Safety Manual

VEGATOR 141, 142

With SIL qualification

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Contents

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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.

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2 Scope

2.1 Instrument version

This safety manual applies to controllers

VEGATOR 141, 142

Input signal:

- 4 … 20 mA

Valid version:

- from HW Ver 1.0.0

2.2 Application area

The controllers can be used with a suitable transducer for level detection or range monitoring in a safety-related system in accordance with IEC 61508 in the *low demand mode* or *high demand mode*.

Due to the systematic capability SC3 this is possible:

- 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:

- VEGATOR 141: relay 1
- VEGATOR 142: relay 1 or relay 2

The NO contacts must be used![1)]

SIL For the execution of a safety function in safety-relevant applications, the use of the following functions is restricted or not possible:

- VEGATOR 141.**S: the fail safe relay is only permitted for informative use (e.g. information on the device status with the proof test)
- VEGATOR 142: only one of the two channels must be used to realized a redundant SIL3 architecture

2.3 SIL conformity

The SIL conformity was independently judged and certified by the *TÜV Rheinland* according to IEC 61508:2010 (Ed.2).[2)]

SIL The certificate is valid for the entire service life of all instruments that were sold before the certificate expired!

[1)] NO = Normal Open
[2)] Verification documents see appendix

3 Planning

3.1 Safety function

Detection of a limit value with single point control

The transducer powered by the controller generates a signal between 3.8 mA and 20.5 mA, proportional to the process variable. A relay for detection of a limit value is switched in dependence on this signal, the selected mode and the set switching point.

This applies for both channels in VEGATOR 142 if the two-point control is not selected.

Detection of a limit value with two-point control

VEGATOR 142 can be used with one transducer to detect limit values with different switch on/switch off points.

The following points must be observed here:

- The two NO contacts must be connected in series
- Both channels must operate in the same mode, Min. or Max.
- Two-point control must be selected

3.2 Safe state

Safe state

The safe condition of the output is independent of the mode, by definition the currentless state of the relay (quiescent current principle).

Therefore only the NO contact may be used for safety-relevant applications.

Fault signals in case of malfunction

Relay outputs:

- NO contacts open

3.3 Prerequisites for operation

Instructions and restrictions

- The measuring system should suit the application. The application-specific limits must be maintained
- The specifications according to the operating instructions manual, particularly the current load on the output circuits, must be kept within the specified limits
- To avoid a fusing of the relay contacts, these must be protected by an external fuse that triggers at 60 % of the max. contact current load.
- The installation site must comply with IP 54 protection
- 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)*"

4 Safety-related characteristics

4.1 Key figures acc. to IEC 61508 for single point control

VEGATOR 141 or one channel of VEGATOR 142

Parameter	Value
Safety Integrity Level	Up to SIL2 in single-channel architecture SIL3 in multiple channel architecture[3)]
Hardware fault tolerance	HFT = 0
Instrument type	Type A
Mode	Low demand mode, High demand mode
SFF	> 60 %
MTBF[4)]	1.42 x 10^6 h (162 years)
Fault reaction time[5)]	< 2 s

Failure rates

λ_S	λ_{DD}	λ_{DU}	λ_H	λ_L	λ_{AD}
231 FIT	21 FIT	76 FIT	0 FIT	0 FIT	0 FIT

PFD_{AVG}	0.063 x 10^{-2}	(T1 = 1 year)
PFD_{AVG}	0.093 x 10^{-2}	(T1 = 2 years)
PFD_{AVG}	0.183 x 10^{-2}	(T1 = 5 years)
PFH	0.076 x 10^{-6} 1/h	

Proof Test Coverag (PTC)

Test type[6)]	Remaining failure rate of dangerous undetected failures	PTC
Test 1	32 FIT	58 %
Test 2	2 FIT	97 %

4.2 Characteristics acc. to IEC 61508 for two-point control

VEGATOR 142

Parameter	Value
Safety Integrity Level	SIL2 in single-channel architecture SIL3 in multiple channel architecture[7)]

3) Homogeneous redundancy possible (see note in the section "Area of Applicaton").
4) Including errors outside the safety function.
5) Time between the occurrence of the event and the output of a fault signal.
6) See section "Proof test".
7) Homogeneous redundancy possible.

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Parameter	Value
Hardware fault tolerance	HFT = 0
Instrument type	Type A
Mode	Low demand mode, High demand mode
SFF	> 60 %
MTBF[8]	1.17 x 10^6 h (134 years)
Fault reaction time[9]	< 2 s

Failure rates

λ_S	λ_{DD}	λ_{DU}	λ_H	λ_L	λ_{AD}
299 FIT	83 FIT	95 FIT	0 FIT	0 FIT	0 FIT

PFD_{AVG}	0.079 x 10^{-2}	(T1 = 1 year)
PFD_{AVG}	0.117 x 10^{-2}	(T1 = 2 years)
PFD_{AVG}	0.229 x 10^{-2}	(T1 = 5 years)
PFH	0.095 x 10^{-6} 1/h	

Proof Test Coverag (PTC)

Test type[10]	Remaining failure rate of dangerous undetected failures	PTC
Test 1	61 FIT	35 %
Test 2	2 FIT	98 %

4.3 Characteristics acc. to ISO 13849-1

Derived from the safety-related characteristics, the following figures result according to ISO 13849-1 (safety of machinery):[11]

Single point control with VEGATOR 141 or one chaannel of VEGATOR 142

Parameter	Value
MTTFd	1179 years
DC	22 %
Performance Level	7.58 x 10^{-8} 1/h

Two-point control with VEGATOR 142

Parameter	Value
MTTFd	643 years
DC	47 %
Performance Level	9.50 x 10^{-8} 1/h

[8] Including errors outside the safety function.
[9] Time between the occurrence of the event and the output of a fault signal.
[10] See section "Proof test".
[11] ISO 13849-1 was not part of the certification of the instrument.

4.4 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 fluctations 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
- To avoid a fusing of the relay contacts, these must be protected by an external fuse

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 = 8 h

Boundary conditions relating to transmitters

The transmitter used, must output an error current if it is powered by a voltage outside its voltage range.

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 operating elements must be set according to the application. The function of the operating elements as well as the parameter adjustment procedure are described in the operating instructions.

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 transducer to the actuator is adapted to the process safety time!

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

Note:
If two-point control is activated, the setting of the switching point must be carried out exactly according to the sequence specified in the operating instructions.

Information:
When two-point control is activated, the channel 2 sensor circuit is inactive.

6 Diagnostics and servicing

6.1 Behaviour in case of failure

Internal diagnosis

The instrument permanently monitored by an internal diagnostic system. If a malfunction is detected, a fault signal will be output on the safety-relevant output (see section "*Safe status*").

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

Error messages in case of malfunction

The occurrence of an error is signalled by the red LED and, if necessary, by the fail safe relay.

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

Defective instruments can only be repaired by the manufacturer.

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 checking the process variable

Conditions

- Use of any 4 … 20 mA transducer
- Output signals correspond to the current process variable

Procedure

1. Push the min./max. switch on the VEGATOR 141, 142
2. Check relay contacts

Expected result

- about 1: Relay and LED display change status
- about 2: Relay contacts open and close according to item 1

Proof Test Coverage

See *Safety-related characteristics*

7.3 Test 2: With check of the process variable

Conditions

- Use of any 4 … 20 mA transducer
- Output signals correspond to the current process variable
- Possibility to change the real process variable

Procedure

1. Change the process variable up to the limit value ("wet test")
2. Check relay contacts

Expected result

- about 1: Relay and LED display correspond to the limit value
- about 2: Relay contacts open and close according to item 1

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 checking the process variable
(…)	Proof test	(…)	With check of the process variable

Mode		Delay times	
Max.	Channel 1 (…); channel 2 (…)	(…)	Switch-on delay
Min.	Channel 1 (…); channel 2 (…)	(…)	Switch-off delay
(…)	Two-point control		

Test result for test 1 and 2

Process variable Channel 1	Min./max. switch Channel 1	Condition Relay 1	Process variable Channel 2	Min./max. switch Channel 2	Condition Relay 2	Test result

Confirmation	
Date:	Signature:

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	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)
PL	Performance Level (ISO 13849-1)

10 Supplement C: SIL conformity

Certificate

Nr./No.: 968/FSP 1025.05/19

Prüfgegenstand **Product tested**	Auswertgerät VEGATOR Serie 100 Signal conditioning instrument VEGATOR 100 Series	**Zertifikats-inhaber** **Certificate holder**	VEGA Grieshaber KG Am Hohenstein 113 77761 Schiltach Germany
Typbezeichnung **Type designation**	VEGATOR 141/142 (4...20 mA)		
Prüfgrundlagen **Codes and standards**	IEC 61508 Parts 1-7:2010 IEC 61511-1:2016+ Corr.1:2016 + AMD1:2017		IEC 61010-1:2017 IEC 61326-3-2:2017
Bestimmungsgemäße Verwendung **Intended application**	Signal conditioning instrument for level detection. The signal conditioning instruments of the VEGATOR 100 Series comply with the requirements of the stated standards and can be used in a safety-related system acc. IEC 61508, in HFT=0 configuration up to SIL 2 and redundant (HFT=1) up to SIL 3. Signal conditioning instrument for level detection. The signal conditioning instruments of the VEGATOR 100 Series comply with the requirements of the stated standards and can be used in a safety-related system acc. IEC 61508, in HFT=0 configuration up to SIL 2 and redundant (HFT=1) up to SIL 3.		
Besondere Bedingungen **Specific requirements**	Die Hinweise in der zugehörigen Installations- und Betriebsanleitung sowie des Sicherheitshandbuchs sind zu beachten. The instructions of the associated Installation, Operating and Safety Manual shall be considered.		

Gültig bis / Valid until 2024-12-16

Der Ausstellung dieses Zertifikates liegt eine Prüfung zugrunde, deren Ergebnisse im Bericht Nr. 968/FSP 1025.01/19 vom 16.12.2019 dokumentiert sind.
Dieses Zertifikat ist nur gültig für Erzeugnisse, die mit dem Prüfgegenstand übereinstimmen.
The issue of this certificate is based upon an examination, whose results are documented in Report No. 968/FSP 1025.01/19 dated 2019-12-16.
This certificate is valid only for products which are identical with the product tested.

TÜV Rheinland Industrie Service GmbH
Bereich Automation
Funktionale Sicherheit
Am Grauen Stein, 51105 Köln
Certification Body Safety & Security for Automation & Grid

Köln, 2019-12-16

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