TÜV Rheinland Energie und Umwelt GmbH

Test Centre for Energy Appliances

Report Nr. V 360.02/15

Extension of the SIL Assessment for Linear Actuators according to
IEC 61508:2010 and IEC 61511:2004

Linear Actuator series:

HDL-Series (HDLSRE, HDLSRR, HDLDA)

L-Series (LSRE, LSRR, LDA)

HDH-Series (HDHSRE, HDHSRR, HDHDA)

H-Series (HSRE, HSRR, HDA)

Company

Automation Technology, LLC.

Houston, Tx., USA

2015

Extension of the SIL Assessment for Linear Actuators according to IEC 61508:2010 and IEC 61511:2004

Manufacturer/Contractor:	Automation Technology, LLC 4950 Cranswick Road Houston, Tx. 7701 USA
Product tested:	*Linear Actuators (pneumatic, hydraulic) with optional override systems*
Type designation:	HDLSRE, HDLSRR, HDLDA, LSRE, LSRR, LDA HDHSRE, HDHSRR, HDHDA, HSRE, HSRR, HDA
Technical data:	
Max. supply pressure:	10.34 bar // 150 psi (HDLSRx, HDLDA, LSRx, LDA) 206.84 bar // 3000 psi (HDHSRx, HDHDA, HSRx, HDA)
Max. temperature:	NBR seal: +4.4 °C - +93.3 °C // +40 °F - +200 °F NBR Low Temp., EPDM: -53.89 °C - +93.3 °C // -65 °F - + 200 °F FKM seals: -28.89 °C - +204.44 °C // -20 °F - +400 °F
Operating medium	Compressed air, clean dry instrument air (pneumatic versions) Texaco Rando HD oil (hydraulic versions)
Safety function:	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.
Test result:	The linear actuators are suitable for use in a safety instrumented system up to SIL 2. Under consideration of the minimum required hardware fault tolerance HFT=1 the devices may be used in a redundant structure up to SIL 3. The instructions of the associated Installation, Operation and Safety Manual have to be considered.
Useful lifetime:	A time of usage of more than 5 years (+ 1.5 years of storage) can only be favored under responsibility of the operator, consideration of specific external conditions (securing of required quality of media, max. temperature, time of impact), and adequate test cycles.
Quality Management:	These statements are bound to a proven and verified deployment of safety-related quality management of the manufacturer.
Validity	The validity of the test report is limited to the period of time until June 2020.

The test results refer only to the test object. The test results do not represent any statement with regard to the safety integrity level (SIL) of the final system. The suitability for certain applications can only be realized through the evaluation of the respective safety-related overall system, including all safety-related components, in accordance with IEC 61508 and IEC 61511.

The test statement is valid for new linear actuators for a period of 5 years after commissioning (+ 1.5 years storage). The test statement presupposes that during this period of time the linear actuators are maintained and operated in accordance with the manufacturer's specifications.

The Test Centre does not assume any further liability for application of the values determined.

Cologne, 08.06.2015	Test Centre for Energy Appliances
Expert	Review
i. A.	i. A.
M.Eng. Christian Schneider	Dr.-Ing. Jan Schumacher

Summary of technical safety characteristics

Table: Device specific values pneumatic spring return extend / retract HDL- / L-Series

(HDLSRR, HDLSRE, LSRR, LSRE)

Device-Specific Values

Probability of Dangerous Failure on Demand	PFD_{spec}	7.97 E-04
Test Interval	Ti	1 a
Confidence Level	1-α	95 %
Safe Failure Fraction	SFF	83.7 %
Hardware Fault Tolerance	HFT	0
Diagnostic Coverage	DC	0 %
Type of Sub System		Type A
Mode of Operation		Low Demand

Derived Values for 1oo1-Architecture

Assumed Demands per Year	f_{np}	1 / a	1.14 E-04 / h
Total Failure Rate	$\lambda_S + \lambda_D$	5.58 E-07 / h	558 FIT
Lambda Dangerous Detected	λ_{DD}	0.00 E+00 / h	0 FIT
Lambda Dangerous Undetected	λ_{DU}	9.10 E-08 / h	91 FIT
Lambda Safe	λ_S	4.67 E-07 / h	467 FIT
Mean Time To Failures	MTTF	1.79 E+06 h	205 a
Mean Time To Dangerous Failures	$MTTF_D$	1.10 E+07 h	1,255 a
Average Probability of Failure on Demand	$\mathbf{PFD_{avg}}$	**3.98 E-04**	

Table: Device specific values pneumatic double acting HDL- / L-Series (HDLDA, LDA)

Device-Specific Values

Probability of Dangerous Failure on Demand	PFD_{spec}	4.34 E-04
Test Interval	Ti	1 a
Confidence Level	1-α	95 %
Safe Failure Fraction	SFF	83.6 %
Hardware Fault Tolerance	HFT	0
Diagnostic Coverage	DC	0 %
Type of Sub System		Type A
Mode of Operation		Low Demand

Derived Values for 1oo1-Architecture

Assumed Demands per Year	f_{np}	1 / a	1.14 E-04 / h
Total Failure Rate	$\lambda_S + \lambda_D$	3.02 E-07 / h	302 FIT
Lambda Dangerous Detected	λ_{DD}	0.00 E+00 / h	0 FIT
Lambda Dangerous Undetected	λ_{DU}	4.96 E-08 / h	50 FIT
Lambda Safe	λ_S	2.53 E-07 / h	253 FIT
Mean Time To Failures	MTTF	3.31 E+06 h	378 a
Mean Time To Dangerous Failures	$MTTF_D$	2.02 E+07 h	2,302 a
Average Probability of Failure on Demand	$\mathbf{PFD_{avg}}$	**2.17 E-04**	

Table: Device specific values hydraulic spring return extend / retract HDH- / H-Series

(HDHSRR, HDHSRE, HSRR, HSRE)

Device-Specific Values

Probability of Dangerous Failure on Demand	PFD_{spec}	2.63 E-03
Test Interval	Ti	1 a
Confidence Level	1-α	95 %
Safe Failure Fraction	SFF	90.6 %
Hardware Fault Tolerance	HFT	0
Diagnostic Coverage	DC	0 %
Type of Sub System		Type A
Mode of Operation		Low Demand

Derived Values for 1oo1-Architecture

Assumed Demands per Year	f_{np}	1 / a	1.14 E-04 / h
Total Failure Rate	$\lambda_S + \lambda_D$	3.19 E-06 / h	3,191 FIT
Lambda Dangerous Detected	λ_{DD}	0.00 E+00 / h	0 FIT
Lambda Dangerous Undetected	λ_{DU}	3.00 E-07 / h	300 FIT
Lambda Safe	λ_S	2.89 E-06 / h	2,891 FIT
Mean Time To Failures	MTTF	3.13 E+05 h	36 a
Mean Time To Dangerous Failures	$MTTF_D$	3.33 E+06 h	381 a
Average Probability of Failure on Demand	**PFD_{avg}**	**1.31 E-03**	

Table: Device specific values hydraulic double acting HDH- / H-Series (HDHDA, HDA)

Device-Specific Values

Probability of Dangerous Failure on Demand	PFD_{spec}	1.76 E-03
Test Interval	Ti	1 a
Confidence Level	1-α	95 %
Safe Failure Fraction	SFF	83.6 %
Hardware Fault Tolerance	HFT	0
Diagnostic Coverage	DC	0 %
Type of Sub System		Type A
Mode of Operation		Low Demand

Derived Values for 1oo1-Architecture

Assumed Demands per Year	f_{np}	1 / a	1.14 E-04 / h
Total Failure Rate	$\lambda_S + \lambda_D$	1.22 E-06 / h	1,224 FIT
Lambda Dangerous Detected	λ_{DD}	0.00 E+00 / h	0 FIT
Lambda Dangerous Undetected	λ_{DU}	2.01 E-07 / h	201 FIT
Lambda Safe	λ_S	1.02 E-06 / h	1,024 FIT
Mean Time To Failures	MTTF	8.17 E+05 h	93 a
Mean Time To Dangerous Failures	$MTTF_D$	4.98 E+06 h	568 a
Average Probability of Failure on Demand	$\mathbf{PFD_{avg}}$	**8.80 E-04**	

Content

1. Task Definition

The aim of the appraisal is to determine the suitability of the test items for utilization in safety-related systems in accordance with IEC 61508:2010 and IEC 61511:2004 for operating modes with a low demand on the safety function (low demand mode).

The linear actuators inspected are used in safety-related systems as part of a final controlling device (shut off valve, control valve). This extension is carried out on the assessment of the HDLSRE, HDLSRR, HDLDA, HDHSRE, HDHSRR and HDHDA heavy duty series documented in the report V 360 2010 S1 (dated 2010-08-30) which was based on the determination of the safe failure fraction of the test item. No constructional changes were made in the assessed type series. Furthermore the versions for use on control valves (LSRE, LSRR, LDA, HSRE, HSRR, HDA) shall be assessed and included into this report.

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.

The evaluation of the test items was carried out on the basis of

- manufacturer declaration of constructive / design / material analogousness of the test items compared to test report V 360 2010 S1
- an updated Failure Mode and Effect Analysis (FMEA) for recalculating the SFF
- statistically evaluation of sales and customer complaint tables
- the previous assessment and results as described in report V 360 2010 S1
- the certified quality management system of the manufacturer.

The test results refer only to the mechanical safety function of the test object. The suitability for certain applications can only be realized through the evaluation of the respective safety-related overall system, including all safety-related components, in accordance with the relevant standard.

1.1 Test Basis

[N1] IEC 61508 Parts 1-2, 4-7:2010

[N2] IEC 61511 Parts 1-3:2004

1.2 Previous Reports

Types	Report-No.
HDLSRE, HDLSRR, HDLDA, HDHSRE, HDHSRR, HDHDA	V 360 2010 S1 (2010-08-30)

2. Description of Test Item

The test item includes the following type series.

Table 1: Overview Actuator types

Groups	Model #	Bore Sizes	Stroke	Max. pressure [psi] / [bar]	Override Optional
Pneumatic Spring Return Extend / Retract	HDLSRE, LSRE HDLSRR, LSRR	4" – 44"	1" – 50"	150 / 10.34	HO1 / JS2
Pneumatic Double Acting	HDLDA, LDA	4" – 44"	1" – 50"	150 / 10.34	HO2 / JS2
Hydraulic Spring Return Extend / Retract	HDHSRE, HSRE HDHSRR, HSRR	2" – 16"	1" – 50"	3000 / 206.84	HO1
Hydraulic Double Acting	HDHDA, HDA	2" – 16"	1" – 50"	3000 / 206.84	HO2

<u>Manufacturers type designation (actuators):</u>

HDLxxx: pneumatic (on / off)

Lxxx: pneumatic (control valves)

HDHxxx: hydraulic (on / off)

Hxxx: hydraulic (control valves)

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 oil is used as control medium.

The difference between the L- and LD-Series respectively the H- and HD-Series is the intended use (control valve, on/off application) and the pressure rating. Their functional behaviour and constructional design is the same.

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 / HO1). Hydraulic and manual overrides ensure the ability to operate the actuator upon complete loss of electricity or air / hydraulic pressure.

The hand wheel override uses a worm gear and a thrust rod to move the actuator without 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 actuators 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 hydraulic cylinder is empty. The piston inside the hydraulic cylinder remains connected to thrust rod.

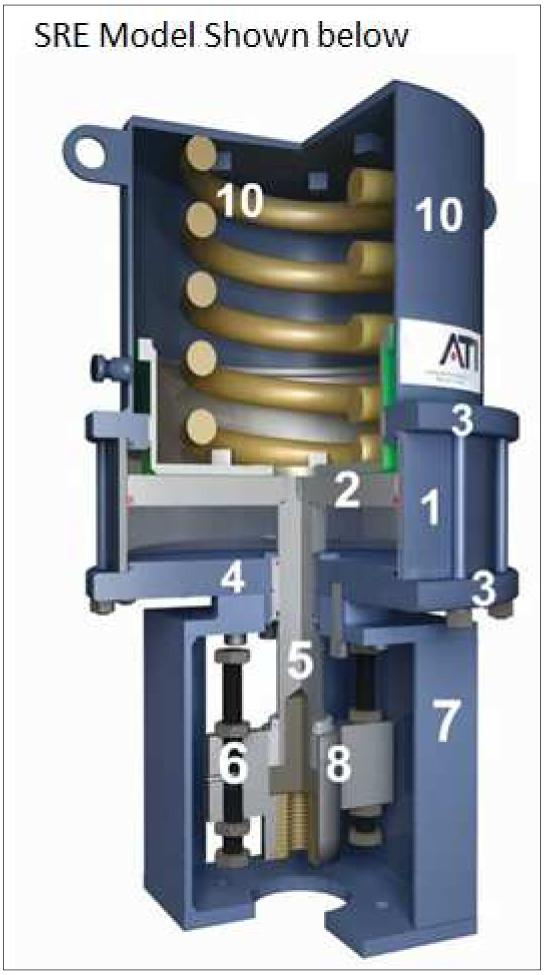
The following options exist for the used elastomeric sealings.

Table 2: Overview used Sealings

Permissible operating temperature [A40, A41]		
Sealing Option	**°F**	**°C**
NBR Sealings	+40 – +200	+4.4 – +93.3
NBR Low Temp Sealings	-65 – +200	-53.89 – +93.3
EPDM	-65 – +200	-53.89 – +93.3

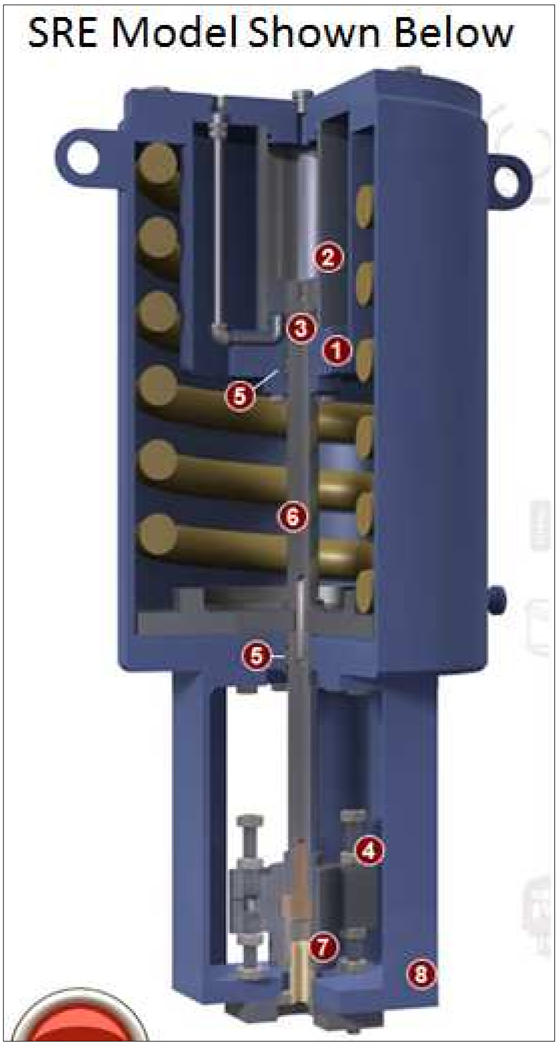
FKM Sealings	-20 – +400	-28.89 – +204.44

2.1 Design Variants of Linear Actuators



Picture 01: Pneumatic Spring Return (SRR & SRE) Actuator

Picture 02: Pneumatic Double Acting (DA) Actuator



Picture 03: Hydraulic Spring Return (SRR & SRE) Actuator

Picture 04: Hydraulic Double Acting (DA) Actuator

2.2 Optional Manual Overrides

JS2 Override:

- capable of extending or retracting the actuator
- can be engaged at any position from full open to full closed
- entire mechanism incorporated in actuator adapter
- allows for removal or service of the power cylinder while maintaining complete control of the valve

HO1 Override:

- one way hydraulic override for use on spring return actuators
- compresses spring and operates valve
- spring force is used to move valve to failure position

HO2 Override:

- used on double acting actuators
- capable of extending or retracting actuator
- allows for precise speed control by regulating flow of hydraulic fluid in system

2.3 Safety Function

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.

3. Assessment

To assess the capability of the test item for its use in safety related applications several parameters are necessary. The following chapter explains how all parameters of the certificate have been determined.

3.1 Mode of Operation

The operation mode of the test item can be classified as an operation mode with a low rate of demand in accordance with IEC 61508-4, 3.5.16.

LDM

3.2 Type of Subsystem

The system is classified as Type A in accordance with IEC 61508-2, Section 7.4.4.1.2.

The FMEA of the test items has shown that the failure behavior of all components is defined sufficiently.

Due to the proven in use data and customer complaints of the test item, the behavior of the test item under fault conditions can be suspected as completely determined.

Type A

3.3 Diagnostic Coverage

The test item itself does not contain any diagnostic measures. If diagnosis is required for the safety function of the test item then this must be provided through external measures as part of the safety-related overall system.

DC = 0 %

3.4 Hardware Fault Tolerance

The test item is a single-channel system and consequently itself has no hardware fault tolerance. If a hardware fault tolerance is necessary then a multichannel structure has to be stipulated as required.

HFT = 0

3.5 Common Cause Factor

The β_{int}-factor states how many failures in redundant architectures can be lead back on a common cause. It was calculated acc. IEC 61508-6, table D.1.

$$\beta_{int} = 10\ \%$$

3.6 Safe Failure Fraction

The safe failure fraction (SFF) states the ratio of safe failures to all possible failures of the safety function of the component. A safe failure of the safety function is a failure that does not lead to a dangerous situation. Therefore *dangerous detected* and *dangerous excluded* failures are also on the top of the fraction bar.

$$SFF = \frac{\sum \lambda_{safe} + \sum \lambda_{dangerous\ detected} + \sum \lambda_{dangerous\ excluded}}{\sum \lambda_{safe} + \sum \lambda_{dangerous}}$$

A reevaluation of all failures was done within the FMEA with the alternative method from EN 161:2011/A3:2013 which pays respect to systematic and random failures.

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.

Table 3: Types used for FMEA

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

The different versions of the pneumatic linear actuators HDLSRR, HDLSRE (heavy duty, on / off application) and LSRR, LSRE (control valve) were considered as technically identical and only differ from the intended use and intended operating conditions. The same was assumed for the double acting versions and the hydraulic versions.

During the FMEA only the normal operating mode for the actuators with disengaged override systems has been considered. Since the hand wheel override (JS1, JS2) is uncoupled from the actuator in normal mode of operation it does not generate additional possible failures. The hydraulic override (HO1, HO2) 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.

Table 4: determined SFF

FMEA results			
Group	**Safe Failures**	**Dangerous Failures**	**SFF**
Pneumatic spring return extend / retract	41	8	83.7 %
Pneumatic double acting(x)	42	9	82.4 %
Hydraulic spring return extend / retract	58	6	90.6 %
Hydraulic double acting(x)	42	9	82.4 %
JS2	-	-	-
HO2, HO1	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 , LDA and HDHDA, HDA.

The number of safe and dangerous failure for the hydraulic override (HO1, HO2) 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.

3.7 Calculated values

Failure rates have been calculated by results of the proven in use data and the customer complaint list (years 2010-2014) submitted by the manufacturer and the recalculated SFF by means of an updated FMEA. According to the manufacturer ca. 25 % of all sold units are used in safety relevant applications (LDM with 1 demand per year). In total 11.5 demands per year were considered for calculation.

For the calculation of specific probability of failures a confidence level of (1-α) = 95 % was assumed. The specific probability of failure was calculated based on Sales Statistics [A28] and Customer Complaint Report [A29] to:

Table 5: sales & reclamations

	HDL-L_Series			
	pneumatic, spring return extend / retract		pneumatic, double acting	
	Sold [pc]	reported failures [qty]	Sold [pc]	reported failures [qty]
2010	184	2	260	2
2011	99	5	238	2
2012	298	1	390	1
2013	235	1	353	2
2014	240	0	413	0

	HDH-H_Series			
	hydraulic, spring return extend / retract		hydraulic, double acting	
	Sold [pc]	reported failures [qty]	Sold [pc]	reported failures [qty]
2010	6	0	45	0
2011	15	0	91	3
2012	10	0	21	1
2013	10	0	11	0
2014	16	0	11	0

Only safety relevant failures shown.

Table 6: calculated values

Type	PFD_{spec}	λ_d
Pneumatic Spring Return Extend / Retract (HDLSRR, HDLSRE, LSRR, LSRE)	7.94 E-04	9.10 E-08 / h
Pneumatic Double Acting (HDLDA, LDA)	4.34 E-04	4.96 E-08 / h
Hydraulic Spring Return Extend / Retract (HDHSRR, HDHSRE, HSRR, HSRE)	2.63 E-03	3.00 E-07 / h
Hydraulic Double Acting (HDHDA, HDA)	1.76 E-03	2.01 E-07 / h

Average probability of failure per demand can be calculated by the following assumptions:

- n_{op} = 1 / year (for safety relevant devices)
- Proof test interval T_i = 1 year
- HFT = 0

$$PFD_{avg} = ½\ PFD_{spec} \cdot n_{op} \cdot T_i$$

Table 7: calculated PFD_{avg}

Type	PFD_{avg}
Pneumatic Spring Return Extend / Retract (HDLSRR, HDLSRE, LSRR, LSRE)	3.98 E-04
Pneumatic Double Acting (HDLDA, LDA)	2.17 E-04
Hydraulic Spring Return Extend / Retract (HDHSRR, HDHSRE, HSRR, HSRE)	1.31 E-03
Hydraulic Double Acting (HDHDA, HDA)	8.80 E-04

3.8 Systematic Safety Integrity

The systematic safety integrity has been proved by a valid ISO 9001 certificate (Annex A 30) and by installation, operation and maintenance instructions (Annex A 14 to A 19) as well as the SIL users guide (Annex A46).

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.

3.9 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 [A30] is a suitable means to meet these requirements.

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

3.10 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 prove 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,

LSRE, LSRR, LDA

HDHSRE, HDHSRR, HDHDA

HSRE, HSRR, HDA

with optionally installed

override systems

of type series

JS2 and HO1 / HO2

of the manufacturer **Automation Technology, LLC**
4950 Cranswick Road
Houston, Tx., 77041
USA

are suitable for use in a safety instrumented system up to SIL 2 according to IEC 61508:2010 and IEC 61511:2004.

Under consideration of the minimum hardware fault tolerance HFT =1 the actuators may be used in a redundant structure up to SIL 3.

List of Inspected Documents

A01	Linear Actuators – Product Overview Brochure
A02	Assembly Drawing & Material List HDHSRR, No. 27305, Rev. A 4/23/15
A03	Assembly Drawing & Material List HDHSRE, No. 27304, Rev. A 4/23/15
A04	Assembly Drawing & Material List HDHDA, No. 27306, Rev. A 4/23/15
A05	Assembly Drawing & Material List HSRR, No. 27308, Rev. A 4/23/15
A06	Assembly Drawing & Material List HSRE, No. 27307, Rev. A 4/23/15
A07	Assembly Drawing & Material List HDA, No. 27309, Rev. A 4/23/15
A08	Assembly Drawing & Material List HDLSRR, No. 26414, Rev. A 4/24/15
A09	Assembly Drawing & Material List HDLSRE, No. 27296, Rev. A 4/24/15
A10	Assembly Drawing & Material List HDLDA, No. 27298, Rev. A 4/24/15
A11	Assembly Drawing & Material List LSRR, No. 27302, Rev. A 4/24/15
A12	Assembly Drawing & Material List LSRE, No. 27299, Rev. A 4/24/15
A13	Assembly Drawing & Material List LDA, No. 27303, Rev. A 4/24/15
A14	Instruction / Operation / Maintenance Manual, Hydraulic Type SRR, IOM 1005 Rev A
A15	Instruction / Operation / Maintenance Manual, Hydraulic Type SRE, IOM 1004 Rev A
A16	Instruction / Operation / Maintenance Manual, Hydraulic Type DA, IOM 1006 Rev B
A17	Instruction / Operation / Maintenance Manual, Pneumatic Type SRR, IOM 1002 Rev C
A18	Instruction / Operation / Maintenance Manual, Pneumatic Type SRE, IOM 1001 Rev B
A19	Instruction / Operation / Maintenance Manual, Pneumatic Type DA, IOM 1003 Rev C
A20	FMEA HDH-SRE, TÜV Rheinland
A21	FMEA HDLDA, TÜV Rheinland
A22	FMEA HDL-JS2, TÜV Rheinland
A23	PFD Calculation HDL-L-Series spring return extension, TÜV Rheinland
A24	PFD Calculation HDL-L-Series double acting, TÜV Rheinland
A25	PFD Calculation HDH-H-Series spring return extension, TÜV Rheinland
A26	PFD Calculation HDH-H-Series double acting, TÜV Rheinland
A27	ATI Sales Presentation

A28 Sales Statistic, ATI, 2010-2014, L-/HDL-/H-/HDH-Series

A29 Customer Complaint Report Log, 2010-2014

A30 ISO 9001 Certificate, ATI, valid until 18. Sept. 2015

A31 QM-Certificate acc. Directive 97/23/EC Module H, ATI, valid until 18. Sept. 2015

A32 Report V360 2010 S1, Examination of Suitability acc. IEC 61508, TÜV Rheinland, 2010-10-06

A33 Private Label Agreement ATI / Fisher Controls International LLC, Mail 9 March 2015

A34 Instruction / Operation / Maintenance Manual, Type DA with hydraulic overrides HO2, IOM 1017 Rev B

A35 ATI Technical Description / Hydraulic Oil Specs, 2010

A36 Test and Inspection Procedure, MP1015, Rev. J 6/16/14

A37 Test and Inspection Report, MF1001, Rev. M

A38 Final Inspection Report QF0009 Rev. J 4/7/15

A39 Order Entry Engineering Form, S-115, 12/6/02

A40 Seal Documentation, Buna / Low Temp Buna / Viton / PTFE wear band (1990/1985/2000)

A41 Seal Documentation, EPDM (-70 to 300 °F), Buna (-35 to +250 °F), Viton (-15 to +400 °F)

A42 Quality Assurance Manual, ISO 9001-2008, Rev. E, 6/2/14

A43 General Product Stress Analysis, #EP4001, Rev. C 4/19/13

A44 Manufacturer Declaration of unchanged design, 2015-05-13

A45 Confirmation only 25% of sold actuators used in safety relevant applications, 2015-05-26

A46 Calculation β-factor

A47 SIL Handbook