FUNCTIONAL SAFETY CERTIFICATE

This is to certify that the

PNL/HYL Spring Return Linear Actuator;
HY Spring Return Hydraulic Scotch Yoke Actuator;
DG Spring Return Direct Gas Scotch Yoke Actuator;
PN Spring Return Pneumatic Scotch Yoke Actuator.

manufactured by

Paladon Systems Ltd
Ferro Fields,
Brixworth,
Northamptonshire,
NN6 9UA
United Kingdom

Paladon Systems Srl
Localita' Ca' Verde (Strada 412/R)
29011 Borgonovo Valtidone
Italy

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

IEC 61508-2:2010

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

SIL 2 (1oo1)*
SIL 3 (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

Initial Certification: 11/11/2013
This certificate issued: 02/10/2023
Renewal date: 10/11/2028

This certificate may only be reproduced in its entirety, without any change.

UKAS PRODUCT CERTIFICATION
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Sira Certification Service
CSA Group UK
Unit 6 Hawarden Industrial Park
Hawarden, CH5 3US, United Kingdom
Tel: +44 (0) 1244 670900
Email: ukinfo@csagroup.org
Web: www.csagroupuk.org

Product description and scope of certification

Pneumatic Linear Actuator – PNL

The PNL&HYL series of pneumatic or hydraulic actuators are spring return linear valve actuators. The body of the actuator is a totally weather proof housing certified to IP66 (as stated in the product specification). It consists of a completely steel structure that is designed to ensure protection against external wear and corrosion whilst operating at temperatures from -65 to +140°C.

The PNL&HYL valve actuator is designed to operate any sliding stem valve at supply pressures of 2.7 to 12 BAR (pneumatic) and 250 BAR (hydraulic) with an output thrust range of up to 222kN.

Figure 1. PNL linear actuator final assembly

Pneumatic Scotch Yoke Actuators – PN

The PN series of pneumatic actuators is a spring return scotch yoke valve actuator. The actuator consists of fully welded nickel plated cylinders allowing for protection against external wear and corrosion whilst operating at temperatures from -65 to +140°C, the actuator is certified to IP66 (as stated in the product specification). The scotch yoke is available in symmetrical, canted or semi-canted designs.

The PN valve actuator is designed to operate any ball, butterfly or plug valve at supply pressures of 2.7 to 12 BAR with an output torque range of up to 500kNm.

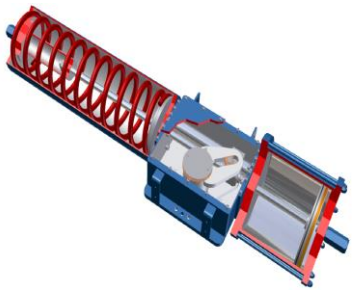

Figure 2. PN pneumatic scotch yoke actuator final assembly

Hydraulic Scotch Yoke Actuators – HY & DG

The HY series of hydraulic actuators is a spring return scotch yoke valve actuator. The actuator consists of fully welded nickel plated cylinders allowing for protection against external wear and corrosion whilst operating at temperatures from -65 to +140°C, the actuator is certified to IP66 (as above). The scotch yoke is available in symmetrical, canted or semi-canted designs.

The HY valve actuator is designed to operate any ball, butterfly or plug valve at supply pressures of 2.7 to 250 BAR with an output thrust range of up to 500kNm. **Note.** The DG (direct gas series) is identical to the HYS series.

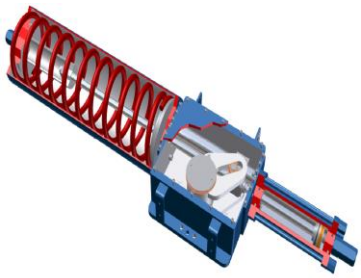

Figure 3. HY/DG hydraulic/direct gas scotch yoke actuator final assembly

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Use in safety function(s)

The element safety function for the PNL, HYL, HY, PN and DG actuators is common to all and defined as follows:

'To move the actuator to a desired safe end position by means of spring.' **Note:** safe end position is to put the actuator in the closed or open position depending on the application.

Certified data in support of use in safety functions

The assessment has been carried out with reference to the *Conformity Assessment of Safety-related Systems* (CASS) methodology[1] using the Route 1_H[2] approach.

A Failure Mode and Effect Analysis (FMEA) has established the failure modes and failure rates from the products assessed as show in Table 1 below. Failure sources have been taken from RIAC NPRD.

The following results in Tables 1 to 9 summarize the PNL, PNL, HYL, HY, PN and DG actuators in both single mode (1oo1) and redundant mode (1oo2) of operation. This also includes results calculated using PVST for both 20% and 60% values.

Table 1: Summary of assessment for the spring return PNL & HYL Actuators in single (1oo1) and redundant (1oo2) modes of operation:

Safety Function: *'To move the actuator to the end position by means of spring return on a demand.'*				
Summary of Clauses 2/7.4.2 and 2/7.4.4		PNL&HYL in single mode 1oo1	PNL&HYL in redundant mode 1oo2	**Verdict**
Architectural constraints		**HFT=0**	**HFT=1**	**Type A**
Safe Failure Fraction (SFF)		**76%**	**76%**	**1oo1=SIL 2 1oo2=SIL 3**
Random hardware failures: [h^{-1}]	λ_{DD}	0.00E+00	0.00E+00	
	λ_{DU}	4.95E-07	5.16E-08	
Random hardware failures: [h^{-1}]	λ_{SD}	0.00E+00	0.00E+00	
	λ_{SU}	1.65E-06	1.89E-07	
Diagnostic coverage (DC)		0.00%	0.00%	
PFD_{AVG} @ PTI = 8760Hrs MTTR = 8 Hrs		**2.17E-03**	**2.22E-04**	**1oo1=SIL 2 1oo2=SIL 3**
Average Frequency of Dangerous failure, (High Demand - PFH) [h^{-1}]		4.95E-07	5.16E-08	
Hardware safety integrity compliance		Route 1_H		
Systematic safety integrity compliance		Route 1_S		
Systematic Capability (SC1, SC2, SC3, SC4)		SC3		
Hardware safety integrity achieved		**SIL 2 (1oo1) & SIL 3 (1oo2)**		

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Table 2: Summary of assessment for the spring return HYS & DG Actuators in single (1oo1) and redundant (1oo2) modes of operation:

Safety Function: *'To move the actuator to the end position by means of spring return on a demand.'*				
Summary of Clauses 2/7.4.2 and 2/7.4.4		HYS&DG in single mode 1oo1	HYS&DG in redundant mode 1oo2	**Verdict**
Architectural constraints Safe Failure Fraction (SFF)		**HFT=0**	**HFT=1**	**Type A**
		63%	**63%**	**1oo1=SIL 2 1oo2=SIL 3**
Random hardware failures: [h^{-1}]	λ_{DD} λ_{DU}	0.00E+00 4.75E-07	0.00E+00 4.95E-08	
Random hardware failures: [h^{-1}]	λ_{SD} λ_{SU}	0.00E+00 8.26E-07	0.00E+00 8.86E-08	
Diagnostic coverage (DC)		0.00%	0.00%	
PFD_{AVG} @ PTI = 8760Hrs MTTR = 8 Hrs		**2.08E-03**	**4.95E-04**	**1oo1=SIL 2 1oo2=SIL 3**
Average Frequency of Dangerous failure, (High Demand - PFH) [h^{-1}]		4.75E-07	2.17E-08	
Hardware safety integrity compliance[		Route 1_H		
Systematic safety integrity compliance		Route 1_S		
Systematic Capability (SC1, SC2, SC3, SC4)		SC3		
Hardware safety integrity achieved		**SIL 2 (1oo1) & SIL 3 (1oo2)**		

Table 3: Summary of assessment for the spring return PN Actuator in single (1oo1) and redundant (1oo2) modes of operation:

Safety Function: *'To move the actuator to the end position by means of spring return on a demand.'*				
Summary of Clauses 2/7.4.2 and 2/7.4.4		PNS in single mode 1oo1	PNS in redundant mode 1oo2	**Verdict**
Architectural constraints Safe Failure Fraction (SFF)		**HFT=0**	**HFT=1**	**Type A**
		63%	**63%**	**1oo1=SIL 2 1oo2=SIL 3**
Random hardware failures: [h^{-1}]	λ_{DD} λ_{DU}	0.00E+00 3.11E-07	0.00E+00 3.20E-08	
Random hardware failures: [h^{-1}]	λ_{SD} λ_{SU}	0.00E+00 5.37E-07	0.00E+00 5.62E-08	
Diagnostic coverage (DC)		0.00%	0.00%	
PFD_{AVG} @ PTI = 8760Hrs MTTR = 8 Hrs		**1.37E-03**	**1.39E-04**	**1oo1=SIL 2 1oo2=SIL 3**
Average Frequency of Dangerous failure, (High Demand - PFH) [h^{-1}]		3.11E-07	3.20E-08	
Hardware safety integrity compliance[		Route 1_H		
Systematic safety integrity compliance		Route 1_S		
Systematic Capability (SC1, SC2, SC3, SC4)		SC3		
Hardware safety integrity achieved		**SIL 2 (1oo1) & SIL 3 (1oo2)**		

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Table 4: PNL Actuator in single (1oo1) and redundant (1oo2) using PVST Method 20%.

Safety Function: *'To move the actuator to the end position by means of spring return on a demand.'*				
Summary of Clauses 2/7.4.2 and 2/7.4.4		PNS in single mode 1oo1 (20%)	PNS in redundant mode 1oo2 (20%)	**Verdict**
Architectural constraints Safe Failure Fraction (SFF)		**HFT=0**	**HFT=1**	**Type A**
		73.90%	**63%**	**1oo1=SIL 2 1oo2=SIL 3**
Random hardware failures: [h^{-1}]	λ_{DD} λ_{DU}	1.60E-07 6.39E-07	1.60E-08 6.74E-08	
Random hardware failures: [h^{-1}]	λ_{SD} λ_{SU}	0.00E+00 1.65E-06	0.00E+00 5.62E-08	
Diagnostic coverage (DC)		20%	20%	
PFD_{AVG} @ PTI = 8760Hrs MTTR = 8 Hrs		**2.80E-03**	**1.39E-04**	**1oo1=SIL 2 1oo2=SIL 3**
Average Frequency of Dangerous failure, (High Demand - PFH) [h^{-1}]		6.39E-07	6.74E-08	
Hardware safety integrity compliance[		Route 1_H		
Systematic safety integrity compliance		Route 1_S		
Systematic Capability (SC1, SC2, SC3, SC4)		SC3		
Hardware safety integrity achieved		**SIL 2 (1oo1) & SIL 3 (1oo2)**		

Table 5: PNL Actuator in single (1oo1) and redundant (1oo2) using PVST Method 60%.

Safety Function: *'To move the actuator to the end position by means of spring return on a demand.'*				
Summary of Clauses 2/7.4.2 and 2/7.4.4		PNS in single mode 1oo1 (60%)	PNS in redundant mode 1oo2 (60%)	**Verdict**
Architectural constraints Safe Failure Fraction (SFF)		**HFT=0**	**HFT=1**	**Type A**
		86.95%	**88%**	**1oo1=SIL 2 1oo2=SIL 3**
Random hardware failures: [h^{-1}]	λ_{DD} λ_{DU}	4.79E-07 3.19E-07	4.79E-08 3.28E-08	
Random hardware failures: [h^{-1}]	λ_{SD} λ_{SU}	0.00E+00 1.65E-06	0.00E+00 1.89E-07	
Diagnostic coverage (DC)		60%	60%	
PFD_{AVG} @ PTI = 8760Hrs MTTR = 8 Hrs		**1.40E-03**	**1.43E-04**	**1oo1=SIL 2 1oo2=SIL 3**
Average Frequency of Dangerous failure, (High Demand - PFH) [h^{-1}]		3.19E-07	3.28E-08	
Hardware safety integrity compliance[		Route 1_H		
Systematic safety integrity compliance		Route 1_S		
Systematic Capability (SC1, SC2, SC3, SC4)		SC3		
Hardware safety integrity achieved		**SIL 2 (1oo1) & SIL 3 (1oo2)**		

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Table 6: HYS & DG Actuators in single (1oo1) and redundant (1oo2) modes of operation (20%):

Safety Function: *'To move the actuator to the end position by means of spring return on a demand.'*				
Summary of Clauses 2/7.4.2 and 2/7.4.4		HYS&DG in single mode 1oo1 (20%)	HYS&DG in redundant mode 1oo2 (20%)	**Verdict**
Architectural constraints Safe Failure Fraction (SFF)		**HFT=0**	**HFT=1**	**Type A**
		75.65%	**76%**	**1oo1=SIL 2 1oo2=SIL 3**
Random hardware failures: [h^{-1}]	λ_{DD} λ_{DU}	6.84E-08 4.75E-07	6.84E-09 2.80E-08	
Random hardware failures: [h^{-1}]	λ_{SD} λ_{SU}	0.00E+00 7.81E-07	0.00E+00 8.35E-08	
Diagnostic coverage (DC)		20%	20%	
PFD_{AVG} @ PTI = 8760Hrs MTTR = 8 Hrs		**2.08E-03**	**1.23E-04**	**1oo1=SIL 2 1oo2=SIL 3**
Average Frequency of Dangerous failure, (High Demand - PFH) [h^{-1}]		4.75E-07	2.80E-08	
Hardware safety integrity compliance[		Route 1_H		
Systematic safety integrity compliance		Route 1_S		
Systematic Capability (SC1, SC2, SC3, SC4)		SC3		
Hardware safety integrity achieved		**SIL 2 (1oo1) & SIL 3 (1oo2)**		

Table 7: HYS & DG Actuators in single (1oo1) and redundant (1oo2) modes of operation (60%):

Safety Function: *'To move the actuator to the end position by means of spring return on a demand.'*				
Summary of Clauses 2/7.4.2 and 2/7.4.4		HYS&DG in single mode 1oo1 (60%)	HYS&DG in redundant mode 1oo2 (60%)	**Verdict**
Architectural constraints Safe Failure Fraction (SFF)		**HFT=0**	**HFT=1**	**Type A**
		87.83%	**88%**	**1oo1=SIL 2 1oo2=SIL 3**
Random hardware failures: [h^{-1}]	λ_{DD} λ_{DU}	2.05E-07 1.37E-07	2.05E-08 1.38E-08	
Random hardware failures: [h^{-1}]	λ_{SD} λ_{SU}	0.00E+00 7.81E-07	0.00E+00 8.35E-08	
Diagnostic coverage (DC)		60%	60%	
PFD_{AVG} @ PTI = 8760Hrs MTTR = 8 Hrs		**6.02E-04**	**6.06E-05**	**1oo1=SIL 2 1oo2=SIL 3**
Average Frequency of Dangerous failure, (High Demand - PFH) [h^{-1}]		1.37E-07	1.38E-08	
Hardware safety integrity compliance[		Route 1_H		
Systematic safety integrity compliance		Route 1_S		
Systematic Capability (SC1, SC2, SC3, SC4)		SC3		
Hardware safety integrity achieved		**SIL 2 (1oo1) & SIL 3 (1oo2)**		

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CSA Group UK
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Hawarden, CH5 3US, United Kingdom
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Table 8: PNS Actuator in single (1oo1) and redundant (1oo2) modes of operation (20%):

Safety Function: *'To move the actuator to the end position by means of spring return on a demand.'*				
Summary of Clauses 2/7.4.2 and 2/7.4.4		PNS in single mode 1oo1 20%	PNS in redundant mode 1oo2 20%	**Verdict**
Architectural constraints Safe Failure Fraction (SFF)		**HFT=0**	**HFT=1**	**Type A**
		75.89%	**77%**	**1oo1=SIL 2 1oo2=SIL 3**
Random hardware failures: [h^{-1}]	λ_{DD} λ_{DU}	6.48E-08 2.59E-07	6.48E-09 2.65E-08	
Random hardware failures: [h^{-1}]	λ_{SD} λ_{SU}	0.00E+00 7.51E-07	0.00E+00 8.00E-08	
Diagnostic coverage (DC)		20%	20%	
PFD_{AVG} @ PTI = 8760Hrs MTTR = 8 Hrs		**1.14E-03**	**1.15E-04**	**1oo1=SIL 2 1oo2=SIL 3**
Average Frequency of Dangerous failure, (High Demand - PFH) [h^{-1}]		2.59E-07	2.65E-08	
Hardware safety integrity compliance[		Route 1_H		
Systematic safety integrity compliance		Route 1_S		
Systematic Capability (SC1, SC2, SC3, SC4)		SC3		
Hardware safety integrity achieved		**SIL 2 (1oo1) & SIL 3 (1oo2)**		

Table 9: PNS Actuator in single (1oo1) and redundant (1oo2) modes of operation (60%):

Safety Function: *'To move the actuator to the end position by means of spring return on a demand.'*				
Summary of Clauses 2/7.4.2 and 2/7.4.4		PNS in single mode 1oo1 60%	PNS in redundant mode 1oo2 60%	**Verdict**
Architectural constraints Safe Failure Fraction (SFF)		**HFT=0**	**HFT=1**	**Type A**
		87.95%	**88%**	**1oo1=SIL 2 1oo2=SIL 3**
Random hardware failures: [h^{-1}]	λ_{DD} λ_{DU}	1.94E-07 1.30E-07	1.94E-08 1.31E-08	
Random hardware failures: [h^{-1}]	λ_{SD} λ_{SU}	0.00E+00 7.51E-07	0.00E+00 8.00E-08	
Diagnostic coverage (DC)		60%	60%	
PFD_{AVG} @ PTI = 8760Hrs MTTR = 8 Hrs		**5.70E-04**	**5.77E-05**	**1oo1=SIL 2 1oo2=SIL 3**
Average Frequency of Dangerous failure, (High Demand - PFH) [h^{-1}]		1.30E-07	1.31E-08	
Hardware safety integrity compliance[		Route 1_H		
Systematic safety integrity compliance		Route 1_S		
Systematic Capability (SC1, SC2, SC3, SC4)		SC3		
Hardware safety integrity achieved		**SIL 2 (1oo1) & SIL 3 (1oo2)**		

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Note 1: The failure data:

1) The PFD_{AVG} figure shown is for illustration only assuming a proof test interval of 8760 hours and MTTR of 8 hours. Refer to IEC 61508-6 for guidance on PFD_{AVG} calculations from the failure data.
2) PVST values claimed in tables 1 to tables 9 have assumed that a PVST system is available once the product is integrated into the final system. The PVST system or devices shall be certified to the relevant standards and safety integrity levels. The PVST system is outside the scope of this certification.

The failure data above is supported by the base information given in Table 4 below.

Table 10: Conditions for maintaining safety integrity capability

1	Product identification:	PNL/HYL Spring Return Linear Actuator; HY Spring Return Hydraulic Scotch Yoke Actuator; DG Spring Return Direct Gas Scotch Yoke Actuator; PN Spring Return Pneumatic Scotch Yoke Actuator.
2	Functional specification:	'To move the actuator to the end position by means of spring return on a demand.'
3-5	Random hardware failure rates:	Refer to tables 1 to 9 of this certificate.
6	Environment limits:	Standard components able to operate at +70°C. Client claims that the product may be able to operate at temperature up to +165°C, however component materials must be selected to be capable to operate at this temperature.
7	Lifetime/replacement limits:	Lifetime expectancy is estimated 45 years as long as regular maintenance is carried out as recommended by the manufacturer in the safety manual.
8	Proof Test requirements:	For proof test intervals, Tables 1,2 and 3 PTI of 8760 hours (1 year) as an example, with this proof test interval the failure analysis show that the PFD is SIL 2 (1oo1) and SIL 3 (1oo2) capable.
9	Maintenance requirements:	Refer to safety manual.
10	Diagnostic coverage:	0% diagnostic coverage. PVST values are calculated at 20% and 60% diagnostic coverage.
11	Diagnostic test interval:	No diagnostic test interval is required as no form of diagnostics is available in the products supported by this certificate.
12	Repair constraints:	None, other than compliance with the safety manual instructions
13	Safe Failure Fraction:	PN/HLYL = 76%, HY/DG & PN = 63%. PVST @ 20% = 76% PVST @ 60% = 88%
14	Hardware fault tolerance (HFT):	HFT=0, (1oo1) & HFT=1, (1oo2)
15	Highest SIL (architecture/type A/B):	Type A, HFT=0, SIL2. Type A, HFT=1, SIL3.
16	Systematic failure constraints:	See PTI as specified in Tables 1, 2 and 3
17	Evidence of similar conditions in previous use:	No previous use assessment performed for this product, assessment performed was proven by design type.
18	Evidence supporting the application under different conditions of use:	Not applicable, see 17 above.
19	Evidence of period of operational use:	Not applicable, see 17 above.
20	Statement of restrictions on functionality:	Not applicable, see 17 above.
21	Systematic capability (SC1, SC2, SC3)	SC3 see report R56A21807 rev1 B.
22	Systematic fault avoidance measures:	Compliance with techniques and measures from IEC 61508-2 Annex B to SIL 2
23	Systematic fault tolerance measures:	Compliance with techniques and measures from IEC 61508-2 Annex A to support the SFF achieved
24	Validation records:	All documents that have been used in support of the hardware assessment have been documented in report R56A21807 rev1A.

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Failure to observe the above conditions will invalidate the certified data and may compromise the integrity of the safety function performed by the valves

Management of functional safety

The assessment has demonstrated that the certified products are supported by an appropriate functional safety management system that meets the relevant requirements of IEC 61508-1:2010 clause 6. See report R56A21807Brev1B

Identification of certified equipment
A full list of certified equipment documents is defined below:

Sira ID	Document no	Rev	Date	Document description
PALFS01	Q066	12	24/10/2018	Installation, commissioning and maintenance manual for the PN pneumatic scotch yoke actuator. This manual includes the full bill of material and mechanical drawing.
PALFS02	Q065	08	24/10/2018	Installation, commissioning and maintenance manual for the HY pneumatic scotch yoke actuator. This manual includes the full bill of material and mechanical drawing. DG series is identical to the HY series.
PALFS03	Q070	02	24/10/2018	Installation, commissioning and maintenance manual for the PNL&HYL pneumatic scotch yoke actuator. This manual includes the full bill of material and mechanical drawing.

Conditions of Certification

The validity of the certified failure 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 certified functional safety.
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 failure data in any specific user application is conditional on the user complying with the following conditions:

1. The user shall comply with the conditions given in Table 10 above and the requirements given in the manufacturer's user instructions in regard to all relevant functional safety aspects such as application of use, installation, operation, maintenance, proof tests, maximum ratings, environmental conditions, repair, etc.

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2. Selection of this equipment for use in safety functions and the installation, configuration, overall validation, maintenance and repair shall only be carried out by competent personnel, observing all the manufacturer's conditions and recommendations in the user documentation.
3. 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.

General Conditions and Notes

1. This certificate is based upon a functional safety assessment of the product described in Sira Test & Certification Assessment Reports R56A21807A, R56A21807B and R70202059A.
2. If certified product 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. No part of the Functional safety related aspects stated in the instruction manual shall be changed without approval of the certification body

Certificate History

Issue	Date	Report no.	Comment
01	11 Nov 13	R56A21807A R56A21807B	Initial certification.
02	30 May 17	R70132189A	Updated certificate following surveillance audit.
03	11 Nov 18	R70202059A	Re-issued following successful recertification audit.
04	11 Oct 19	80021323	Update to systematic capability SC 3.
05	07 Feb 20	80023108	Certificate updated to reflect addition of Italy manufacturing facility.
06	22 Jan 21	80067818	Updated to include claim of PVST, results updated accordingly.
07	02 Oct 23	80182877	Re-issued following successful recertification audit.

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Hawarden, CH5 3US, United Kingdom
Tel: +44 (0) 1244 670900
Email: ukinfo@csagroup.org
Web: www.csagroupuk.org