FUNCTIONAL SAFETY CERTIFICATE

This is to certify that the

IQ3 Valve Actuator

manufactured by

Rotork Controls Ltd
(A Division of Rotork PLC)
Brassmill Lane
Bath, BA1 3JQ
UK

have been assessed by Sira Certification Service with reference to the CASS methodologies and found to meet the requirements of

IEC 61508-2:2010
Routes 1_H & 1_S
Systematic Capability (SC3)

as an element/subsystem suitable for use in safety related systems performing safety functions up to and including

SIL 2 capable with HFT = 0 (1oo1)*
SIL 3 capable with HFT = 1 (1oo2)*

when used in accordance with the scope and conditions of this certificate.

* This certificate does not waive the need for further functional safety verification to establish the achieved Safety Integrity Level (SIL) of the safety related system

Certification Decision:

James Lynskey
Product Group Manager - Functional Safety

Initial Certification	: 26 August 2015
This certificate issued	: 25 June 2021
Renewal date	: 25 November 2025

0011

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Product Description and Scope of Certification

Rotork's IQ3 product range is a family of electric valve actuators categorised by output torque and speed.

The design comprises a mechanical and an electronics module. The mechanical module includes a gearcase and an enclosure cast in LM20/25 aluminium alloy which is bolted to a cast iron base providing connection to a valve or gearbox. Output movement is derived from an electrical motor driving a worm and wheel gear running in an oil bath. The motor is controlled by the electronics module which also provides the user's interface. Actuators include a clutch to engage a handwheel for manual operation in case of loss of power.

The IQ3 SIL actuators are designed and certified to be used from -40°C to +70°C within hazardous areas under the ATEX directive, international Standard IEC Ex and North American NFPA – NEC and CSA standards.

This document is the third party assessed certificate for the IQ3 SIL 3-phase actuator range for all sizes and speeds. It provides the reliability data of the unit and all information pertinent to its assessment to IEC61508:2010. It should be read in conjunction with Rotork's IQ3 Safety Manual PUB002-057 which details the installation and user requirements necessary to uphold this certificate. The IQ3 SIL actuator is permitted to be used with any Rotork option card although the use of the functionality provided by any such card is not certified to IEC61508:2010.

Figure 1. IQ3 SIL Valve Actuators.

Assessed Modules

Although the IQ3 SIL actuator is an integrated unit, each constituent module has been assessed for its suitability to IEC61508:2010. These individual modules are:

Mechanical Module:

- Electronics Interface -looms/connectors
- Terminal Bung
- Electronics Cover
- Terminal Cover
- Gearbox
- Base
- Manual hand wheel
- Drive Motor
- Piezo torque sensor

Electronics Module:

- Absolute Position Encoder
- User Interface Board
- Control Board
- Power Supply module (including motor switching module)
- Option cards

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Element Safety Function

The IQ3 SIL actuator is designed for 2 safety functions with various configurable modes which are detailed within the Safety Manual. Whilst the various configurations permit subtle variations to these functions, they are broadly defined as below:

Safety Function 1; Stay-Put
Upon the removal of a signal at the actuator's SF1 input, the actuator shall not provide movement in static mode and shall cease movement in dynamic mode if the actuator was previously moving.

Safety Function 2; Will Move To Limit
Upon the removal of a signal at the actuator's SF2 input, the actuator shall perform a configured action (open the actuator to its 100% limit, close the actuator to its 0% limit or enter the actuator into Stay-Put mode).

Diagnostics

The IQ3 SIL actuator performs internal diagnostics which assist the detection of failures. Any failure or mode of operation which inhibits or compromises any safety function is indicated through the use of a dedicated SIL relay.

Further assessment of the actuator's condition is indicated through the use of a standard monitor relay. Further details are provided within the Safety Manual.

Certified Data in Support of Use in Safety Functions

The assessment has been carried out with reference to the Conformity Assessment to Safety-related Systems (CASS) methodology using the Route 1_h approach (calculated concept).

As part of the product assessment and supporting evidence of conformity in respect of 'hardware safety integrity' against the requirements of IEC 61508-2, Rotork have submitted the IQ3 SIL Actuator for FMECA verification.

Rotork have taken the failure rate for each component from one of the following sources:

- RIAC Automated Data book
- IEC TR 62380
- Handbook of Reliability Prediction Procedures for Engineers (RPPFME) and manufacturer's data
- Manufacturer's data

The failure modes allocated to components in the Rotork FMECA were appropriately implemented as required in IEC TR 62380.

The IQ3 SIL Actuator has been verified in 5 size variants; 1, 2, 3, 4 and 5, summarized as shown below.

Table 1: IQ3 SIL Actuator Size variants

Size	Actuator Number
Size 1	IQ10, IQ12, IQ18
Size 2	IQ19, IQ20, IQ25
Size 3	IQ35
Size 4	IQ40, IQ70
Size 5	IQ90, IQ91, IQ95

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Reliability Data

The following tables provide the failure data for the IQ3 SIL actuator (all failure rates are in failures per hour).

Table 2: Safety Function One: Stay Put (High Demand)

	Size 1	Size 2	Size 3	Size 4	Size 5
SFF	96%	96%	96%	95%	95%
λdd	0	0	0	0	0
λdu	4.00e-7	5.00e-7	6.00e-7	4.40e-7	4.70e-7
λsd	0	0	0	0	0
λsu	1.15e-5	1.15e-5	1.15e-5	9.60e-6	9.60e-6
DC	0%	0%	0%	0%	0%
β	10%	10%	10%	10%	10%
MRT (hours)	8	8	8	8	8
PTI (hours)	8760	8760	8760	8760	8760
1oo1					
PFH	4.00e-7	5.00e-7	6.00e-7	4.40e-7	4.70e-7
Capability Level	SIL 2				
1oo2					
PFH	4.11e-08	5.18e-08	6.26e-08	4.54e-08	4.86e-08
Capability Level	SIL 3				

Table 3: Safety Function Two: Will Move to Limit (Low Demand)

	Size 1	Size 2	Size 3	Size 4	Size 5
SFF	98%	97%	97%	98%	97%
λdd	7.34E-07	7.68E-07	7.68E-07	7.84E-07	7.84E-07
λdu	1.70E-06	1.96E-06	1.88E-06	1.77E-06	2.51E-06
λsd	1.98E-05	8.24E-06	8.24E-06	8.18E-06	8.18E-06
λsu	6.62E-05	6.41E-05	6.45E-05	6.35E-05	6.25E-05
DC	30%	28%	29%	31%	37%

As safety function two is a low demand function, its overall Probability of Failure on Demand (PFD) is dependent on the test interval of the system and the time to repair any detected fault (see Rotork's IQ3 Safety Manual PUB002-057 for a more detailed explanation on detected faults).

The equation below allows the PFD to be calculated for the given variables:

- T_{PTI} – Full Proof Test Interval (PTI) time in hours (user variable)
- MRT – Mean Repair Time in hours (user variable)
- λdu – Dangerous-Undetected Failure rate of actuator (variable – see table 3)

$$PFD_{avg0} = \lambda du \times \left(\frac{T_{PTI}}{2} + MRT\right)$$

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Example: For a 12 month Proof Test Interval and MRT of 8 hours, the PFD and SIL level is shown below:

Table 4: PFD & SIL Capability Example

	Size 1	Size 2	Size 3	Size 4	Size 5
DC	30%	28%	29%	31%	37%
1oo1					
PFD	7.5E-03	8.7E-03	8.3E-03	7.8E-03	1.1E-02
Capability Level	**SIL 2**				**SIL 1**
1oo2					
PFD	4.5E-04	5.3E-4	5.0E-4	4.7E-04	6.9E-04
Capability Level	**SIL 3**				

The diagnostic coverage represents the proportion of components involved in the safety function which are internally and automatically monitored for faults. Any detected faults are indicated over the SIL relay.

To increase this level of detection, regular electrical movement of the actuator in both directions may be performed (including movement as part of regular operation either remotely or locally). This is referred to as Powered Operation. Although internal faults are detected, external movement must be confirmed to have operated correctly. This operation increases the Diagnostic Coverage to 95%.

The table below provides PFD values for various Powered Operation intervals with a MRT of 8 hours, and a 12 month proof test interval.

Table 5: PFD Examples

PO Interval		PFD values for actuator size					SIL Capability Rating (applies across all sizes)
Months	**Hours**	**1**	**2**	**3**	**4**	**5**	
1	**730**	9.95E-04	1.15E-03	1.10E-03	1.03E-03	1.46E-03	SIL2
2	**1460**	1.58E-03	1.82E-03	1.75E-03	1.64E-03	2.32E-03	SIL2
3	**2190**	2.17E-03	2.49E-03	2.39E-03	2.25E-03	3.18E-03	SIL2
4	**2920**	2.75E-03	3.17E-03	3.04E-03	2.86E-03	4.04E-03	SIL2
5	**3650**	3.34E-03	3.84E-03	3.69E-03	3.46E-03	4.90E-03	SIL2
6	**4380**	3.92E-03	4.52E-03	4.34E-03	4.07E-03	5.76E-03	SIL2

Note that the Safe Failure Fraction stated within Table 2 & Table 3 still applies and in some cases will be the limiting factor when determining the SIL capability rating.

The equation used to calculate the above PFD values is described below. This may be used to calculate custom values based on variable PO intervals, full test intervals and MRT.

$$PFD_{pvst} = \left[DCF \times \lambda_{DU}\left(MRT + \frac{T_{pvst}}{2}\right) + (1 - DCF) \times \lambda_{DU} \times \frac{T_{pti}}{2}\right] \times \left(1 - PFD_{avg\_em}\right) + PFD_{avg0} \times PFD_{avg\_em}$$

Where:

- PFD_{avg0} = PFD for actuator without PVST (see Table 4 and equation above). - Variable across sizes
- DCF (Diagnostic Coverage Factor when using PO) – Fixed (95%)
- MRT (Mean Repair Time) – User variable
- PFDavg_em (probability of Failure on Demand for internal module) – Fixed – see Table 6.
- T_{PTI} (full Proof Test Interval) – User variable

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- Tpvst (PO Test Interval) – User Variable
- λdu (Undetected Dangerous Failure Rate) – Fixed – see Table 2 & Table 3.
- λdd (Detected Dangerous Failure Rate) – Fixed – see Table 2 & Table 3.

Table 6: PFDavg_em information for PVST calculation

Actuator Type	PFDavg_em	λDU	λDD	DCF
IQ10, IQ12, IQ18, IQ19, IQ20, IQ25, IQ35	2.75E-04	1.80E-06	7.34E-07	0.95
IQ40, IQ70, IQ90, IQ91, IQ95	3.80E-04	2.51E-06	7.84E-07	0.95

Notes on Reliability Data

Note 1: Verified powered operation means any suitable operations including either a PVST (partial valve stroke test) or any electrical operation of the actuator in both directions (open and closed) that can be confirmed to have operated correctly.

Note 2: Attaching hardware option cards does not impact the operation of the safety function and they are not part of the assessment.

Note 3: Assumptions used in the FMEA:

- Numerical failure data in this report is based on the FMEA and assumes that failure rates are constant. Infant mortalities and wear-out mechanisms are not included.
- Figures derived from the FMEA are random hardware failures. Systematic hardware failures (such as installation or maintenance errors and software) are not accounted for in the FMEA but are assessed qualitatively in this report and reviewed in the safety manual.
- All components that are not part of the safety function (and thus do not affect the failure rate of the safety function) are excluded from the FMEA and do not contribute to the SFF.
- An estimated partial test diagnostic coverage of the partial valve stroke testing is 95%.
- The software assessment completed as part of this SIL assessment includes the PVST diagnostic functionality and fault indication.
- The failure data above is supported by the base information given in Table 7 below.

Table 7: Base Information for the IQ3 SIL Actuator

Product identification	IQ3 SIL Actuators (sizes 1 to 5)
Functional specification	When the ESD signal is removed the IQ3 SIL actuator shall perform the pre-determined commissioned ESD action. When the ME signal is removed the IQ3 actuator shall stay put
Random hardware failure rates	Refer to Table 2 & Table 3.
Environment limits	Temperature range: -40°C to +70°C operational
Lifetime/replacement limits	10 years or: Sizes IQ10 - IQ35: 500,000 output turns Sizes IQ40 - IQ95: 250,000 output turns (whichever occurs first)
Proof Test requirements	Refer to Safety Manual
Maintenance requirements	Refer to Safety Manual
Diagnostic coverage	Refer to Table 2 & Table 3.
Diagnostic test interval	Refer to Table 2 & Table 3.
Repair constraints	None, other than compliance with the Safe Use and Installation Manual (PUB002-039) and Safety Manual (PUB002-057)
Safe Failure Fraction	Refer to Table 2 & Table 3.
Hardware fault tolerance (HFT)	1oo1 and 1oo2
Highest SIL (architecture/type A/B)	Type B SIL 2 capable, HFT=0 (1oo1) SIL 3 capable, HFT=1 (1oo2)

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Systematic failure constraints	IQ3 SIL is software controlled
Evidence of similar conditions in previous use:	Not applicable
Evidence supporting the application under different conditions of use:	Not applicable
Evidence of period of operational use:	Not applicable
Statement of restrictions on functionality:	Not applicable
Systematic capability:	Up to SC3.
Systematic fault avoidance measures:	Refer to systematic failures introduced during the realization lifecycle from 61508 /2 /3.
Systematic fault tolerance measures	Assessment to Annexes A and B of IEC 61508-2 applied.
Validation records	Functional testing assessed in Sira reports.
Firmware records (SIL)	V101, V103, V104, V105, V106 (Latest version)

Management of Functional Safety

The assessment has demonstrated that the product is supported by an appropriate functional safety management system that meets the relevant requirements of IEC 61508-1:2010 clause 6.

Software Development Process Assessment

The product has been assessed to the main requirements for the software development processes that are based on IEC 61508-3, using route 1_S. The assessment was based on software verification, audit and document review to architectural constraint requirements where the highest safety integrity level selected is SIL 3 under HFT = 1.

This certificate is applicable to modules with the installed software shown below:

Software Version	Checksum	Build
V101	B37E9AC4873D5F256EB62872D7851D90	2283
V103	1D50109AB1FAFAEC07B0B8591535BDDA	4072
V104	02C4B29F45455725D6C8C8ED0C0B0585	4156
V105	01889638BBC04CCE0AE63F6B032BFCC2	4268
V106	D980BE468CAA845CCC819E8AB852E3AE	4274

Identification of Certified Equipment

The IQ3 SIL Actuators (sizes 1 to 5) certified equipment and its safe use is defined in the manufacturer's documentation listed in the list of audited documents table in CSA-Sira report R70204329_SW_mod_rev_C.

Additional manufacturing facilities

The following locations have been assessed by CSA Group UK and were found to be in conformance with IEC61508:2010 and follow the same level of rigor and process quality and control as Rotork Controls Ltd (UK).

Rotork Controls (India) Private limited
H.O & Manufacturing
28B, Ambattur Industrial Estate (N)
Chennai – 600 098
Tamil Nadu
India

Rotork Actuation (Shanghai) Co.,Ltd.
Building G, No.260 Liancao Road
Minhang District
Shanghai, 201108
China

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Conditions of Certification

The validity of the certified base data is conditional on the manufacturer complying with the following conditions:

1. The manufacturer shall analyse failure data from returned products on an on-going basis. Sira Certification Service shall be informed in the event of any indication that the actual failure rates are worse than the certified failure rates. (A process to rate the validity of field data should be used. To this end, the manufacturer should co-operate with users to operate a formal field-experience feedback programme).
2. Sira shall be notified in advance (with an impact analysis report) before any modifications to the certified equipment or the functional safety information in the user documentation is carried out. Sira may need to perform a re-assessment if modifications are judged to affect the product's functional safety certified herein.
3. On-going lifecycle activities associated with this product (e.g., modifications, corrective actions, field failure analysis) shall be subject to surveillance by Sira in accordance with 'Regulations Applicable to the Holders of Sira Certificates'.

Conditions of Safe Use

The validity of the certified base data in any specific user application is conditional on the user complying with the following conditions:

1. Selection of this equipment for use in safety functions applications, the installation, configuration, overall validation, maintenance and repair shall only be carried out by competent personnel, observing the manufacturer's conditions and recommendations in the user safety manual documentation.
2. All information associated with any field failures of this product should be collected under a dependability management process (e.g., IEC 60300-3-2) and reported to the manufacturer.
3. A proof test interval is set to 1 year. Use of power operating function for partial test coverage is also applicable as stated above.

General Conditions and Notes

1. This certificate is based upon a functional safety assessment of the product described in Sira Test & Certification Assessment Reports R70004934A_IQ3SIL_v1.0, R70004934B_IQ3SIL_v1.0, R700049343C_v1.0, R70080758C_SW_mod_RevC and R80001390_SW_mod_RevD.
2. If certified product or system is found not to comply, Sira Certification Service should be notified immediately at the address shown on this certificate.
3. The use of this Certificate and the Sira Certification Mark that can be applied to the product or used in publicity material are subject to the 'Regulations Applicable to the Holders of Sira Certificates' and 'Supplementary Regulations Specific to Functional Safety Certification'.
4. This document remains the property of Sira and shall be returned when requested by the issuer.
5. The IQ3 SIL range of actuators has a local display to indicate the percentage position and has volt free relay contacts to allow remote indication of safe and dangerous failures. These relays are purely for indication and are not considered in the implementation of the safety functions.
6. The actuator can only perform its safety function in the presence of a mains supply. Therefore, integrity of this supply is to be ensured by the end user.
7. No part of the Functional safety related aspects stated in the instruction manual shall be changed without approval of the certification body.

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Certificate History

Issue	Date	Report no.	Comment
00	21/07/2015	R70004934A, R56A33000A & R70004938B	Certificate issue for safety function 2 'Willmove'.
01	28/10/2015	R70004934A_IQ3SIL_v1.0, & R70004934B_IQ3SIL_v1.0and R70004934C rev 0.6	Certificate issued for updating validations results, review of FMEA and safety functions 1 & 2.
02	08/12/2015	R70004934A_IQ3SIL_v1.0, & R70004934B_IQ3SIL_v1.0and R70004934C rev 0.6	Certificate updated to correct table 6.
03	16/05/2017	R70080758C_SW_mod_RevC.	Certificate updated to reflect new software revision (V104.0) and additional of IQ19 to size category 1.
04	28/02/2019	R70204329_SW_mod_rev_C	Certificate updated to include new software revision (V105).
05	10/06/2019	R80001390_SW_mod_rev_D	Certificate updated to include new software revision (V106).
06	19/08/2020	R70004934A_IQ3SIL_v1.0, & R70004934B_IQ3SIL_v1.0and R70004934C rev 0.6	Certificate date extended due to Covid-19.
07	27/08/2020	R80046752A	Certificate updated to reflect addition of new manufacturing location following successful audit.
08	16/10/2020	R80054605A	Certificate re-issued following successful desktop audit.
09	25/06/2021	R80081292A	Additional manufacturing audit.

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