SIL Certification
HVT Series, JKS-HVT Series

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1	2022-08-05	Removed absoleet paragraph
2	2022-08-17	Updated logo
3	2023-01-16	Modification HVT-300-SIL
4	2023-01-31	Added HVT400-SIL-XX
5	2023-10-19	Added brand name JKS-HVT

Parties

About Mütec Instruments

Mütec Instruments was founded in 1970 and offers solutions for complex and safety-critical problems. Mütec's team of highly experienced professionals and engineers works closely with each client to design a perfectly tailored solution and often forms a close and long-term working relationship with those customers.

About Risknowlogy

Risknowlogy was founded in 2002 and is a family-owned business. We offer products, services, consulting, coaching, certification and training to business operators. Risknowlogy certifies hardware, software, solutions, sites, management systems, organisations, and professionals according to international standards.

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Terms and Definitions

Term	Definition
DC	Diagnostic coverage
DD	Dangerous detected failure rate
DU	Dangerous undetected failure rate
NE	No effect failure rate
NP	No part failure rate
PFDavg	Average probability of failure on demand
SC	Systematic capability
SD	Safe detected failure rate
SF	Safety Function
SFF	Safe failure fraction
SIL	Safety integrity level
STL	Spurious trip level
SU	Safe undetected failure rate
T1	Proof Test Interval

1. Introduction

1.1. Purpose

The purpose of this report is to document the functional safety certification of the HVT-300-SIL-XX and HVT400-SIL-XX series, further referred to as the HVT series. These products are designed, developed and manufactured by Mütec Instruments, Germany (Mütec). The certification process is carried out to demonstrate that these products meet the applicable SIL requirements according to IEC 61508 [1].

The above products are also sold as JKS-HVT-300-SIL-XX and JKS-HVT400-SIL-XX series. These are 100% identical products. In this report, we only refer to the original names.

1.2. About the Project

Mütec Instruments is the designer and manufacturer of the HVT series. These products are used as part of safety functions according to IEC 61508 [1] and IEC 61511 [2].

1.3. Certification basis

The following standard(s) have been used as the basis for the certification:

- IEC 61508 - Functional safety of E/E/PE safety-related systems [1].

1.4. Certification scope

The certification scope of Risknowlogy, as agreed upon with Mütec, is limited to the product(s) listed in Chapter 2, is based on proven in use (route 2h and 2s) and addresses the following subject matters:

- Management of functional safety;
- Hardware requirements;
- Hardware architecture;
- Hardware reliability;
- Software;
- Basic safety;
- User documentation;

1.5. History

HVT300-SIL-XX is not a new device. It is derived from and rebranded from the MSK200-SIL-DX. The development of MSK 200-SIL-DX itself is based on the MSK200 development from 1998. MSK200 owned a certificate according to DIN V VDE 0801 and DIN V 19250 for AK4 from TÜV Nord e.V. The MSK 200-SIL-DX includes a safety-related architecture and sufficient diagnostic coverage. The MSK200-SIL-DX device was re-certified according to IEC 61508 [1] and IEC 61511 [2] for SIL2. The latter certification is documented in [3].

The HVT400-SIL-XX is derived from the HVT300-SIL-XX, where the only difference is the offering of a wider voltage range.

2. Product Description

2.1. About the HVT Series

The products subject to the analysis are the HVT300-SIL-XX and HVT400-SIL-XX series, further referred to as the HVT series. The HVT series is a Balance Voltage Supervisor for Chlorine-Alkali electrolysis. Furthermore, it is used for voltage monitoring in test systems used in the automotive sector. The HVT series measures input voltages with absolute or differential mode. Output is a 4-20mA analogue signal and an alarm signal. Example products of the HVT series are shown in Figure 1.

Figure 1 - HVT300-SIL-DV and HVT400-SIL-DX.

The series subject to the analysis documented in this report and available for safety-related applications consists of the configuration listed in Table 1.

Table 1 - Configuration subject to analysis

Configuration	HW Version	SW Versions
HVT300-SIL-XX*	3.3.2	msk_dx_20210412.s2
HVT400-SIL-XX**	3.2.2 (A), 4.6.3 (B)	hvt_dv_20220518.s2

* XX represents the variations DX, DP, DU, DV

** XX represents the variations DX, DP

2.2. Differences Between MSK200-SIL-DX, HVT300-SIL-XX, and HVT400-SIL-XX

The HVT300-SIL-XX design is based on the certified MSK200-SIL-DX [3]. The main difference between the HVT300-SIL-XX and the MSK200-SIL-DX is the power supply. The power supply of the HVT300-SIL-XX has been redesigned to guarantee an isolation voltage of up to 1000V. Furthermore, the MSK200-SIL-DX has a digital output which has been removed from the HVT300-SIL-XX. These differences do not affect the actual design of the safety functionality. The main body of evidence for this certification is based on the MSK200-SIL-DX documentation.

The HVT400-SIL-XX enhances the HVT300-SIL-XX and offers a wider voltage range of up to 1500V. To accomplish this, the voltage-input circuity was slightly modified and moved to a separate printed circuit board. These differences do not affect the actual design of the safety functionality. This certification's main body of evidence is based on the MSK200-SIL-DX and HVT300-SIL-XX documentation.

2.3. Safety function and functional safety parameters

A single HVT carries out two safety functions:

Safety function 1:
Measure the input voltage and set the output of a 4-20mA current signal within a specified accuracy of 0.2-5%. When the accuracy cannot be maintained, de-energise the alarm relays (REL3 and REL4).

Safety function 2:
*Upon demand (violation of configured limit value) open the limit relay**s** (REL1 or REL2). When the limit relay cannot be switched or in case of an internal failure, de-energize the alarm relays (REL3 and REL4)*

The implementation of the above safety functions takes into account the following functional safety parameters according to IEC 61508 [1] and the existing certification [3]:

- Type B;
- HFT = 0 - Low demand;
- HFT = 1 - Low or High demand;
- Safe state safety function 1: REL3 and REL4 open, and the alarm output current to <3.6 mA;
- Safe state safety function 2: REL1 or REL2 open, and REL3 and REL4 open.

3. Certification results

3.1. Quality management

Mütec has a certified ISO 9001 quality management system [4].

3.2. Functional safety management

Mütec Instruments holds a valid Functional Safety Management certificate [5] according to the requirements of IEC 61508 [1]. Nevertheless, the device series are certified [3] according to route 2h (hardware integrity) and 2s (systematic integrity) of IEC 61508 [1] and meet the systematic capability SC2 in 1oo1.

3.3. Restricted functionality

The purpose of the HVT series is to monitor voltage [6]. The functionality of the HVT series is restricted to this purpose. There are no other functions available.

3.4. Conditions of use

The HVT series subject to this proven in use study has been used in similar environments. These include over 10 typical process industry environments [7].

3.5. Field data

Mütec Instruments has collected 10+ years of operational field data for the HVT300-SIL-XX series since 2010 [7]. The typical operating time in the process industry is 24 hours per day. From these operational hours, 25% has been excluded from taking into account non-operating hours due to, for example, storage time, non-operating time, maintenance downtime, etc. This resulted in a total of 23.800.000 operating hours for this proven in use study.

Mütec Instruments has collected and stored customer feedback and repair data [8]. This data demonstrates that for the above-claimed operating hours, 72 failures have occurred. 41 of these failures are classified as dangerous failures related to the safety function. None of the failures is related to systematic failures. See Table 2.

Table 2 - Collected field data

Product(s)	Operating hours	Dangerous failures	Safe failures
HVT300-SIL-XX	23.800.000	41	31

3.6. Modifications HVT300-SIL-XX

During the above period, the hardware and software have been modified. The hardware was released in 2006 (version 1.0), and in 2008, a minor modification was performed (v1.01) [9]. Since 2008 the hardware circuitry has been unmodified, except for modifications of component values to adapt the input measurement circuitry to different measurement ranges (version 1.10, 1.11, 3.3.0) and modifications of the power supply (version 2.2.1 and 3.0.9) [9]. The hardware modifications are not in contradiction with the proven in use verification process because they are limited and minor.

The firmware was released in 2006, and the last modification was introduced in 2015, which led to version 4.04. Since 2015 the firmware has been unmodified [10]. The 4 modifications from 2006 to 2015 were related to product improvements and bug fixes. Summarised, the modifications are classified as limited, traceable and minor. The modifications are not in contradiction with the proven in use verification process. The systematic capability is sufficient for route 2s according to IEC 61508-7, Annex D, with 99% confidence for SIL 2.

3.7. Reliability analysis

A qualitative and quantitative reliability study and a proven in use study have been carried out in line with the requirements of the IEC 61508 standard. The reliability study consists of a statistical proven in use study and FMEDA [11,17]. Table 3 depicts the statistical analysis of the proven in use data for the stated operating hours in paragraph 3.5 [12].

Table 3 - Statistical analysis results - HVT300-SIL-XX

Property	Failure rate	90% upper confidence limit failure rate
Dangerous failure rate	172 FIT	223 FIT
Safe failure rate	134 FIT	180 FIT

IEC 61508 requires a minimum diagnostic coverage (DC) of 60% for Type B products. To obtain the DC value, FMEDAs have been carried out. The FMEDAs use the component failure rates from SN29500 [13] and the failure models from IEC 62061: 2005, Annex D [14]. For the analyses, an environmental temperature of 40 °C was assumed.

The results of the FMEDAs are presented in the next table.

Table 4 - FMEDA analysis

Property	HVT300-SIL-XX	HVT400-SIL-XX
Type	B	B
Safe detected failure rate	0 FIT	0 FIT
Safe undetected failure rate	331 FIT	391 FIT
Dangerous detected failure rate	325 FIT	331 FIT
Dangerous undetected failure rate	37 FIT	22 FIT
Safe failure fraction	95%	97%
Diagnostic coverage	90%	94%

The FMEDA analysis, which represents design expectations, corresponds with the data from the proven in use data, which represents operational experience. The hardware reliability analysis demonstrates that the product series meets the SIL 2 requirements for proven in use.

3.8. PFD

For the HVT series, the PFD has been calculated over a period of 1, 5, and 10 years without proof testing and an expected repair time of 72 hours [12]. The worse case results are listed in the table below.

Table 5 - PFDavg calculations - 1oo1

	HVT300-SIL-XX			HVT400-SIL-XX		
Property	**1 Year**	**5 Years**	**10 Years**	**1 Year**	**5 Years**	**10 Years**
PFDavg	1.6E-04	8.1E-04	1.6E-03	9.6E-05	4.8E-04	9.6E-04
%SIL 2	1.6%	8.1%	16.0%	1.0%	4.8%	9.6%

The PFH for a single HVT300-SIL-XX and HVT400-SIL-XX are 3.7E-8 and 2.2E-8. The products can be used in a SIL 2 application from a hardware probability point of view.

3.9. Basic safety evaluation

The HVT series complies with

- EMC directive 2014/30/EU [15,18];
- LVD directive 2014/35/EU [16,19].

The LVD testing was performed according to IEC 61010-1. EMC testing was performed according to IEC 61326-3-1.

3.10. User documentation evaluation

The safety manual describes the conditions of use and constraints [6].

4. Conclusions

4.1. End user responsibilities

To achieve SIL-compliant safety (instrumented) functions, it is the end user's responsibility to correctly design the final solution taking into account the products listed in Table 1 of paragraph 2.1. Furthermore, it is the responsibility of the end user:

- To perform their functional safety analysis according to the applicable functional safety standard (e.g., IEC 61511, IEC 61508).
- To install, commission and validate (SAT) the products correctly;
- To operate, maintain and repair the products according to the instructions given by the supplier;
- To operate the products in an environment that does not exceed the limits presented in the user documentation.

4.2. Modifications

Future modifications by Mütec to the products listed in Table 1 of paragraph 2.1 need to go through an IEC 61508 compliant modification procedure and are subject to re-verification, re-validation, re-assessment and re-certifications. Future modifications that require re-certification are documented in Appendix A of this report.

4.3. Conclusions

Risknowlogy concludes that the products listed in Table 1 of paragraph 2.1, summarised as HVT series, meet the applicable hardware integrity requirements of IEC 61508 according to the certification basis, the certification scope and the safety requirements specification. The products can be used in applications that need to comply with IEC 61508 and/or IEC 61511, taking into account the restrictions in paragraph 4.1.

In summary, the HVT series meets the hardware and systematic integrity requirements of SIL 2. For low demand mode applications, the products can be used in HFT=0 or HFT=1. For high demand mode applications, the products must be used in HFT=1.

On behalf of Risknowlogy,

Dr Michel Houtermans
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Richard Vittoni
Verifier

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Appendix A - Modifications

As of the release of this document, modifications have taken place. Future modifications to the hardware need to go through an IEC 61508 [1] compliant modification procedure and are subject to re-verification, re-validation and/or certifications.

Modification 1 - HVT300-SIL-XX

Two small modifications have been made to the circuit board of the HVT300-SIL-XX. The first modification increased the resistance of a resistor to allow wider-range voltage surveillance. The second modification replaced a diode for a better inhibit voltage.

The modification was performed according to the modification procedure of the certified FSM system [5]. The modifications were documented in [20,21] and did not affect the FMEDA results. A new safety evaluation was required and performed according to the LVD requirements [22]. The modifications did not impair safety.

Risknowlogy reviewed the modification documentation for completeness and correctness. The safety functionality of the product did not change, and the implementation followed the modification procedure correctly.

Modification 2 - HVT400-SIL-XX

The HVT400-SIL-XX is a copy of the HVT300-SIL-XX except for the voltage input circuity. This circuitry was copied to a separate printed circuit board and slightly modified to allow input voltage up to 1500V (instead of 1000V).

The modification was performed according to the modification procedure of the certified FSM system [5]. The modification was documented in [23]. The modification required the reliability performance to be documented in the FMEDA [17] to be updated and to redo the EMC and LVD testing [18,19] for the HVT400-SIL-XX

Risknowlogy reviewed the modification documentation for completeness and correctness. The safety functionality of the product did not change, and the implementation followed the modification procedure correctly.