TÜV Rheinland Energie und Umwelt GmbH
Test Laboratory for Energy Appliances

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Report No. V360 2010 S1

Examination of Suitability according IEC 61508

Linear Actuators

Series:

HDLSRx, HDxDA, HDHSRx

Company:

Automation Technology Inc.
Houston, Tx.

United States of America

2010

Examination of safe failure fraction and systematic safety integrity according to IEC 61508 of linear actuators

Manufacturer/Contractor:	Automation Technology Incorporated 4950 Cranswick Road Houston, Tx., 77041 USA		
Test item:	Linear actuators with optional override systems		
Type designation actuators:	HDLSRE, HDLSRR, HDLDA, HDHDA, HDHSRE, HDHSRR		
Type designation override:	HO2, JS2		
Technical data:			
Permissible temperature range:	°F	°C	
	+40 – +200	+4,4 – 93,3	NBR seals
	-65 – +200	-53,89 – 93,3	NBR Low Temp
	-20 – +400	-28,89 – 204,44	FKM seals
Max. supply pressure:	psi	bar	
	150	10,34	HDLSRx,HDLDA
	3000	206,84	HDHDA, HDHSRx

Test cause:
Assessment of safe failure fraction and systematic safety integrity according to IEC 61508. In the examination the normal mode of operation during which the test item is operated by an automatic control system has been considered.

Test results:

	HDLSRE HDLSRR	HDLDA HDHDA	HDHSRE HDHSRR	HO2	JS2
Safe Failure Fraction	91,8%	90,2%(X)	96,8%	90%	-(XX)

(X) In Addition to the failures considered in this report, possible failures for the pressure supply have to be considered for the double acting types HDLDA and HDHDA. (XX) The JS2 override is decoupled during normal operation.

In the opinion of the test laboratory the systematic safety integrity of the test items is suitable to use components of the examined types in safety related systems according to IEC 61508 with a safety integrity of up to and including SIL 3. For a final assessment of the test item additional requirements, especially the safety integrity of the test item, haves to be considered.

The report only covers the linear actuators with optional override systems. The results do not represent any direct statement regarding a Safety Integrity Level, SIL. For a final assessment of a SIL, the specific safety related system incorporating the test items has to be evaluated according to IEC 61508.

These statements are bound to the proven and verified deployment of a safety-related quality management by the manufacturer. These statements are only applicable if the test item is operated according to the documentation and recommendations of the manufacturer.

The test laboratory does not assume any further liability for the application of the data determined.

Dated in Cologne, 2010-08-30

Expert

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Test Laboratory for
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1. Task definition

Task of this examination is to determine the safe failure fraction of the test item and to determine whether or not suitable measure have been taken to ensure the systematic safety integrity of the safety function of the test item.

The safety function of the actuators using spring return is to return into the default position (open or closed) when the control medium is cut off and vented.

The safety function of the double acting actuator models is to maintain functionality under all conditions so that the actuator can be moved into the application dependent safe position by means of the control medium.

This expert report only refers to the actuators themselves. This report does not cover further components required for the safe operation of the test item, as, for example, the pressure supply for the double acting actuators.

The assessment of the type series in accordance with IEC 61508 is based on the following information:

- Failure Mode and Effect Analysis (FMEA)
- Documentation regarding the design, the assembly and the operation of the test item, submitted by the manufacturer

Precise classification in a SIL can only be stated for complete safety-related systems in which the relay only represents one component. Therefore only appliance-specific values are stated as the results of this examination.

These statements are bound to the proven and verified deployment of safety-related quality management of the manufacturer, which ensures the constant quality of the products supplied in accordance with the documentation submitted and a 100% testing of pieces produced.

All statements in the test report are based on the documentation submitted by the manufacturer and only refer to the test items as listed in the report as long as it complies with the provided documentation.

2. Description of the type series

The test item includes the following type series.

Groups	Model #	Bore Sizes	Stroke	Max. pressure [psi] / [bar]	Override Optional
Pneumatic Spring Return	HDLSRE HDLSRR	4" – 44"	1" – 50"	150 / 10,34	HO2 / JS2
Pneumatic Double Acting	HDLDA HDHDA	4" – 44" 2" – 16"	1" – 50"	150 / 10,34 3000 / 206,84	HO2 / JS2 HO2
Hydraulic Spring Return	HDHSRE HDHSRR	2" – 10" 2" – 10"	1" – 50"	3000 / 206,84	HO2

xxxSRE: Spring return extend
xxxSRR: Spring return retract
xxxDA: Double acting

The test items are linear actuators. In the normal mode of operation the test items are actuated by means of the respective control medium. For the pneumatic versions clean, dry air is used, for the hydraulic versions Texaco Rando HD is used as control medium.

The examined type series contain optional override mechanisms. In override mode the test items can be actuated by a hand wheel override (JS2) or a hydraulic override (HO2).

The hand wheel override uses a worm gear and a thrust rod to move the actuator whithout control medium. The hand wheel override is coupled via a screw with the actuator. In normal mode the screw is retracted and the hand wheel override and the actuator are uncoupled.

The hydraulic override uses a hand pump which fills a hydraulic cylinder installed on top of the pneumatic cylinder / spring compartment of the actuator. The hydraulic cylinder contains a piston connected to the acutators thrust rod. By filling one side of the hydraulic cylinder using the hand pump the actuator is moved in the corresponding direction. In normal mode of operation the hydraulich cylinder is empty. The piston inside the hydraulic cylinder remains connected to thrust rod.

The following options exist for the used elastomeric sealings.

Permissible operating temperature		
Sealing Option	°F	°C
NBR Sealings	+40 – +200	+4,4 – +93,3
NBR Low Temp Sealings	-65 – +200	-53,89 – +93,3
FKM Sealings	-20 – +400	-28,89 – +204,44

3. Examination

The basis of the examination is formed by:

- a Failure Mode and Effect Analysis (FMEA)
- the documentation submitted by the manufacturer

3.1. Determination of the Safe Failure Fraction SFF

The Safe Failure Fraction states the proportion of safe failures from the total number of failures. A safe failure is a failure of the safety function that leads to a safe state or a failure that can be detected before a dangerous state occurs.

The SFF has been calculated from the proportion of failures found in the FMEA.

For the FMEA one type of each actuator group has been select as a worst case scenario for the whole group. The following types have been selected.

Types used for FMEA	
Group	Type
Pneumatic spring return	HDLSRE with JS2
Pneumatic double acting	HDLDA with HO2
Hydraulic spring return	HDHSRE

During the FMEA only the normal operating mode for the actuators with disengaged override systems has been considered. Since the hand wheel override can be uncoupled from the actuator it does not generate additional possible failures. The hydraulic override does generate additional possible failures since during normal operation the piston of the hydraulic override remains connected to the thrust rod of the actuator.

Using the specified types, the FMEA lead to the following results.

FMEA results			
Group	Safe Failures	Dangerous Failures	SFF
Pneumatic spring return	45	4	91,8%
Pneumatic double acting[X]	46	5	90,2%
Hydraulic spring return	62	2	96,8%
JS2	-	-	-
HO2	9	1	90,0%

[X] In Addition to the failures considered in this report, possible failures for the pressure supply have to be considered for the double acting types HDLDA and HDHDA.

The number of safe and dangerous failure for the hydraulic override has to be added to any actuator equipped with this override and the safe failure fraction has to be recalculated according to the result of this addition.

In addition to the numbers from the FMEA additional failures that can lead to a failure of the control medium supply have to be considered for the double acting design.

3.2. Requirements concerning the systematic safety integrity

To be able to use a component in a safety related system according to IEC 61508, this component has to fulfil requirements regarding the systematic safety integrity to proof an adequate safety against systematic failures.

A systematic failure is defined in accordance with IEC 61508-4 as a failure whose cause can be clearly identified. Examples for causes of systematic failures are errors during design, assembly and installation of the product.

Possible causes for systematic failures have been identified during the FMEA.

3.3. Requirements for the prevention of failures

To prevent failures because of errors during the design of the component a suitable range of methods has to be employed according to IEC 61508-2. It is the opinion of the test centre, that a quality management system fulfilling the requirements of ISO 9001 is a suitable means to meet these requirements for up to and including SIL 3.

The specific measures employed to prevent specific systematic failures have been identified and documented in the FMEA.

3.4. Requirements for the control of systematic failures

In addition to the requirements for the prevention of systematic failures IEC 61508-2 presents requirements to ensure that the design of the booster relays is tolerant against:

1. the remaining design errors present, unless it is possible to exclude the possibility of remaining design errors.
2. stress induced by the ambient conditions of the examined system
3. errors made by the operator of the equipment.

It is the opinion of the test centre, that it is a valid assumption, that no design errors remain in the mechanical component of the examined actuator, because the test item consists of well known mechanical components and a long history and experience in the use of this components and their design exists. Therefore the first point can be seen as fulfilled. The maintenance interval of 5 years specified in the Installation, Operation and Maintenance Manual seems suitable to detect aging effects before these effects can lead to a dangerous condition.

The ambient conditions of the actuators are well defined and do not present a harmful condition for the mechanical part of the actuators as documented by the specification of the sealing. Therefore the second point can be seen as fulfilled.

Errors made by the operator of the equipment might proof to be harmful. Since the "operator" of the actuator is a control system, it is valid to pass this requirement on to the design of this system. Information for the safe use of the manual override is included in the operating manual. Therefore all three points can be seen as fulfilled.

4. Test statement

The

linear actuators

of the type series

HDLSRE, HDLSRR, HDLDA, HDHDA, HDHSRE, HDHSRR

with optionally installed

override systems

of type series

JS2 and HO

of the company

Automation Technology Incorporated
4950 Cranswick Road
Houston, Tx., 77041
USA

have been examined by means of an FMEA to determine the safe failure fraction and to assess the systematic safety integrity.

As a result of this examination it is the opinion of the test centre, that the systematic safety integrity of the test items is suitable for an incorporation of the test items into safety related systems with SIL 3.

During the FMEA the following safe failure fractions were determined.

	HDLSRE HDLSRR	HDLDA HDHDA	HDHSRE HDHSRR	HO2	JS2
Safe Failure Fraction	91,8%	90,2%(X)	96,8%	90%	-(xx)

(X) In Addition to the failures considered in this report, possible failures for the pressure supply have to be considered for the double acting types HDLDA and HDHDA. (xx) The JS2 override is decoupled during normal operation.

The test statement does apply only to components conforming to the documentation provided for this examination and which are installed and operated according to the requirements and recommendations of the manufacturer documented in this report and the FMEA.

The test statement does not state a SIL level for the assessed components. Also safe failure fraction and systematic safety integrity only partly proof that a component is suitable for a safety related system according to IEC 61508. Additional steps have to be taken before the assessment can be made whether or not the test items can be used in a specific system.

The suitability for specific applications can only be determined in connection with the assessment of all components of a safety related system according to IEC61508.

The test centre does not assume any further liability for the application of the data determined.

Enclosures

1	FMEA HDLSRE w/JS2, 2010-08-30
2	FMEA HDLDA w/HO2, 2010-08-30
3	FMEA HDHSRE, 2010-08-30
4	Cross sectional drawings HDLSRE w/JS2, 2010-23-06
5	Cross sectional drawings HDLDA w/HO2, 2010-22-06
6	Cross sectional drawings HDHSRE, 2010-23-06
7	Installation, operating and maintenance manual, Rev. A, 2010-08-24
8	MP1015 ATI testing and inspection procedure, 2010-08-18
9	MF1001 test and inspection report, 2010-08-18
10	M100 quality inspection report, 2002-12-19
11	S-115 order entry-engineering form, 2002-12-6
12	Seal Manufacturer Documentation
13	ATI Quality Assurance Manual 2002-02-19
14	EP 4001 General Product stress analysis, 2010-08-24

All documentation is at hand at the test laboratory.