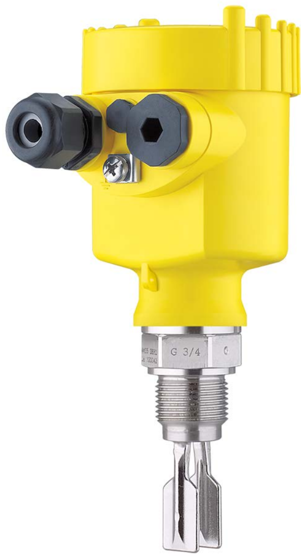
Safety Manual

VEGASWING 61, 63

NAMUR

With SIL qualification



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1 Document language

DE	Das vorliegende *Safety Manual* für Funktionale Sicherheit ist verfügbar in den Sprachen Deutsch, Englisch, Französisch und Russisch.
EN	The current *Safety Manual* for Functional Safety is available in German, English, French and Russian language.
FR	Le présent *Safety Manual* de sécurité fonctionnelle est disponible dans les langues suivantes: allemand, anglais, français et russe.
RU	Данное руководство по функциональной безопасности *Safety Manual* имеется на немецком, английском, французском и русском языках.

2 Scope

2.1 Instrument version

This safety manual applies to point level sensors

VEGASWING 61 with SIL qualification

VEGASWING 63 with SIL qualification

Electronics module:

- NAMUR (IEC 60947-5-6)

2.2 Application area

The transmitter can be used for level detection of liquids in a safety-related system according to IEC 61508 in the modes *low demand mode* or *high demand mode*:

- Up to SIL2 in single-channel architecture
- Up to SIL3 in a multiple-channel architecture (systematic suitability SC3)

The following interface can be used to output the measured value:

- NAMUR current output 1.2/2.1 mA

2.3 SIL conformity

The SIL conformity was independently judged by *exida* Certification LLC according to IEC 61508. [1]

[1] Verification documents see appendix.

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3 Planning

3.1 Safety function

Safety function

To monitor a limit level, the sensor detects via the conditions " *Vibrating element uncovered*" or " *Vibrating element covered*" a limiting value defined by the mounting location.

The determined status is signalled at the output with " *Current < 1.2 mA*" or " *Current > 2.1 mA*".

3.2 Safe state

Safe state

The safe state of the output signal is independent of the mode adjusted on the sensor.

Mode	Overflow protection (mode max.)	Dry run protection (mode min.)
Vibrating element	covered	uncovered
Output current	0.4 … 1 mA	0.4 … 1 mA

Fault signals in case of malfunction

Possible fault currents:

- < 1 mA ("fail low")
- > 6.5 mA ("fail high")

3.3 Prerequisites for operation

Instructions and restrictions

- The measuring system should be used appropriately taking pressure, temperature, density and chemical properties of the medium into account. The application-specific limits must be observed.
- The specifications according to the operating instructions manual, particularly the current load on the output circuits, must be kept within the specified limits
- When used as dry run protection, buildup on the vibrating system should be avoided (probably shorter proof test intervals will be necessary)
- The instructions in chapter " *Safety-related characteristics*", paragraph " *Supplementary information*" must be noted
- All parts of the measuring chain must correspond to the planned " *Safety Integrity Level (SIL)*"

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4 Safety-related characteristics

4.1 Characteristics acc. to IEC 61508

Parameter	Value
Safety Integrity Level	SIL2 in single-channel architecture SIL3 in multiple channel architecture [2]
Hardware fault tolerance	HFT = 0
Instrument type	Type A
Mode	Low demand mode, High demand mode
SFF	> 60 %
MTBF = MTTF + MTTR [3]	3.76×10^6 h (429 years)
Fault reaction time [4]	< 1.5 s

Failure rates

λ_S	λ_{DD}	λ_{DU}	λ_H	λ_L	λ_{AD}	λ_{AU}
126 FIT	0 FIT	45 FIT	9 FIT	9 FIT	0 FIT	5 FIT

PFD_{AVG}	0.038×10^{-2}	(T1 = 1 year)
PFD_{AVG}	0.108×10^{-2}	(T1 = 5 years)
PFD_{AVG}	0.197×10^{-2}	(T1 = 10 years)
PFH_D	0.045×10^{-6} 1/h	

Proof Test Coverag (PTC)

Test type [5]	Remaining failure rate of dangerous undetected failures	PTC
Test 1	22 FIT	52 %
Test 2	2 FIT	97 %

4.2 Characteristics acc. to ISO 13849-1

Derived from the safety-related characteristics, the following figures result according to ISO 13849-1 machine safety): [6]

Parameter	Value
MTTFd	1812 years
DC	29 %
PFH_D	4.50×10^{-8} 1/h

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[2] Homogeneous redundancy possible.
[3] Including errors outside the safety function.
[4] Time between the occurrence of the event and the output of a fault signal.
[5] See section "Proof test".
[6] ISO 13849-1 was not part of the certification of the instrument.

4.3 Supplementary information

Determination of the failure rates

The failure rates of the instruments were determined by an FMEDA according to IEC 61508. The calculations are based on failure rates of the components according to **SN 29500**:

All figures refer to an average ambient temperature of 40 °C (104 °F) during the operating time. For higher temperatures, the values should be corrected:

- Continuous application temperature > 50 °C (122 °F) by factor 1.3
- Continuous application temperature > 60 °C (140 °F) by factor 2.5

Similar factors apply if frequent temperature fluctuations are expected.

Assumptions of the FMEDA

- The failure rates are constant. Take note of the useful service life of the components according to IEC 61508-2.
- Multiple failures are not taken into account
- Wear on mechanical parts is not taken into account
- Failure rates of external power supplies are not taken into account
- The environmental conditions correspond to an average industrial environment

Calculation of PFD_{AVG}

The values for PFD_{AVG} specified above were calculated as follows for a 1oo1 architecture:

$$PFD_{AVG} = \frac{PTC \times \lambda_{DU} \times T1}{2} + \lambda_{DD} \times MTTR + \frac{(1 - PTC) \times \lambda_{DU} \times LT}{2}$$

Parameters used:

- T1 = Proof Test Interval
- PTC = 90 %
- LT = 10 years
- MTTR = 24 h

Boundary conditions relating to the configuration of the processing unit

A connected control and processing unit must have the following properties:

- The failure signals of the measuring system are judged according to the idle current principle
- " *fail low*" and " *fail high*" signals are interpreted as a failure, whereupon the safe state must be taken on

If this is not the case, the respective percentages of the failure rates must be assigned to the dangerous failures and the values stated in chapter *Safety-related characteristics*“ redetermined!

Multiple channel architecture

Due to the systematic capability SC3, this instrument can also be used in multiple channel systems up to SIL3, also with a homogeneously redundant configuration.

The safety-related characteristics must be calculated especially for the selected structure of the measuring chain using the stated failure rates. In doing this, a suitable Common Cause Factor (CCF) must be considered (see IEC 61508-6, appendix D).

5 Setup

5.1 General information

Mounting and installation

Take note of the mounting and installation instructions in the operating instructions manual.

Setup must be carried out under process conditions.

5.2 Adjustment instructions

Adjustment elements

The adjustment elements must be set according to the specified safety function:

- Slide switch for changeover of the mode (min./max.)
- Slide switch for changeover of the sensitivity

The function of the adjustment elements is described in the operating instructions manual.

Please note!

SIL During adjustment process, the safety function must be considered as unreliable!

If necessary, you must take other measures to maintain the safety function.

SIL With regard to the switch on/swich off delay it must be ensured that the sum of all switching delays from the transmitter to the actuator is adapted to the process safety time!

SIL The instrument must be protected against inadvertent or unauthorized adjustment!

6 Diagnostics and servicing

6.1 Behaviour in case of failure

Internal diagnosis

The instrument is permanently monitored by an internal diagnostic system. If a malfunction is detected, the respective output signals change to the safe status (see section " *Safe status*").

The fault reaction time is specified in chapter " *Safety-relevant characteristics*".

SIL

If failures are detected, the entire measuring system must be shut down and the process held in a safe state by other measures.

The manufacturer must be informed of the occurrence of a dangerous undetected failure (incl. fault description).

6.2 Repair

Electronics exchange

The procedure is described in the operating instructions manual. Note the instructions for setup.

7 Proof test

7.1 General information

Objective

To identify possible dangerous, undetected failures, the safety function must be checked by a proof test at adequate intervals. It is the user's responsibility to choose the type of testing. The time intervals are determined by the selected PFD_{AVG} (see chapter " *Safety-related characteristics*").

For documentation of these tests, the test protocol in the appendix can be used.

If one of the tests proves negative, the entire measuring system must be switched out of service and the process held in a safe state by means of other measures.

In a multiple channel architecture this applies separately to each channel.

Preparation

- Determine safety function (mode, switching points)
- If necessary, remove the instruments from the safety chain and maintain the safety function by other means

Unsafe device status

Warning:
During the function test, the safety function must be treated as unreliable. Take into account that the function test influences downstream connected devices.

If necessary, you must take other measures to maintain the safety function.

After the function test, the status specified for the safety function must be restored.

7.2 Test 1 - without filling/emptying or dismounting the sensor

Conditions

- Instrument can remain in installed condition
- Output signal corresponds to the level (covered or uncovered vibrating element)

Procedure

1. Carry out a restart (push the test key on the sensor or controller or switch the instrument off and then on again)
2. Push the min./max. switch on the sensor

Expected result

to 1: Output signal corresponds to the level

to 2: Output signal changes status

Proof Test Coverage

See *Safety-related characteristics*

7.3 Test 2 - with filling/emptying or dismounting the sensor

Conditions

- **Alternative 1:** the instrument remains mounted; the condition " *Vibrating element uncovered*"/" *Vibrating element covered*" can be changed by filling or emptying to the switching point.

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- **Alternative 2:** the instrument is dismounted; the condition "*Vibrating element uncovered*"/" *Vibrating element covered*" can be changed by dipping the instrument into the original medium
- Output signal corresponds to the level (covered or uncovered vibrating element)

Procedure

Filling or emptying up to the switching point or immersion into the original medium and assessing the corresponding switching status by a current measurement

Expected result

Current value of the output signal corresponds to the modified level (0.4 … 1.0 mA or 2.2 … 6.5 mA)

Proof Test Coverage

See *Safety-related characteristics*

8 Appendix A - Test report

Identification	
Company/Tester	
Plant/Instrument TAG	
Meas. loop TAG	
Instrument type/Order code	
Instrument serial number	
Date, setup	
Date, last function test	

Test reason		**Test scope**	
(…)	Setup	(…)	without filling or dismounting the sensor
(…)	Proof test	(…)	with filling or dismounting the sensor

Mode		**Sensitivity**	
(…)	Overflow protection	(…)	≥ 0.7 g/cm³ (0.025 lbs/in³)
(…)	Dry run protection	(…)	≥ 0.5 g/cm³ (0.018 lbs/in³)

Test result

Test step	**Level**	**Expected measured value**	**Real value**	**Test result**

Confirmation	
Date:	Signature:

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9 Appendix B - Term definitions

Abbreviations

SIL	Safety Integrity Level (SIL1, SIL2, SIL3, SIL4)
SC	Systematic Capability (SC1, SC2, SC3, SC4)
HFT	Hardware Fault Tolerance
SFF	Safe Failure Fraction
PFD_{AVG}	Average Probability of dangerous Failure on Demand
PFH_D	Average frequency of a dangerous failure per hour (Ed.2)
FMEDA	Failure Mode, Effects and Diagnostics Analysis
FIT	Failure In Time (1 FIT = 1 failure/10^9 h)
λ_{SD}	Rate for safe detected failure
λ_{SU}	Rate for safe undetected failure
λ_S	$\lambda_S = \lambda_{SD} + \lambda_{SU}$
λ_{DD}	Rate for dangerous detected failure
λ_{DU}	Rate for dangerous undetected failure
λ_H	Rate for failure, who causes a high output current (> 21 mA)
λ_L	Rate for failure, who causes a low output current (≤ 3.6 mA)
λ_{AD}	Rate for diagnostic failure (detected)
λ_{AU}	Rate for diagnostic failure (undetected)
DC	Diagnostic Coverage
PTC	Proof Test Coverage (Diagnostic coverage for manual proof tests)
T1	Proof Test Interval
LT	Useful Life Time
MTBF	Mean Time Between Failure = MTTF + MTTR
MTTF	Mean Time To Failure
MTTR	IEC 61508, Ed1: Mean Time To Repair IEC 61508, Ed2: Mean Time To Restoration
$MTTF_d$	Mean Time To dangerous Failure (ISO 13849-1)

10 Supplement C - SIL conformity

SIL Declaration of conformity

Functional safety according to IEC 61508 / IEC 61511 / NE130

Vibrating level switch

VEGASWING 61, 63

NAMUR

VEGA Grieshaber KG hereby declares, in sole responsibility, that the instruments can be used for level detection of liquids in a safety-related system according to IEC 61508:

- Up to SIL2 / HFT=0 in a single-channel architecture
- Up to SIL3 / HFT=1 in a multiple-channel architecture

Level of Integrity to:

- Systematic Capability: SC3 (SIL3 capable)
- Random Capability: Type A Element

Safety-related characteristics [1)]

λ_S	λ_{DD}	λ_{DU}	λ_H	λ_L	SFF	PFD_{AVG} [2)]	PTC1	PTC2
126 FIT	0 FIT	45 FIT	9 FIT	9 FIT	76%	$0{,}038 \times 10^{-2}$	52%	97%

[1)] independently evaluated by exida as per IEC 61508-2:2010

[2)] calculated with T1= 1 year and PTC=90%

This declaration of conformity applies only in connection with the valid operating and safety instructions manuals from VEGA.

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07.03.2016

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SIL_VEGASWING 61, 63 (N)

Failure Modes, Effects and Diagnostic Analysis

Project:
VEGASWING 61 / 63 with oscillator SWING E60 N (Ex)
Level limit switch with two-wire NAMUR output
Applications with level limit detection in liquids (MIN / MAX detection)

Customer:
VEGA Grieshaber KG
Schiltach
Germany

Contract No.:VEGA 03/4-04
Report No.: VEGA 03/4-04 R003
Version V2, Revision R1; August 20, 2015
Stephan Aschenbrenner

Management summary

This report summarizes the results of the hardware assessment carried out on the VEGASWING 61 / 63 with oscillator SWING E60 N (Ex). The devices manufactured in the USA by the Ohmart / VEGA Corporation carry the same name and are identically constructed under comparable quality aspects. Table 1 gives an overview of the different configurations that exist.

The hardware 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) can be calculated for a subsystem. For full assessment purposes all requirements of IEC 61508 must be considered.

Table 1: Overview of the considered variants

VEGASWING 61	Standard (fixed length)
VEGASWING 63	Tube version (variable length)

The different devices can be equipped with:

- Fork-variants uncoated, coated, enamels
- High temperature version with temperature separator

For safety applications only the described variants of the VEGASWING 61 / 63 with oscillator SWING E60 N (Ex) have been considered. All other possible variants and configurations are not covered by this report.

The failure modes used in this analysis are from the *exida* Electrical Component Reliability Handbook (see [N2]). The failure rates used in this analysis are the basic failure rates from the Siemens standard SN 29500 (see [N3]). This failure rate database is specified in the safety requirements specification from VEGA Grieshaber KG for the VEGASWING 61 / 63 with oscillator SWING E60 N (Ex).

The VEGASWING 61 / 63 with oscillator SWING E60 N (Ex) can be considered to be Type A[1] elements with a hardware fault tolerance of 0.

For Type A components with a SFF of 60% to < 90% a hardware fault tolerance of 0 according to table 2 of IEC 61508-2 is sufficient for SIL 2 (sub-) systems.

The qualitative analysis of the forks (see [D14]) has shown that only unspecified use of the forks or incorrect installation can lead to an unintended system reaction. All other faults lead to a safe state. Therefore a failure rate of the fork is not included in the calculation. However, the failure rates of all other parts of the sensor system have been considered.

Assuming that a connected logic solver can detect both over-range (fail high) and under-range (fail low), high and low failures can be classified as safe detected failures or dangerous detected failures depending on whether the VEGASWING 61 / 63 with oscillator SWING E60 N (Ex) are working as "high level switches" or "low level switches". For these applications the following tables show how the above stated requirements are fulfilled.

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

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Table 2: VEGASWING 6* N (MIN detection) – failure rates per IEC 61508:2010

Failure category	SN29500 [FIT]
Fail Safe Detected (λ_{SD})	**0**
Fail Safe Undetected (λ_{SU})	**126**
Fail Dangerous Detected (λ_{DD})	**18**
Fail Dangerous Detected (λ_{dd}), detected by internal diagnostics	0
Fail Annunciation Detected (λ_{AD}) , detected by internal diagnostics	0
Fail High (λ_{H}), detected by safety logic solver	9
Fail Low (λ_{L}), detected by safety logic solver)	9
Fail Dangerous Undetected (λ_{DU})	**45**

Fail Annunciation Undetected (λ_{AU})	5
No effect	70
No part	2

Total failure rate of the safety function (λ_{Total})	**188**
Safe failure fraction (SFF) [2]	**77%**
DC_D	**29%**

SIL AC [3]	**SIL 2**

[2] The complete sensor subsystem will need to be evaluated to determine the overall Safe Failure Fraction. The number listed is for reference only.
[3] SIL AC (architectural constraints) will need to be evaluated on sensor subsystem level. The indicated value if is for reference only and means that the calculated values are within the range for hardware architectural constraints for the corresponding SIL but does not imply all related IEC 61508 requirements are fulfilled.

Table 3: VEGASWING 6* N (MAX detection) – failure rates per IEC 61508:2010

Failure category	SN29500 [FIT]
Fail Safe Detected (λ_{SD})	**0**
Fail Safe Undetected (λ_{SU})	**126**
Fail Dangerous Detected (λ_{DD})	**18**
Fail Dangerous Detected (λ_{dd}), detected by internal diagnostics	0
Fail Annunciation Detected (λ_{AD}) , detected by internal diagnostics	0
Fail High (λ_{H}), detected by safety logic solver	9
Fail Low (λ_{L}), detected by safety logic solver)	9
Fail Dangerous Undetected (λ_{DU})	**43**

Fail Annunciation Undetected (λ_{AU})	5
No effect	72
No part	2

Total failure rate of the safety function (λ_{Total})	**187**
Safe failure fraction (SFF) [6]	**77%**
DC_D	**29%**

SIL AC [7]	**SIL 2**

The failure rates are valid for the useful life of the VEGASWING 61 / 63 with oscillator SWING E60 N (Ex) (see Appendix A) when operating as defined in the considered scenarios.

[6] The complete sensor subsystem will need to be evaluated to determine the overall Safe Failure Fraction. The number listed is for reference only.

[7] SIL AC (architectural constraints) will need to be evaluated on sensor subsystem level. The indicated value if is for reference only and means that the calculated values are within the range for hardware architectural constraints for the corresponding SIL but does not imply all related IEC 61508 requirements are fulfilled.

Printing date:

All statements concerning scope of delivery, application, practical use and operating conditions of the sensors and processing systems correspond to the information available at the time of printing.
Subject to change without prior notice

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