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**Automation - Functional Safety**

**Report about the evaluation  
of the ESW<sup>®</sup>-small-Transmitter**

**Report-No.: 968/FSP 1298.00/16  
Date: 2016-07-11**

### Report about the evaluation of the ESW®-small-Transmitter

<b>Report-No.:</b>	968/FSP 1298.00/16
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<b>Product :</b>	ESW®-small-Transmitter 10-**-SIL ESW®-small-Transmitter M 10-**-SIL ESW®-small-Transmitter Ex-d M 10-**-SIL ESW®-small-Transmitter Ex-i M 10-**-SIL
<b>Customer/Manufacturer:</b>	Holthausen Elektronik GmbH Wevelinghoven 38 41334 Nettetal Germany
<b>Customer-Order-No./Date:</b>	607452 dated 2014-09-12
<b>Certification Body:</b>	TÜV Rheinland Industrie Service GmbH Automation - Functional Safety (A-FS) Am Grauen Stein 51105 Köln Germany
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<b>Assessor/Expert:</b>	Dipl.- Ing. Björn Callsen
<b>Duration:</b>	September 2014 - July 2016

The results are exclusively related to the product/project.

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## 1. Scope

This report summarises the results of the assessment of the ESW®-small-Transmitter series. The ESW®-small-Transmitter has been subject to an assessment in reference to the requirements of the standard listed under sections 2.

The following criterion has to be fulfilled:

- Safety Integrity Level: SIL 2 (HFT=0, Type A)

ATEX requirements were not in the scope of this approval.

## 2. Standards forming the basis for the requirements

[N1] IEC 61508 Parts 1 -2 and 4-7:2010  
 Functional safety of electrical/electronic/programmable electronic safety-related systems

## 3. Identification of the product

### 3.1. Description of the product



Picture 1: ESW Small Transmitter

The ESW Small Transmitter is used to monitor vibrations of rotating components such as centrifuges, pumps etc. It's generally mounted on the place, where an inadmissible vibration occurs or is expected. The sensor converts mechanical oscillations into an electrical alternating voltage. The subsequent electronics converts the AC signal into a DC voltage, which is equivalent to the measured oscillation speed. A current range of 4 to 20mA, which is proportional to the measuring range, is provided to the "analog output" cable.

There are 4 variants available:

ESW®-small-Transmitter 10-\*\*-SIL

ESW®-small-Transmitter M 10-\*\*-SIL (housing resisting to sea water)

ESW®-small-Transmitter Ex-d M 10-\*\*-SIL (ex-d housing)

ESW®-small-Transmitter Ex-i M 10-\*\*-SIL (same as ESW®-small-Transmitter M 10-\*\*-SIL)

\*\* : customer option to accommodate different frequency ranges.

### 3.2. Documents provided by the customer and compiled by TÜV Rheinland

No.	Document	Revision	Date
[D1]	1-Design-Specification.doc	1.05	09.06.2016
[D2]	2-V&V-Plan.doc	1.05	09.06.2016
[D3]	2a_Daten zum V&V-Plan.doc	1.03	14.03.2016
[D4]	Prooftest.doc	-/-	28.06.2016
[D5]	10g-Test.doc 100°C-Test.doc Meßdaten_Transmitter.xls	-/-	24.06.2016 15.10.2014 28.12.2015
[D6]	8-2B_Schaltung_Version 10-25.pdf 8-2C_Bestückung_Version 10-25_top.pdf 8-2D_Bestückung_Version 10-25_bot.pdf	Rev G	-/-
[D7]	8-2E_Stückliste_Version 10-25.doc	-/-	24.06.2016
[D8]	6-Projektmanagement.doc	1.05	10.06.2016
[D9]	ISO-Zertifikat.jpg	-/-	24.07.2015
[D10]	7-3_Verfahren - Geräte-Änderungen.doc	0	10.06.2016
[D11]	Checklist_Fault_Control_Hardware_IEC61508_holthausen.xls	-/-	8.12.2014
[D12]	3-FMEA.doc 3-FMEA.xls	1.05 -/-	24.06.2016 24.06.2016
[D13]	E147585E1.pdf EMC Report	-/-	11.05.2015
[D14]	U147585E1 Environmental Report	-/-	28.08.2015
[D15]	U147585E2 IP Protection report	-/-	03.06.2015
[D16]	U147585E3 Vibration report	-/-	28.08.2015
[D17]	5-Safety Manual.doc	1.05	24.06.2016
[D18]	8-2A_Datenblatt_M_10-25-D.doc	-/-	09.06.2016
[D19]	Benutzer-Handbuch-Deutsch.doc	-/-	10.06.2016
[D20]	Verpflichtungserklärung.jpg	-/-	29.06.2016
[D21]	OpenItemListESW_Transmitter_29062016.xls List of Open/Closed Points provided by TÜV	2.0	29.06.2016
[D22]	FIT_Bericht_ESW_Transmitter_1.0.doc Fault Insertion Test	1.0	29.06.2016

### 3.3. Evaluation samples

The assessment of the realized safety function has been carried out mainly by an analysis of the provided documents. Fault Insertion Tests have been performed on representative models which are listed in [D20]). Furthermore, practical tests were performed in cooperation with Holthausen Elektronik GmbH (see [D22]).

The used test samples will be stored by the manufacturer according to [D20].

## 4. Objects and results of the assessment

### 4.1. General

The measuring and test equipment, which has been used by the TÜV Rheinland Group in the tests described in the following, is subject to regular inspection and calibration. Only devices with valid calibration have been used. The devices used in the various tests are recorded in the inspector's documentation.

All considerations concerning uncertainty of the measurements, so far applicable, are stated in the inspector's documentation, too.

In cases where tests have been executed in an external test lab or in the test lab of the manufacturer and where the results of these tests have been used within the here documented approval, this has occurred after a positive assessment of the external test lab and the achieved test results in detail according to the Quality Management procedure QMA 3.310.05.

### 4.2. Results of the functional and safety analyses

Safety Function: Conversion of mechanical oscillations into a 4-20mA signal

Diagnostic: The external safety controller has to initiate the safe state in case of the 4-20mA signal is  $\leq 3,8\text{mA}$  or  $\geq 22\text{mA}$ .  
It is highly recommended to treat a 4mA output signal within the external safety controller during normal operation of the machine as a failure condition and to initiate the safe state. During normal operation of the machine it can be expected, that mechanical vibration exists and an output signal  $>4\text{mA}$  can be expected.

The ESW transmitter uses only type A components and has a HFT=0 structure.

No software/firmware is used.

The reliability block diagram is divided into three blocks:

Power supply -> Sensor -> Signal Conversion

Every block has an SFF (Safe Failure fraction)  $> 60\%$ . (see D12)

The diagnostic function has to be performed and initiated by the external safety controller (see [D17]).

**Result:** The system structure and the measures for the detection and control of faults comply with the requirements for a device conforming to SIL 2 in accordance with IEC 61508, implied that the external safety controller detects the failures as described in the safety manual (see [D17]).

### 4.3. Measures for the avoidance of faults according to IEC 61508

The measures for fault avoidance during the relevant life cycle phases according IEC 61508-2 for SIL 2 are listed in the Management Plan ([D8]). Especially the following representative measures were applied:

- Design Specification and V&V plan with requirement tracking/numbers (see [D1] and [D2])
- Functional- and fault insertion testing (see [D2] and [D22])
- Environmental testing ([D12] to [D15])
- ISO 9001 certified ([D9])

The manufacturer has investigated the device under test and its possible failure modes with a Failure Mode Effect Analysis (FMEA) (see [D12]). As a result, possible measures for fault control and diagnosis were defined. Especially the measures for fault detection described in the safety manual (see [D17]) were defined.

The planning of the verification and validation activities is done in the V&V-Plan (see [D2]). In a final review and walkthrough step it was followed-up if all requirements were implemented and tested (see [D2] to [D5]).

All measures are documented as far as applicable. The documents are present at the Test Institute.

**Result:** The applied measures for the avoidance of faults comply with the requirements for a device conforming to SIL 2 in accordance with IEC 61508.

**4.4. Functional / Fault insertion testing**

The ESW®-small-Transmitter was tested by the manufacturer both in positive (functional verification) as well as in negative tests (fault insertion) (see [D2]).

In addition, exemplary fault insertion tests on hardware were performed in presence of the TÜV Rheinland inspector. The results are recorded by the inspectors and can be found in [D21].

**Result:** All tests were finished with a positive test result. In particular the fault insertion tests confirmed the effectiveness of the FMEA. The results are accepted by the Test Institute.

**4.5. Determination of the safety related parameters**

The technique applied for the calculation was the Reliability Block Diagram in combination with a failure analysis on component level. Therefore it was necessary, that in a first step the hardware parts used to execute the safety function are broken down into sub-systems. The safety relevant parts uses only type A components and is based on a single channel structure.

Power supply -> Sensor -> Signal Conversion (see D12)

This results in a Hardware Fault Tolerance of HFT = 0 and a required Safe Failure Fraction (SFF) of SFF >= 60 % (see IEC 61508, Table 1).

Every block has an SFF (Safe Failure fraction) > 60 % (see D12).

The calculation was done based on the electronic component data provided by the manufacturer. The electronic components were derived from the electronic components part lists (see [D7]), which has been partitioned with respect to the assignment of components to various function blocks, see Block Diagram in [D12]. The correlation and effectiveness of the diagnostic measures were judged in accordance with IEC 61508-2 annex A (see [D11]).

	PFD (Proof Test 5 years)	$\lambda_{SD}$	$\lambda_{SU}$	$\lambda_{dd}$	$\lambda_{du}$ or (PFH)	SFF
ESW®-small-Transmitter	5,3 E-4	18,45 FIT	66,3 FIT	0 FIT*	23,96 FIT	78%

**Result:** With these values it is shown that the ESW®-small-Transmitter fulfils the requirements for SIL 2 according to IEC 61508.

#### 4.6. EMC tests

The EMC tests were performed according to the requirements of the basic standards. EMC testing was performed by the accredited test lab Phoenix Test lab. The following tests were performed:

- Electrostatic discharge immunity tests EN 61000-4-2
- Radiated, radio-frequency, electromagnetic field immunity test EN 61000-4-3
- Electrical fast transient/burst immunity test EN 61000-4-4
- Immunity to conducted disturbances,  
induced by radio-frequency fields EN 61000-4-6

All test results are documented in the reports mentioned under [D13].

**Result:** All test reports are present at the Test Institute. The tests according the basic standard EN 61000-4-x have been passed with a positive test result.

The EMC tests according IEC 61326-3-1 are missing and it has been agreed with the manufacturer, that these additional EMC tests have to be performed until November 2016. The appropriated reports shall be delivered unsolicited until this date.

#### 4.7. Environmental tests (mechanical, climatic and IP)

The mechanical tests (IEC 60068-2-6) have been performed according to IEC 60068-2-6 (see [D12], [D14]) by the accredited test lab Phoenix Test Lab.

The climatic tests (Dry Heat, Cold, Damp Heat, Cyclic Salt Mist) have been performed according to IEC 60068-2-2, IEC 60068-2-1, IEC 60068-2-30, IEC 60068-2-52, (see [D14], [D15]) by the accredited test lab Phoenix Test Lab.

The IP protection is IP68. The tests have been performed according to DIN EN 60529 by the accredited test lab Phoenix Test Lab (see [D15]).

##### Result:

All test reports are present at the Test Institute. The tests have been passed with a positive test result. The results are accepted by the Test Institute.

#### 4.8. Electrical safety

The required DC power supply range is 24V +/- 10%. The maximum supply voltage shall be safely limited by the supplying unit. The insulation resistance and dielectric characteristic was verified by the accredited test lab Phoenix Test lab (see [D14]).

##### Result:

All test reports are present at the Test Institute. The tests have been passed with a positive test result. The results are accepted by the Test Institute.

#### 4.9. Review of the User Manual/Safety Manual

The user/safety contains all the information necessary for the proper and safe operation and information of the ESW®-small-Transmitter (see [D17] to [D19]).

#### 5. Summary

Based on the results of the inspection / review of the submitted documents (see chapter 3.2) and the test sample it can be confirmed that the ESW®-small-Transmitters (see chapter 3.1) can be used in combination with an external safety controller in safety related applications up to SIL 2.



Output currents  $<3.8\text{mA}$  and  $>22\text{mA}$  have to be considered by the safety controller as a failure condition and the safety state has to be issued.

It is highly recommended to treat a  $4\text{mA}$  output signal within the external safety controller during normal operation of the machine as a failure condition and to initiate the safe state. During normal operation of the machine it can be expected, that mechanical vibration exists and an output signal  $>4\text{mA}$  can be expected.

The information provided in the safety manual, user manual and the datasheets shall be considered.

The EMC tests according the basic standard EN 61000-4-x have been passed with a positive test result. The EMC tests according IEC 61326-3-1 are missing and have to be performed until November 2016. The appropriated reports shall be delivered unsolicited until this date (see chapter 4.6).

Cologne, 2016-07-11  
TIS/A-FS/Kst. 968 ca-nie

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The assessor



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