With on-line monitoring | 1 | 7,66E-09 | 7,75E-08 | 0,00E+00 |
| RC88 spring return - No on-line monitoring | 1 | 6,53E-08 | 0,00E+00 | 0,00E+00 |
| RC88 spring return - With on-line monitoring | 1 | 5,88E-09 | 5,95E-08 | 0,00E+00 |
| RC double acting - No on-line monitoring | 1 | 2,61E-08 | 0,00E+00 | 0,00E+00 |
| RC double acting - With on-line monitoring | 1 | 2,35E-09 | 2,37E-08 | 0,00E+00 |
| RC88 double acting - No on-line monitoring | 1 | 3,49E-08 | 0,00E+00 | 0,00E+00 |
| RC88 double acting - With on-line monitoring | 1 | 3,15E-09 | 3,18E-08 | 0,00E+00 |

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|---|---|
| Spurious trip rate | <ul style="list-style-type: none"> Spring return actuators: <ul style="list-style-type: none"> RC: 8,70E-08 [1/h] RC88: 1,25E-07 [1/h] <p>NOTE: failures of components of the cylinder which can generate spurious trips shall be correctly classified as “No Part” and not “Safe”, being related to components that “play no part in implementing the safety function” (see definition 3.6.16 of IEC 61508 Part 4). Anyway the spurious trip rate is estimated.</p> <ul style="list-style-type: none"> Double acting actuators: 0,00E+00 [1/h] <p>NOTE: failures of components of the cylinder cannot generate spurious trips. The “spurious trip rate” is therefore 0,00E+00 [1/h]</p> |
| DC | <p>The product does not include internal diagnostics. Diagnostic is only possible via external means, e.g. with on-line monitoring by the process.</p> <p>The procedure for the external diagnostic tests is described in the Safety Manual.</p> |
| SFF | <p>Considering that $\lambda_S=0$, according to definitions 3.6.15 of IEC 61508 Part 4:</p> <ul style="list-style-type: none"> SFF=0 without external diagnostic tests SFF>0 with external diagnostic tests, carried out according to definition 3.8.7 of IEC 61508 Part 4, and according to what written in the Safety Manual |
| PFH | <ul style="list-style-type: none"> RC spring return - No on-line monitoring: 8,52E-08 [1/h] RC spring return - With on-line monitoring: 7,66E-09 [1/h] RC88 spring return - No on-line monitoring: 6,53E-08 [1/h] RC88 spring return - With on-line monitoring: 5,88E-09 [1/h] RC double acting - No on-line monitoring: 2,61E-08 [1/h] RC double acting - With on-line monitoring: 2,35E-09 [1/h] RC88 double acting - No on-line monitoring: 3,49E-08 [1/h] RC88 double acting - With on-line monitoring: 3,15E-09 1/h] |
| β factors | <p>$\beta=\beta_D=0,05$</p> <ul style="list-style-type: none"> The above value is the value for 1oo2 architecture. The values for other architectures shall be calculated according to IEC 61508 Part 6, Table D.5. The above value is calculated in the hypothesis of redundancy without diversity <p>The β factors can be used when performing calculations for redundant architectures.</p> |
| MRT | <p>24 h</p> <p>The MRT considered is the Technical Mean Repair Time, i.e., it takes in consideration availability of skilled personnel, adequate tools and spare parts.</p> |
| PTC | <p>The procedure for the Proof Test is described in the Safety Manual.</p> |
| Architectural constraints | <p>The product can be used in:</p> <ul style="list-style-type: none"> single channel configuration: <ul style="list-style-type: none"> up to SIL 1 without on-line monitoring by the process up to SIL 3 considering on-line monitoring by the process double channel configuration: up to SIL 3 |
| Expected lifetime | <p>25 years</p> |
| Behaviour of the safety function under fault conditions | <p>The product does not include internal diagnostics.</p> |
| Safety related SW | <p>No SW is used to implement the safety function.</p> |
| Systematic Capability | <p>3</p> |
| Behaviour under environmental conditions | <p>The behaviour in environmental conditions is assessed evaluating the relevant environmental tests.</p> |

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|---|---|
| Limitations for use | Make reference to the Safety Manual. |
| Remarks | |
| <ul style="list-style-type: none"> The random failure rates in the above table are valid for all the possible configurations of the product. According to the definition of IEC 61508 (in particular definitions 3.6.8 and 3.6.13 of IEC 61508 Part 4), no Safe Failures are possible in a single acting actuator: each failure mode of the actuator itself shall be classified as “Dangerous” or “No Effect” (failures which can generate the spurious operation of the safety function are only external to the actuator itself, or are related to components that “play no part in implementing the safety function”); hence, $\lambda_S=0$ for each type of single acting actuator. Failures of components of the cylinder which can generate spurious trips shall be correctly classified as “No Part” and not “Safe”, being related to components that “play no part in implementing the safety function” (see definition 3.6.16 of IEC 61508 Part 4). Anyway the spurious trip rate is estimated. According to the definition of IEC 61508 (in particular definitions 3.6.8 and 3.6.13 of IEC 61508 Part 4), no Safe Failures are possible in a double acting actuator: each failure mode of the actuator itself shall be classified as “Dangerous” or “No Effect” (failures which can generate the spurious operation of the safety function are only external to the actuator itself, and even in the case of loss of power supply the actuator “stays put”); hence, $\lambda_S=0$ for each type of double acting actuator. Failures of components of the cylinder cannot generate spurious trips. The “spurious trip rate” is therefore 0,00E+00 [1/h] The λ_S values are not divided in λ_{SD} and λ_{SU}, as this subdivision has no relevance for any of the SIL parameters. For further details, make reference to the Safety Manual. | |
| Reference documents | |
| SIL Assessment Report | TÜV AUSTRIA document no. TAI-FS-R-22-0082 Rev. 01 |
| Safety Manual | Rotork document no. SM-RC-A-00-E |