Supplementary information

Recurring function test

for VEGAPULS series 60

Document ID:
36553

Contents

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1 About this document

Why a function test?

The recurring function test serves to check the safety function and reveal possible undetected, dangerous failures (λ_{du}). The functional capability of the measuring system has to be tested in adequate time intervals. It is the user's responsibility to select an appropriate type of testing. The time intervals are subject to the PFD_{avg}-value according to the specifications in the Safety Manual (SIL).

With high demand rate, a recurring function test is not requested in IEC 61508. The functional efficiency of the measuring system is demonstrated by the frequent use of the system. In double channel architectures it is a good idea to verify the effect of the redundancy through recurring function tests at appropriate intervals.

Scope

This supplementary information applies to measuring systems consisting of radar sensor VEGAPULS series 60 in two-wire and four-wire 4 … 20 mA/HART versions:

VEGAPULS 61, 62, 63, 65, 66, 67, 68

Valid hardware and software versions:

	Serial number of the electronics	Sensor software
VEGAPULS 61, 62, 63, 65, 66	> 13978716	from version 3.22 up to version 3.80
VEGAPULS 61, 62, 63 with increased sensitivity	> 14165303	from version 3.25 up to version 3.80
VEGAPULS 67, 68	> 14165303	from version 3.25 up to version 3.80

With this supplementary information you can carry out a recurring function test of VEGAPULS series 60 level sensors without dismounting the instrument or moving the product level to the switching point.

With this procedure, 88 % or 96 % of all dangerous undetected instrument failures (λ_{du}) are detected (DC_{Proof}).

The described function test fulfils the requirements according to SIL.

Fault detection rate λ_{du} 96 %

If you have already created a sensor documentation during setup, you can check the sensor at a detection rate of 96 % of all dangerous undetected failures.

The remaining dangerous undetected failures are 11 FIT.

FIT = Failure In Time (1 FIT = 1 failure/10^9 h)

Make sure that also a later sensor documentation is possible. This sensor documentation of a recurring function test must be at least 6 months old.

Fault detection rate λ_{du} 88 %

If you created no sensor documentation during setup, you can check the sensor only at a detection rate of 88 % of all dangerous undetected failures.

The remaining dangerous undetected failures are in this case 32 FIT.

FIT = Failure In Time (1 FIT = 1 failure/10^9 h)

Please note the Ex-specific safety information for installation and operation in Ex areas. These safety instructions are part of the scope of delivery and come with the Ex-approved instruments.

Warning:
The recurring function test influences connected devices. Take note that downstream devices may be activated during the test.

Information:
Proceed according to the specified, recommended sequence of these instructions to isolate possible device failures systematically.

Information:
Document the recurring function test, for example, in the test protocol in the supplement. To facilitate the recording and for further function tests, we recommend to copy the empty test protocol before completing it.

This supplementary information manual can be downloaded from our download section.

The recurring function test cannot replace the prescribed test according to WHG (Water Resources Act).

2 Prerequisites

2.1 Authorised personnel

All operations described in this operating instructions manual must be carried out only by trained specialist personnel authorised by the plant operator.

During work on and with the device the required personal protective equipment must always be worn.

2.2 Required tools

- This test instruction
- PACTware
- Actual VEGA DTM Collection
- Device-DTM of the corresponding sensor (part of the VEGA DTM Collection)
- Communication-DTM (part of the VEGA DTM Collection)
- Interface adapter VEGACONNECT
- mA-meter or PLC resp. DCS (accuracy ≤±0.2 %)
- Operating instructions manual of the sensor
- Safety Manual

2.3 Required comparative data

The setup data should be used for verification of the settings.

The following setup data are required:

- Sensor documentation of the setup with all parameters or a sensor documentation created at least 6 months ago
- Documentation of all parameter changes since the setup

If the sensor documentation of the setup or a sensor documentation created at least 6 months ago is not available, then the described recurring function test (λ_{du} 96 %) cannot be carried out completely. In this case, only the test at a detection rate of 88 % of all dangerous, undetected failures is possible.

2.4 Required plant situation

Caution:
Make sure that there are no considerable process-relating changes in your plant during the recurring function test. This means also that the level in the vessel should not change significantly by filling or emptying during the test. Make sure that also temperature changes, stirrers, current reactions in the vessel, etc. can cause level changes.

Information:
Document the recurring function test, for example, in the test protocol in the supplement.

The following conditions must be fulfilled when performing the recurring function test:

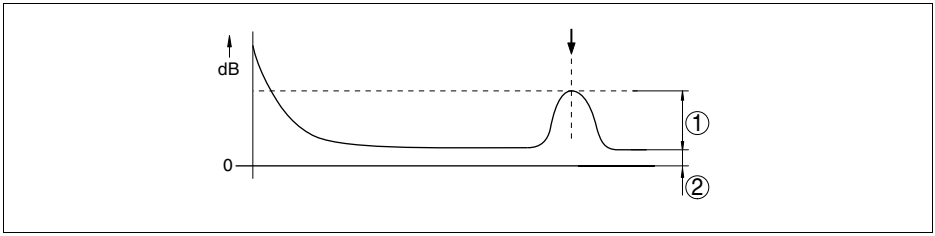

Fig. 1: Level echo - VEGAPULS
1 Amplitude of the useful echo above the noise level (signal/noise ratio)
2 Noise level

- The level must be in the following areas:
  - Min. distance to the level: Lower antenna edge +200 mm
  - Level above the vessel bottom ≥ 250 mm
  - Reliability at least 20 dB (amplitude of the useful logarithmic echo above the noise level). The reliability can be verified during the test.
- The process conditions must be nearly constant (level, process pressure, process temperature).
- The medium must be the same as during setup or the medium must at least belong to the same product group
  - Solvents/Liquid gases/Hydrocarbons/Oils (DK value < 3)
  - Chemical mixtures (DK value 3 … 10)
  - Water/Acids/Bases (DK value > 10 or conductive)

3 Sequence of the recurring function test

Carry out the recurring function test in the following sequence:

- 3.1 Restart the sensor
- 3.2 Verification of the current output
- 3.3 Verification of the instrument parameters (only with sensor documentation)
- 3.4 Verification of the echo data (only with sensor documentation)
- 3.5 Sensor reaction to a level change

Information:
Document the recurring function test, for example, in the test protocol in the supplement.

Function test not successful

If one of the test points was not terminated successfully, there is probably an undetected dangerous failure. The recurring function test has failed.

In this case, proof of functional safety can only be provided by moving the level to the switching point.

3.1 Restart of the sensor

With this test point, it is possible to check of the sensor ouputs the same value within the prescribed min. accuravy after a restart.

Warning:
The recurring function test influences connected devices. Take note that downstream devices may be activated during the test.

Carry out a restart of the sensor. Proceed as follows:

Before the restart

1 Start PACTware and the corresponding sensor DTM.

Make sure that the conditions to the plant situation are maintained. See "*Required plant situation*".

(range of the actual level or the reliability at least 20 dB)

2 Set the indication to "Current".

3 The level is subject to plant or process-relevant fluctuations. Control the indicated current values over an adequate period.

Make sure that a damping is probably adjusted on the sensor.

4 Note the upper and lower limit values of the measured value.

5 Measure the output current of the sensor.

Preferrably use the indication of the input current value in the processing system.

If you do not have this possibility, connect an mA-meter according to the following illustration.

You require the mA-meter for the verification of the current output in the next test point. The accuracy of the mA-meter should be better than 0.2 %. Select the smallest measuring range covering 4 … 20 mA.

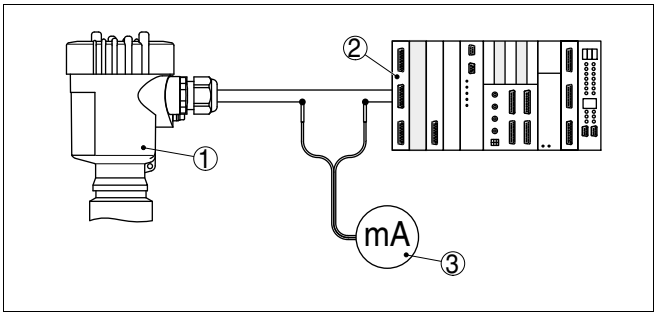

Fig. 2: Connection of the mA-meter

1 Level sensor
2 Processing system
3 mA-meter

6 Switch off the power supply.

7 Switch the voltage supply on again after approx. 10 s.

If the software signals a communication error during or after switching off the power supply, you have to acknowledge it.

After connecting the sensor to power supply respectively after the voltage recurrence, the instrument carries out a self-check for approx. 30 seconds:

- Internal check of the electronics
- The output signal jumps to the set error current

Then the current corresponding to the level is outputted to the cable.

After switching on again

1 The level is subject to plant or process-relevant fluctuations. Control the indicated current values over an adequate period.

2 Note the upper and lower limit values of the measured value.

3 Compare the actually noted current values with the previously noted values.

The two values must correspond within the safety accuracy of 2 % (±0.32 mA).

If the two differential values are within the safety accuracy, then the test of the restart was successful.

Continue with the next test point.

3.2 Verification of the current output

In this test point you simulate certain level values via the current output. With this you can test the reaction of the sensor with different current output values and the switching behaviour.

Warning:
The recurring function test influences connected devices. Take note that downstream devices may be activated during the test.

Simulation 4 mA

1 Select in the DTM under the menu "*Service*" the menu item "*Simulation*".
2 Select "Current" as measured variable for the simulation.
3 Activate the simulation.
4 Set the simulation value to 4 mA.
Take note that downstream devices may be activated.
5 Accept the simulation value.
Wait approx. 30 s.
The simulation is running and a corresponding current is being outputted.
6 Note the displayed value (4 mA simulation) of the mA-meter.
The value must correspond with the simulated value within the safety accuracy of 2 % (±0.32 mA).

Continue with the simulation if the two values correspond.

Simulation 20 mA

1 Set the simulation value of the current simulation to 20 mA.
Take note that downstream devices may be activated.
2 Accept the simulation value.
Wait approx. 30 s.
The simulation is running and a corresponding current is being outputted.
3 Note the displayed value (20 mA simulation) of the mA-meter.
The value must correspond with the simulated value within the safety accuracy of 2 % (±0.32 mA).

The verification of the current output was successful if the two values correspond.

Caution:
Deactivate the simulation.

Continue with the next test point.

3.3 Verification of the instrument parameters

For this test point, the sensor documentation of the setup or the last sensor documentation (at least 6 months old) is required. If a parameter was changed since then, you also require the protocol or the sensor documentation of this parameter change.

If this sensor documentation is not available, then the described recurring function test cannot be carried out completely. In this case, only the test with a detection rate of 88 % of all dangerous, undetected failures is possible.

In this case, you continue with the test point "*Sensor reaction on level change*" or create an actual sensor documentation and carry out the function test after at least 6 months. The actual parameter adjustment must be checked for correctness in the respect.

A sensor documentation was generated directly after the setup or at least 6 months ago. For assessment of the instrument parameters, this sensor documentation of the setup, the actual sensor documentation of the last parameter change or the sensor documentation generation and checked 6 months ago must be taken into consideration.

Create a current sensor documentation

Create now a sensor documentation with the current instrument parameters. Proceed as follows:

1 Select the function "Print" in the DTM.

2 For complete sensor documentation, you have to select all instrument parameters (except laboratory parameters).

   A multiple-page pdf documentation containing all relevant sensor data is then generated.

3 Save this documentation as pdf document and, where appropriate, print out the documentation to be on the safe side.

4 Compare the instrument parameters of this actual sensor documentation with the sensor documentation of the setup or the last parameter change.

   Deviating parameters must be documented, justified and checked on correctness.

If the actual sensor documentation corresponds to the stored sensor documentation or if the modified parameters are correct, then the verification of the instrument parameters was successful.

Continue with the next test point.

3.4 Verification of echo data

For this test point, you require the sensor documentation of the setup or a sensor documentation created at least 6 months ago.

If none of these sensor documentations is available, the described recurring function test (λ_{du} 96 %) cannot be carried out.

Only the test at a detection rate of 88 % of all dangerous undetected failures is possible. In this case, just skip this test point.

In this case, continue with the test point "*Sensor reaction on level change*".

Use the two pdf files of the sensor documentation again for assessment of the level echo.

Under chapter "Echo curve" you will find a short chart containing the "Echo data". The data of this chart are relevant for the assessment.

Compare the values of the two echo data charts. The echo curve itself cannot be compared.

Calculation of the correction factor

Proceed as follows:

1 Compare the distance [m] of the two level echoes (actual/setup).

2 Divide the distance [m] of the current level through the distance [m] of the level echo during setup.

Round this ratio "V" mathematically to one decimal point.

3 Search in the following chart the correction value (dB) belonging to the calculated ration "V".

4 Calculate with the correction value the corrected value of the amplitude.

This corrected value of the amplitude [dB] of the actual level echo can be higher, but only max. 6 dB lower than the amplitude of the level echo during setup.

Ratio "V"	Correction value (dB)
0.5	-6
0.6	-4.5
0.7	-3
0.8	-2
0.9	-1
1.0	-0

Ratio "V"	Correction value (dB)
1.1	+0.8
1.2	+1.5
1.3	+2.3
1.4	+3
1.5	+3.5
1.6	+4
1.7	+4.6
1.8	+5
1.9	+5.6
2.0	+6

Example
During setup, the level echo had 32 dB. The distance [m] to the medium was 12.9 m.

The actual level echo has 25 dB. The distance [m] to the medium is 15.8 m.

Division of the current distance [m] by the distance [m] during setup: 15.8 m : 12.9 m = 1.224

Round mathematically to one position after the decimal point: 1.224 --> 1.2

Correction value for the ratio (1.2): + 1.5

Calculation of the corrected value of the amplitude: 25 dB + 1.5 = 26.5 dB

The result of the example (26.5 dB) is thus within the permissible tolerance range of - 6 dB (32 dB - 6 dB = 26 dB)

In this example, the test point would be successfully fulfilled.

The following criteria must correspond when comparing the echo data:

- If there are false echoes in front of the level echo (highest useful echo probability), they must have a useful echo probability of 0 %.
- The amplitude [dB] (with correction factor) of the actual level echo (highest useful echo probability) corresponds to the respective value of the level echo from the setup (tolerance max. -6 dB). This means that the actual level echo can be higher, but only max. 6 dB lower than the level echo during setup.

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If all the above conditions are fulfilled, the measurement works correctly and the verification of the echo data was successful.

Continue with the next test point.

3.5 Sensor reaction to a level change

With this test point, you monitor the reaction of the sensor during a level change.

1 Set the indication of the sensor DTM to "Distance".

2 Change the filling of your vessel.

It doesn't matter if you fill or empty the vessel.

The filling speed is also not relevant.

The level change must be at least 50 mm.

3 Take note of the sensor reaction.

Does the measured value [m(d)] move in the correct direction during emptying/filling?

The displayed measured value (distance) is the distance between seal surface of the sensor and the product surface.

- The measured value will decrease during filling.
- The measured value will increase during emptying.

When the level value changes analogue to the level change, the measurement works correctly and the assessment of the sensor reaction was successful.

If all function tests were successful, the recurring function test is finished.

If you used an mA-meter for the recurring function test, switch off the sensor and remove the mA-meter from the sensor cable after finishing the recurring function test.

3.6 Result of the recurring function test

Function test successful

If all test points could be terminated successfully, then the recurring function test was successful.

Fulfilled test points	
3.1 / 3.2 / 3.3 / 3.4 / 3.5	Fault detection rate λ_{du} 96 %
3.1 / 3.2 / 3.5 (sensor documentation of the setup or a sensor documentation which is at least 6 months old, is not available)	Fault detection rate λ_{du} 88 %

The test must be repeated in regular intervals. The time periods depend on the PFD_{avg} value according to the sepcifications in the Safety Manual (SIL).

Function test not successful

If one of the test points (3.1 / 3.2 / 3.5) could not be terminated successfully, there is probably an undetected dangerous failure. The recurring function test has failed.

In this case, proof of functional safety can only be provided by moving the level to the switching point.

4 Test protocol - Recurring function test

If you copy this protocol, please note the date of the function test, the measurement loop and the sensor serial number on each page.

Specifications VEGAPULS	
Tester	
Measurement loop name (sensor-TAG)	
Sensor type	
Serial number of the sensor	
Software version	
Required plant situation (according to chapter 2.4)	☐ maintained
Safety-instrumented system (SIS)	☐ yes
SIL activated	☐ yes
Medium or product group	
Date of the setup (sensor documentation)	
Date of the last function test (if carried out)	

Test 3.1 - Restart of the sensor		
Measured value before switching off	Current value min. in mA	Current value max. in mA
Measured value after switching on again	Current value min. in mA	Current value max. in mA
Difference of the current values	Current value min. in mA	Current value max. in mA
Duration of the inspection in s		
Test result Min. and max. values	☐ Deviation ≤ 2 % (test point successful)	☐ Deviation > 2 % (test point not successful)

Test 3.2 - Verification of the current output		
Lower simulation value (4 mA)	Indication mA-meter in mA	
Intermediate result ≤ 2 % (≤0.32 mA)	☐ Corresponds	☐ Does not correspond
Upper simulation value (20 mA)	Indication mA-meter in mA	
Intermediate result ≤ 2 % (≤0.32 mA)	☐ Corresponds	☐ Does not correspond
Test result - Total	☐ Corresponds	☐ Does not correspond

☐ Sensor documentation of the setup available or ☐ Sensor documentation (at least 6 months old) is available	File name:	
	☐ Parameters correspond	
	☐ Parameters do not correspond - however checked on correctness	File name:
	☐ Parameters do not correspond - deviation not acceptable	File name:
☐ Sensor documentation of the setup not available	☐ Parameters checked on correctness and saved (recheck after 6 months necessary)	File name:
Test result	☐ All parameters correct or checked on correctness	☐ Parameters not correct
	Tester:	

Test 3.4 - Verification of the echo data		
No false echoes or echoes with useful echo probability 0 %	☐ Corresponds	☐ Does not correspond
Corresponding amplitude	☐ In the tolerance range	☐ Not in the tolerance range
Test result	☐ Corresponds	☐ Does not correspond

Test 3.5 - Verification of the sensor reaction		
Reduction of the level	☐ Distance value [m] increases	☐ Other reaction
Increase of the level	☐ Distance value [m] decreases	☐ Other reaction
Test result	☐ Corresponding sensor reaction	☐ Sensor reaction does not correspond

● **Summary 96 % (λ_{du})**		
	Date	Signature
Test 3.1 / 3.2 / 3.3 / 3.4 / 3.5	☐ All five test points passed	☐ One or several test points did not pass

● **Summary 88 % (λ_{du})**		
	Date	Signature

● **Summary 88 % (λ_{du})**		
Test 3.1 / 3.2 / 3.5	☐ All three test points passed	☐ One or several test points did not pass

Date _____

Signature _____

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