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**Report about the results of the review of
the PFD calculation for the PG2 gas Warning System**

Report-No.:	968/FSP 1286.00/16
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Test :	Review of the PFH/PFD calculation for the PG2 Gas Warning System according chapter 4.8 (SIL 1) of EN 50271:2010
Customer/Manufacturer:	MSR Electronic GmbH Würdinger Str. 27a 94060 Würding
Customer-Order-No./Date:	B160336 dated 07.04.2016
Test Institute:	TÜV Rheinland Industrie Service GmbH Automation - Functional Safety (A-FS) Am Grauen Stein 51105 Köln Germany
TÜV-Quotation-No./Date:	Email Callsen dated 2015-09-10 Email Callsen dated 2016-05-30
TÜV-Order-No./Date:	21233400 dated 2016-05-02
Assessor:	Dipl. -Ing. Björn Callsen
Test location:	see Test Institute
Test duration:	April 2016 - June 2016

The test results are exclusively related to the test samples.

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1. Scope

Within this assessment it was investigated if the PFD/PFH calculation for the Polygard 2 gas Warning System meets the requirements according to EN 50271:2010, chapter 4.8 (SIL 1) and chapter 4.7 (l) (Instruction Manual).

2. Standards forming the basis for the requirements

[N1] **EN 50271:2010**
Elektrische Geräte für die Detektion und Messung von brennbaren Gasen, giftigen Gasen oder Sauerstoff - Anforderungen und Prüfungen für Warngeräte, die Software und/oder Digitaltechnik nutzen

3. Identification of the test object

Polygard 2 gas Warning System:

- DGC06 & SC2-34XX for flammable gases

- DGC06 & SC2-11XX for toxic gases and oxygen

3.1. HW/SW Versions

Bezeichnung	HW-Vers.	SW.Vers.
DGC06 -Zentrale (MIOZ)	MIO_06-004	01.02.00
Sensorboard (SB)	104-PGSB_03-002	01.02.00
Multisensorboard (MSC)	MIO_MSC2_01-002	01.02.00
Relaisplatine (MIO)	MIO_06-004	01.02.00
Kopf Tox	SC_T_03-003	01.02.00
Kopf Ex	SC_C_03-001	01.02.00

4. Documents

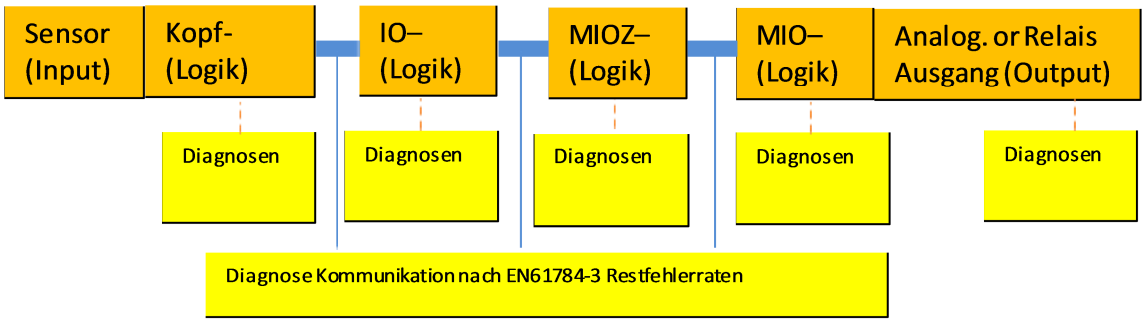
No.	Document	Version	Date
[D1]	Type approval report TÜV Rheinland Energy GmbH acc. 50545-1 S 497 2016 T1	n/a	10.05.2016
[D2]	Protokoll nach DIN EN 50271 für Bericht Nr. S 497 2016 T1-signed.pdf	n/a	02.05.2016
[D3]	Instruction manual GAPG2_D_1.1	1.1	May 2016
[D4]	Description of FMEDA Calculation PG_DGC_FMEDA_Zusatz.pdf	1.1	03.06.2016
[D5]	Description of diagnostic measures 3-SIL-Diagnose-Massnahmen-PX2.xls	n/a	n/a
[D6]	FMEDA with final results FMEDA_MIOZ_2016-02-12a_sort.xls	n/a	02.06.2016
[D7]	FMEDA of PG2 Detector including the Ex sensor PG2_Detector_Ex_RS_485_out-2016-06-01 mit Sensor.xls	n/a	01.06.2016
[D8]	FMEDA of PG2 Detector including the Tox sensor PG2_Detector_Tox_RS_485_out-2016-06-01 mit Sensor.xls	n/a	01.06.2016
[D9]	Calculation/Description of the BUS 3-Design_Kommunikationsberechnung_XSII.xls	1.0	17.03.2016

No.	Document	Version	Date
[D10]	Reliability Data for Ex Sensor PG_FMEDA_Sensorerkl_2016.pdf	n/a	May 2016
[D11]	Reliability Data for Tox Sensor PX_FMEDA_Sensorerkl_2016.pdf	n/a	May 2016
[D12]	Reliability Calculation for Ex and Tox Sensors GWW_2016-06-01 PG - SIL-Report Pellistoren und EC-Sensoren.pdf	n/a	01.06.2016
[D13]	SIL Report from Dr. Wenker GWW_2016-06-01 SIL-Report Polygard 2.pdf	n/a	01.06.2016
[D14]	Schematics and Bill of Material Schematics+BOM.zip	n/a	n/a
[D15]	List of Open Points, created by the Test Institute LOP_Rev1 1_PG2.xls	1.1	02.06.2016

5. Review of the PFD calculation

The following chapters describe the review of the PFD calculation to fulfil the requirements of chapter 4.8 of EN 50271 (SIL 1) and chapter 4.7 (l).

5.1. Reliability Block Diagram of Safety Functions 1 and 2



Picture 1: Reliability Block Diagram of SF1 + 2 (please refer to [D4] and [D5])

The reliability block diagram describes the realization of the safety functions 1 + 2 as basis for the calculation of the safety related reliability values.

5.2. Safety Function 1 (Gas Sensor to 4-20mA Output)

The gas concentration is measured and mapped into an analogue output signal of 4-20mA.

The accuracy of the gas concentration measurement is specified with +/-10%.

The safety controller used by the customer has to detect current values <3mA and >21.2mA as an error condition.

5.3. Safety Function 2 (Gas Sensor to Relay/Alarm Output)

The gas concentration is measured and, if a configurable threshold is exceeded, an alarm relay is triggered.

The accuracy of the gas concentration measurement is specified with +/-10%.

It is required to evaluate the alarm relay and the fault relay at the same time, meaning, if one of them is deactivated, the safe state has to be initiated.

5.4. Diagnostic measures

The implemented diagnostic measures are described in [D4], [D5] and [D9].

5.5. SFF >60% based on EN 50271:2010

The fulfilment of chapter 4.1 to 4.6 of EN 50271:2010 has been approved in parallel by TÜV Rheinland Energy GmbH within the type approval according to DIN EN 50545-1 (refer to [D1] + [D2]).

It can be confirmed that the requested SFF of >60% according to EN 50271 clause 4.8 is fulfilled. Furthermore an estimation has been made, that even an SFF of >90% can be stated. This statement is based upon the PFD calculation documented in [D6]. This corresponds to SIL 2 in a HFT=0 configuration.

5.6. PFD calculation

Based on the usage of different sensors for flammable (pellistor sensors) and toxic/oxygen sensors (electro chemical) two PFD calculations were performed by MSR Electronic GmbH. The results can be found in Table 2.

	DGC06 & SC2-34XX (flammable Gases**)**	**DGC06 & SC2-11XX** (toxic gases and oxygen)
	Pellistor Sensor	Electro Chemical Sensor
Safety Function	1 + 2	
HFT	0	
PFD	$7{,}08 \times 10^{-4}$	$7{,}29 \times 10^{-4}$
SFF	>95 %	>94 %
PFH or λ_{DU}	$1{,}38 \times 10^{-7}$ 1/h	$1{,}64 \times 10^{-7}$ 1/h
λ_{DD}	$1{,}30 \times 10^{-6}$ 1/h	$1{,}30 \times 10^{-6}$ 1/h
λ_{SU}	$1{,}33 \times 10^{-6}$ 1/h	$1{,}33\times 10^{-6}$ 1/h
λ_{SD}	$4{,}63 \times 10^{-8}$ 1/h	$4{,}84 \times 10^{-8}$ 1/h
Proof test interval T1	≤ 1 year	
MTTR	72 hours	

Table 2: PFD/PFH Values

In order to simplify the use and the description of the PFD values for the customer the “worse” PFD values of safety function 2 (Gas Sensor to Relay/Alarm Output) were also specified to be valid for safety function 1 (Gas Sensor to 4-20mA output).

The general description to get to the final PFD/PFH values is described in [D4].

The final calculation results of the two safety functions can be found in [D6]. Intermediate FMEDA results can be found in [D7] and [D8].

The failure rate of the electro chemical and the pellistor sensors can be found in [D10] to [D13]. No safety relevant failures occurred from 2005 to 2015. (at least 8000 pieces of each sensor has been sold).

Exemplary plausibility checks of the FMEDA’s ([D6] to [D8]) based on the schematics [D14] have been performed by the Test Institute.

The minimum required PFD value to achieve SIL 1 according to IEC 61508 is 1 x 10^{-1} for the entire safety function. The Polygard 2 Warning System is specified to use up to 35% of SIL 1, respectively a PFD value smaller than 3.5 x 10^{-2} has to be achieved. The PFD values shown in table 2 fulfil the requirements for SIL 1 according to IEC 61508 for low demand Systems.

Result: The calculation results are accepted by the Test Institute based on a review.

6. Review of the instruction manual to fulfil chapter 4.7 (l)

Chapter 8 of the instruction manual (refer to [D3]) includes all the required information to fulfil chapter 4.7 (l) according EN 50271.

7. Summary

As the result of the review of the PFD calculations it can be confirmed, that the Polygard 2 gas Warning Systems listed under chapter 3 fulfil the SIL 1 requirements according to EN 50271:2010 chapters 4.7 (l) and 4.8.

Cologne, 2016-06-06
TIS/A-FS/Kst. 968 ca-me

Report released after review:
Date: 2016-06-06

The assessor

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