Failure Modes, Effects and Diagnostic Analysis

Project:
Temperature switches ML1H / L1X, MT1H / T1X, L2H and T2H / T2X

Customer:
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Management summary

This report summarizes the results of the hardware assessment carried out on the temperature switches ML1H / L1X, MT1H / T1X, L2H and T2H / T2X. Table 1 gives an overview of the different versions that belong to the considered temperature switches.

The mechanical assessment consists of a Failure Modes, Effects and Diagnostics Analysis (FMEDA). A FMEDA is one of the steps taken to achieve functional safety assessment of a device per IEC 61508. From the FMEDA, failure rates are determined and consequently the Safe Failure Fraction (SFF) is calculated for the device. For full assessment purposes all requirements of IEC 61508 must be considered.

Table 1: Version overview [1]

Type	Comment
MLH / L1X	Single temperature switch, Ex i approval, L1X additional with Explosion proof housing and Ex d approval
MT1H / T1X	Single temperature switch with remote sensor, Ex i approval, T1X additional with Explosion proof housing and Ex d approval
L2H	Dual temperature switch, Ex i approval
T2H / T2X	Dual temperature switch, Terminal clip integrated, Ex i approval, T2X additional with Explosion proof housing and Ex d approval,

For safety applications only the described versions of the temperature switches have been considered. All other possible variants and configurations are not covered by this report.

Barksdale GmbH and *exida* together did a quantitative analysis of the temperature switches ML1H / L1X, MT1H / T1X, L2H and T2H / T2X to calculate the failure rates using *exida's* experienced-based data compilation for the different mechanical components.

The temperature switches ML1H / L1X, MT1H / T1X, L2H and T2H / T2X are classified as Type A[2] elements according to IEC 61508, having a hardware fault tolerance of 0.

All types can be used as monitoring devices which are switching at increasing temperature (max) or decreasing temperature (min).

The failure rates listed in this report do not include failures due to wear-out of any components. They reflect random failures and include failures due to external events, such as unexpected use, see section 4.2.3.

The failure rates according to IEC 61508:2010 2nd edition for the temperature switches ML1H / L1X, MT1H / T1X, L2H and T2H / T2X are listed in the following tables.

[1] All versions are available in several temperature ranges and switching contact materials (gold or silver). The listed versions are representative for the type series.

[2] Type A element: "Non-complex" element (all failure modes are well defined); for details see 7.4.4.1.2 of IEC 61508-2.

Table 2: Summary – IEC 61508:2010 failure rates[3] for increasing temperature detection

All types are with Ex i approval, L1X, T1X and T2X additional with Ex d approval.

	Failure rates (in FIT) according to *exida* Profile 2			
Failure category	**ML1H / L1X**	**MT1H / T1X**	**L2H**	**T2H / T2X**
Fail Safe Detected (λ_{SD})	**0**	**0**	**0**	**0**
Fail Safe Undetected (λ_{SU})	**139**	**139**	**265**	**265**
Fail Dangerous Detected (λ_{DD}) [4]	**0**	**0**	**27**	**27**
Fail Dangerous Undetected (λ_{DU})	**72**	**89**	**45**	**62**
Fail Annunciation Undetected (λ_{AU}) [5]	0	0	30	30
No effect	77	85	91	99
No part	0	0	0	0
Total failure rate (safety function)	**211**	**228**	**337**	**354**
SFF	**65%**	**60%**	**86%**	**82%**
SIL AC [6]	**SIL2**	**SIL2**	**SIL2**	**SIL2**

[3] It is assumed that practical fault insertion tests can demonstrate the correctness of the failure effects assumed during the FMEDAs.

[4] The device does not contain any internal diagnostics. The DD failures result from the fact that the redundant switch is considered to be a safety measure for the primary switch providing a DC of 90% by considering a common cause factor of 10%.

[5] The AU failures result from the fact that the redundant switch is considered to be a safety measure and therefore is contributing to the "annunciation" failure category.

[6] SIL AC (architectural constraints) means that the calculated values are within the range for hardware architectural constraints for the corresponding SIL. For full assessment purposes all requirements of IEC 61508 must be considered.

Table 3: Summary – IEC 61508:2010 failure rates[7] for decreasing temperature detection

All types are with Ex i approval, L1X, T1X and T2X additional with Ex d approval.

	Failure rates (in FIT) according to *exida* Profile 2			
Failure category	**ML1H / L1X**	**MT1H / T1X**	**L2H**	**T2H / T2X**
Fail Safe Detected (λ_{SD})	**0**	**0**	**0**	**0**
Fail Safe Undetected (λ_{SU})	**146**	**161**	**266**	**281**
Fail Dangerous Detected (λ_{DD}) [8]	**0**	**0**	**32**	**32**
Fail Dangerous Undetected (λ_{DU})	**65**	**67**	**33**	**35**
Fail Annunciation Undetected (λ_{AU})[9]	0	0	36	36
No effect	77	85	91	99
No part	0	0	0	0
Total failure rate (safety function)	**211**	**228**	**331**	**348**
SFF	**69%**	**70%**	**90%**	**89%**
SIL AC [10]	**SIL2**	**SIL2**	**SIL3**	**SIL2**

The failure rates are valid for the useful life of the considered temperature switches ML1H / L1X, MT1H / T1X, L2H and T2H / T2X (see Appendix 2) when operating as defined in the considered scenarios.

[7] It is assumed that practical fault insertion tests can demonstrate the correctness of the failure effects assumed during the FMEDAs.

[8] The device does not contain any internal diagnostics. The DD failures result from the fact that the redundant switch is considered to be a safety measure for the primary switch providing a DC of 90% by considering a common cause factor of 10%.

[9] The AU failures result from the fact that the redundant switch is considered to be a safety measure and therefore is contributing to the "annunciation" failure category.

[10] SIL AC (architectural constraints) means that the calculated values are within the range for hardware architectural constraints for the corresponding SIL. For full assessment purposes all requirements of IEC 61508 must be considered.