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Special Documentation
Micropilot FMR60B, FMR62B, FMR63B, FMR66B, FMR67B PROFINET with Ethernet-APL

Application package
Heartbeat Verification + Monitoring

Endress+Hauser
People for Process Automation

1 About this document

1.1 Document function

This manual is a Special Documentation and does not replace the Operating Instructions included in the scope of supply. It is a part of the Operating Instructions and serves as a reference for using the Heartbeat Technology function integrated in the measuring device.

1.2 Content and scope

This document contains descriptions of the additional parameters and technical data of the application package and detailed explanations regarding:

- Application-specific parameters
- Advanced technical specifications

1.3 Symbols

1.3.1 Safety symbols

⚠ CAUTION

This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.

⚠ DANGER

This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.

NOTICE

This symbol contains information on procedures and other facts which do not result in personal injury.

⚠ WARNING

This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.

1.3.2 Symbols for certain types of information and graphics

ℹ Tip
Indicates additional information

1., 2., 3. Series of steps

1, 2, 3, ...
Item numbers

Bluetooth
Wireless data transmission between devices over a short distance.

1.4 Documentation

For an overview of the scope of the associated Technical Documentation, refer to the following:
- *Device Viewer* (www.endress.com/deviceviewer): Enter the serial number from the nameplate
- *Endress+Hauser Operations app*: Enter serial number from nameplate or scan matrix code on nameplate.

1.5 Registered trademarks

ethernet-apl™
- Ethernet-APL ADVANCED PHYSICAL LAYER
- Registered trademark of the PROFIBUS Nutzerorganisation e.V. (Profibus User Organization), Karlsruhe - Germany

2 Product features and availability

2.1 Product features

The Heartbeat Verification + Monitoring application package offers diagnostic functionality through continuous self-monitoring, the transmission of additional measured variables to an external Condition Monitoring system and the in-situ verification of devices in the application.

The test scope achieved using these diagnostic and verification tests is expressed as the **total test coverage** (TTC). The TTC is calculated using the following formula for random errors (calculation based on FMEDA as per IEC 61508):

$TTC = (\lambda_{TOT} - \lambda_{du}) / \lambda_{TOT}$

λ_{TOT}: Rate of all theoretically possible failures

λ_{du}: Rate of undetected dangerous failures

The undetected dangerous failures are not diagnosed by the device diagnostics. If these failures occur, they can falsify the measured value that is displayed or interrupt the output of measured values.

Heartbeat Technology confirms that the device is functioning within the specified measuring tolerance with a defined TTC.

The TTC is at least:
95 % for PROFINET communication

The current value for the TTC depends on the configuration and integration of the measuring device. It is determined under the following basic conditions:
- **Simulation** parameter **Off** option
- Settings for diagnostic behavior correspond to factory settings

2.2 Availability

The Heartbeat Verification + Monitoring application package can be ordered with the device or enabled subsequently with an activation code. Detailed information on the order code is available on the website www.endress.com or from your Endress+Hauser sales organization.

The availability of the application package can be checked as follows:
- Order code with breakdown of the device features on the delivery note
- On the web using the Device Viewer: enter the serial number from the nameplate and check whether the order code is displayed
- In the operating menu: here you can see if the application package is enabled.
  Navigation: System → Software configuration → Software option overview

2.2.1 Activation code

If ordered subsequently, a retrofit kit is supplied. This kit includes a wired-on tag plate with modified device data and an activation code.

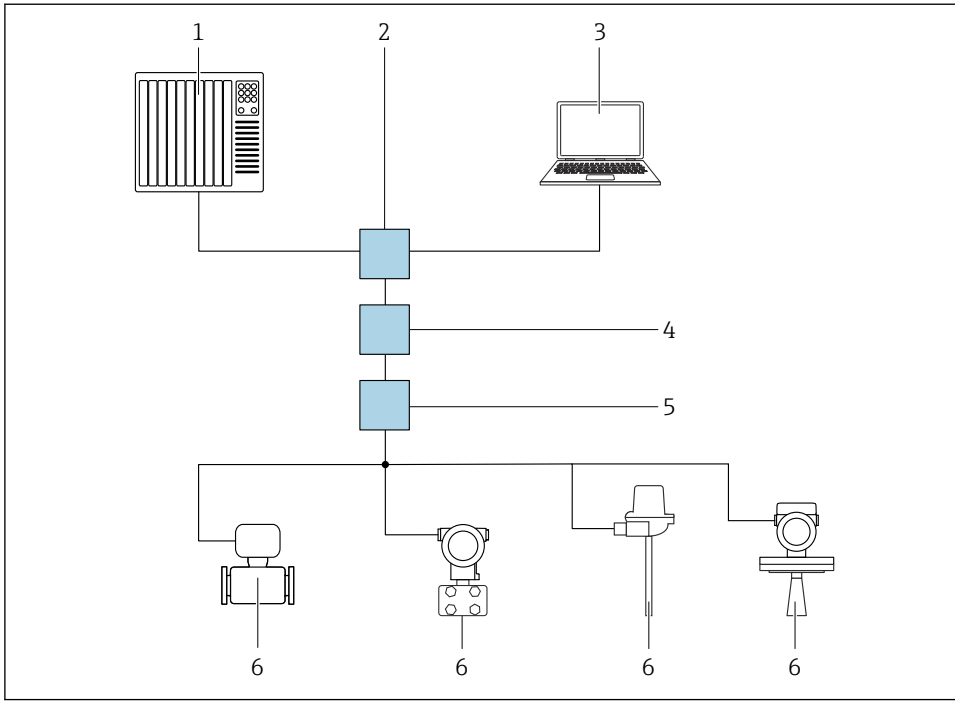
Enter the activation code in:
System → Software configuration → Activate SW option

2.2.2 Access

Heartbeat Technology is compatible with all the system integration options. Interfaces with digital communication are required to access the data saved in the device. The speed of data transmission depends on the type of communication interface used.

3 System integration

The Heartbeat Technology functions are available on the web server and can be used either via an Asset Management System or the automation infrastructure (e.g. PLC).



1 *Options for remote operation via PROFINET with Ethernet-APL network: star topology*

1 *Automation system, e.g., Simatic S7 (Siemens)*
2 *Ethernet switch*
3 *Computer with Web browser (e.g., Microsoft Edge) for accessing the integrated device Web server or computer with operating tool (e.g., FieldCare, DeviceCare, SIMATIC PDM) with iDTM Profinet Communication*
4 *APL power switch (optional)*
5 *APL field switch*
6 *APL field device*

Perform Heartbeat Verification using one of the following interfaces:
- System integration interface of a higher-level system
- Service interface (CDI = Endress+Hauser Common Data Interface)
- Web server
- PROFINET cyclic or acyclic
- Onsite display (optional)
- Bluetooth (optional)

External access to the device in order to start a verification and signal the result (**Passed** option or) **Failed** optionmust be performed by a higher-level system via a system integration interface. The Heartbeat verification can be started cyclically via PROFINET by the BinaryOutput Block. The results are signaled via the BinaryInput Block in slot 80.

The detailed results of the verification are saved in the device and provided in the form of a verification report. The last result in each case is saved in the device.

Verification reports can be created using the Plant Asset Management Software FieldCare, DeviceCare, the web server or SmartBlue app and FieldXpert.

3.1 Data exchange performed by the user (asset management system)

Heartbeat Verification
- Start of verification
- Upload, archive and document the verification results including detailed results

Heartbeat Monitoring
- Configuration of the monitoring function: specify which monitoring parameters are output continuously via the system integration interface.
- The user can read the monitoring measured variables in the operating menu.

3.2 Data management

The result of a verification is saved as a non-volatile parameter set in the measuring device memory. Previous data are Verification results overwritten by new data; only the last result is saved.

3.2.1 Verification report

Verification report must be pressed

The Verification report is output in PDF format.

Prerequisite: A verification has already been performed.

3.2.2 File management

Netilion Library

Heartbeat verification reports can be saved in Netilion with the Netilion Library (www.netilion.endress.com). They can be uploaded by notebook, smartphone or a Field Xpert tablet.

The verification reports are then:
- online
- automatically assigned to their digital twin
- easier to find
- always readily available

4 Heartbeat Verification

Heartbeat Verification is carried out on request and supplements self-monitoring, which is performed continuously, by carrying out further tests. During verification, the system checks

whether the device components comply with the factory specifications. Both the sensor and the electronics modules are included in the tests.

Heartbeat Verification confirms the device function on request within the specified measuring tolerance with a total test coverage TTC (Total Test Coverage) in percent.

Heartbeat Verification meets the requirements for metrological traceability in accordance with ISO 9001 (ISO9001:2015 Section 7.1.5.2).

The result of the verification is either Passed or Failed. The verification data are saved in the device and optionally archived on a PC with the FieldCare asset management software or in the Netilion Library. Based on this data, a verification report is generated automatically to ensure that traceable documentation of the verification results is available.

It is possible to manually record reference data relating to the operator and the location. These reference data appear on the verification report.

4.1 Device behavior and interpretation

- Result: Passed
  All test results are within the specification.
- Result: Failed
  One or more test results are "Out of specification (S)".

Verification result Failed

If the result of a verification is **"Failed" option**, repeat the verification.

Consider the following measures when doing so:

1. Establish defined and stable process conditions in order to rule out process-specific influences as much as possible.
2. Compare current process conditions with those of the previous verification to identify possible deviations.
3. Take remedial measures based on the diagnostic information of the device.

The cause of the error can be narrowed down by identifying the test group with a "Failed" verification.

Operation continues during the entire Heartbeat Verification.

4.2 Verification

Performing verification

1. Navigation: Guidance → Heartbeat Technology → Heartbeat Verification → Heartbeat Verification
2. Select the **Start verification** option.

Displaying the status

▶ Navigation: Diagnostics → Heartbeat Technology → Heartbeat Verification → Status

Displaying the result

▶ Navigation: Diagnostics → Heartbeat Technology → Heartbeat Verification → Overall result

4.3 Verification results

Access to the verification results via:
- SmartBlue app
- DTM-based tools (e.g. FieldCare or DeviceCare)
- FieldXpert
- Web server

4.3.1 Classification of results

Individual result:
- ☒ **Failed**
  At least one individual test in the test group was **Out of specification (S)**.
- ☑ **Passed**
  All individual tests in the test group complied with the specifications.
  The result is **Passed** even if the result of an individual test is **Not done** and the result of all other tests is **Passed**.
- ☒ **Not done**
  No test has been performed for this test group. For example, because this parameter is not available or activated in the current device configuration.

Overall result:
- ☒ **Failed**
  At least one test group has **Failed**.
- ☑ **Passed**
  All verified test groups were within the specification.
  The overall result is **Passed** even if the result of individual test groups is **Not done** and the result of all other tests is **Passed**.

Heartbeat Verification confirms on demand that the device is functioning within the specified measuring tolerance with a total test coverage (TTC) specified as a percentage.

4.4 Verification report

The results of the verification can be documented via DTM-based tools or the SmartBlue app Verification report in the form of a verification report. Since the Verification results verification results are automatically and uniquely identified with the Operating time, they are suitable for the traceable documentation of the verification of devices.

The following information is provided on each report page/section for unique identification:
- Serial number
- Device tag
- Operating time (Verification)

4.4.1 Verification report, section 1

Measuring point identification, presentation of the overall verification result and confirmation of completion:
- **Device information**
  (Information on the place of operation, Device tag, Device name, Order code, Firmware version, Hardware version)
- **Calibration / Configuration**
  (Information on the device configuration such as Empty calibration, Full calibration, Medium type, Media group, CRC device configuration)
- **Verification information**
  (Operating time (Verification) for the clear allocation of the Verification results for the purpose of traceable documentation of the verification)
- **Verification result**
  (Overall result of the verification is **Passed** if all individual results are **Passed**)

4.4.2 Verification report, section 2

Details on the individual results of the following test groups:
- Verification pre-condition
- Mainboard module
- Sensor module

4.4.3 Verification report, section 3

Details with values for the individual tests from section 2.

4.4.4 Verification report, section 4

Additional data and information that can influence the assessment of the measurement results or the appraisal of the process conditions:
- Process condition (at the time of verification)
- Device history
- Sensor history

4.5 Test criteria for the test objects

4.5.1 Verification pre-condition

System status
Checks active measurement device errors at diagnostical behavior 'alarm'. If an active error is detected, then verification will be performed but the overall result will always be 'Failed'.

4.5.2 Mainboard module

Module operating voltages

Checks, if the internal module voltages are within the allowable range.

Module voltage	Permitted range
1.20 V	1.0988 to 1.2012 V
1.35 V	1.2818 to 1.4512 V
1.80 V	1.7088 to 1.8912 V
3.30 V	3.1180 to 3.4720 V
8.25 V	7.1270 to 9.2730 V

Software integrity

Checks whether the function blocks of the software are executed in the correct order. Checks whether certain events are currently active, e.g. in the mainboard, the device checks the incrementation of the sequence counter with each new measured value in the sensor module. If this is not the case, Failed is output.

RAM check

Checks the correct function of the RAM (Random Access Memory). If a RAM cell is defective, this is detected by the read-back value of the RAM cell and Failed is output.

ROM check

Checks the correct function of the ROM memory (Read-Only-Memory). If the checksum of the checked program code area does not match, Failed is output.

4.5.3 Sensor module

Signal quality

The Relative echo amplitude is used for evaluation purposes.

"Signal quality" parameter
Shows the quality of the evaluated level signal.
- Strong (>10 dB)
- Medium (≤10 dB)
- Weak (≤5 dB)
- No signal (0 dB)

"Relative echo amplitude" parameter
Shows the relative amplitude (i.e. the distance to the evaluation curve) of the evaluated level signal.

Radar Accuracy Index (RAI)

The Radar Accuracy Index (RAI) evaluates the Micropilot reference accuracy. The test method to determine the RAI is based on the generation of a test signal via the high-frequency oscillator and the measurement of the signal using the sample oscillator.

"Radar Accuracy Index (RAI)" parameter
The Radar Accuracy Index (RAI) [ppm] is output as the relative deviation between two RAI measurements:
- Traceable measurement which was performed during production as part of device calibration
- Measurement which is performed in the application as part of Heartbeat Verification

Failed option is output if the relative RAI deviation exceeds or drops below the limit values.

Limit values: −200 to +200 ppm

Clock and analog path

To ensure correct measurement, a test signal is generated and evaluated via the normal measuring path (frequency and amplitude).

"Reference echo frequency" parameter
The frequency of the test signal is evaluated and compared with the limit values
Limit values: 990 000 to 1 010 000 Hz

"Reference echo amplitude" parameter
The amplitude of the test signal is evaluated and compared with the limit values
Limit values: device-specific

IF signal

The check of the intermediate frequency signal (IF signal) ensures the sensor electronics and the associated signal path are functioning correctly. The permitted range is defined by limit values for the amplitude and amplitude swing.

"Maximum value IF amplitude" parameter
Measured maximum value of the IF amplitude
Limit values: max. 65 525 digits

"Minimum value IF amplitude" parameter
Measured minimum value of the IF amplitude
Limit values: min. 10 digits

"IF amplitude span" parameter
Amplitude swing; difference between the maximum value for the IF amplitude and the minimum value for the IF amplitude
Limit values: min. 10 digits

Sensor integrity

Checks the function of the sensor (no event active).

Energy boundaries

Checks whether the energy states are within the limits.

Energy monitoring

Checks the energy balance on the sensor.

"Energy storage capacity" parameter
Checks whether measuring capacitors are in the valid range.
Limit value: 1 000 to 3 000 µF

"Radar signal input strength" parameter
Checks the input power in the sensor module
Limit value: >8 mW

"Energy consumption of measurement" parameter
Checks whether the energy consumption of the sensor module is in the valid range
Limit value: 1 to 20 mWs

Sensor module voltage

Checks the supply voltages.

"Value for power supply 1.8 V" parameter
Supply voltage for the logic part of the sensor module (processor, memory)
Limit value: 1.71 to 1.95 V

"Value for DCS power supply" parameter
Supply voltage transmitted by the mainboard to the sensor module
Limit value: 6 to 20 V

RAM check

Checks the correct function of the RAM (Random Access Memory). If a RAM cell is defective, this is detected by the read-back value of the RAM cell and Failed is output.

ROM check

Checks the correct function of the ROM memory (Read-Only-Memory). If the checksum of the checked program code area does not match, Failed is output.

Build-up detection

Prerequisite: The Heartbeat Monitoring buildup detection function has been activated beforehand via the wizard. Checks whether there is buildup on the antenna.

"Build-up index" parameter
Build-up index 0% means: no build-up. Build-up index 100% means: maximum detectable build-up.
Limit value: customer-specific setting

Foam detection

Prerequisite: The Heartbeat Monitoring foam detection function has been activated beforehand via the wizard. Checks whether there is foam on the liquid medium.

"Foam index" parameter
Foam index 0% means: no foam. Foam index 100% means: maximum detectable foam.
Limit value: customer-specific setting

4.6 Other Verification information

Additional data and information that can influence the assessment of the measurement results or evaluation of the process conditions.

The following parameters are information values only and do not include an evaluation with respect to Passed / Failed.

4.6.1 Process conditions at the time of verification

"Signal to noise ratio" parameter
Shows the signal-to-noise ratio of the Ethernet-APL connection. Value > 21 dB is good and greater than 23 dB very good

"Electronics temperature" parameter
Current Electronics temperature and permitted Minimum/maximum values

"Sensor temperature" parameter
Current Sensor temperature and permitted Minimum/maximum values

"Level linearized" parameter
Displays linearized level

"Absolute echo amplitude" parameter
Shows the absolute amplitude of the evaluated level signal.

"Relative echo amplitude" parameter
Shows the relative amplitude (i.e. the distance to the evaluation curve) of the evaluated level signal.

4.6.2 Device history

"Electronics temperature" parameter
Displays the current temperature of the main electronics. Including the Minimum/maximum valuesachieved since the last reset.

4.6.3 Sensor history

"Sensor temperature" parameter
Displays the current temperature of the sensor electronics. Including the Minimum/maximum valuesachieved since the last reset.

"Time min. sensor temperature" parameter
Time of the operating time counter at which the Minimum sensor temperature was reached

"Time max. sensor temperature" parameter
Time of the operating time counter at which the Maximum sensor temperature was reached

"Max. filling speed" parameter
Shows the maximum Filling speedachieved since the last reset; used to detect possible measurement peaks

"Max. draining speed" parameter
Shows the maximum Draining speedachieved since the last reset; used to detect possible measurement peaks

"Level linearized" parameter
Displays the linearized level. Including the Minimum/maximum valuesachieved since the last reset.

"Time min. level" parameter
Time of the operating time counter at which the Min. level value was reached. Helps assign the recorded measurement peak to the process sequence

"Time max. level" parameter
Time of the operating time counter at which the Max. level value was reached. Helps assign the recorded measurement peak to the process sequence

"Counter underfilling" parameter
Shows the number of level undershoots less than 0%

"Counter overfilling" parameter
Shows the number of level overshoots greater than 100%

Switch-on operations
Shows the number of switch-on operations of the device

Ethernet failure counter
Shows all detected Ethernet failures (Total Number of failed received packets + Number of failed sent packets) since the device was started.

4.7 Heartbeat Technology in safety instrumented systems

Verification (Heartbeat Verification) enables the documentation of the current device diagnostic or device status as a proof of testing.

- This supports the documentation of proof tests in accordance with IEC 61511-1, Section 16.3.3, "Documentation of proof tests and inspection".
- The verification is based on automatically executed device-specific test sequences. From a safety point of view, verification cannot replace the proof-testing of a sensor, since random errors are usually not detected.
- Nevertheless, verification can be usefully applied as a step in a proof-test scenario as per NA 106 as a flexible proof-testing strategy.
- The verification report should be regarded as a supplement to the proof-test report.

5 Heartbeat Monitoring

Foam detection wizard and **Build-up detection** wizard are available, process windows can be configured. Furthermore, additional monitoring parameters can be displayed and used for predictive maintenance or application optimization.

5.1 Monitoring parameters

The following monitoring parameters can be assigned to the various outputs of the device for continuous transmission to a Condition Monitoring system.

- **Level linearized**
  Displays the linearized level.
- **Distance**
  Distance from process connection to product surface
- **Electronics temperature**
  Temperature measured in the main electronics
- **Sensor temperature**
  Temperature measured in the sensor electronics
- **Absolute echo amplitude**
  Shows the absolute amplitude of the evaluated level signal.
- **Relative echo amplitude**
  Shows the relative amplitude (i.e. the distance to the evaluation curve) of the evaluated level signal.
- **Area of incoupling**
  Ringing integral within the detection area. Shows the area under the echo curve in the range up to 1 m (3.28 ft) in order to determine the buildup quantity on the antenna.
- **Build-up index**
  Visibility depends on order options or device settings
  Build-up index 0% means: no build-up. Build-up index 100% means: maximum detectable build-up.
- **168 Build-up detected**
  Visibility depends on order options or device settings. Shows whether the customer-specific threshold for buildup detection has been exceeded.
- **Foam index**
  Visibility depends on order options or device settings
  Foam index 0% means: no foam. Foam index 100% means: maximum detectable foam.
- **952 Foam detected**
  Visibility depends on order options or device settings
  Shows whether the customer-specific threshold for foam detection has been exceeded.
- **Percent of range**
  Measured variable of the first dynamic variables (PV) as a percentage

Setting monitoring parameters via cyclic PROFINET communication

1. Navigation: Application → PROFINET → Analog input → Analog input 1 to 11 → Assign process variable
2. Analog input **Build-up index** parameter Select slot 26.
3. Analog input **Foam index** parameter Select slot 27.
4. Binary input **Build-up detected** parameter Select slot 81 bit 0.
5. Binary input **Foam detected** parameter Select slot 81 bit 1.

Selecting the measured value that is shown on the local display:

1. Navigation: System → Display

2. Select the measured value.

5.2 "Foam detection" wizard

This wizard configures the automatic foam detection.

Foam detection can be linked to an output variable or status information e.g. to control a sprinkler used to dissolve the foam. It is also possible to monitor the foam increase in a so called foam index. The foam index can also be linked to an output variable and can be shown on the display.

Preparation:
The Foam monitoring initialization should only be done without or less foam.

5.2.1 Areas of application

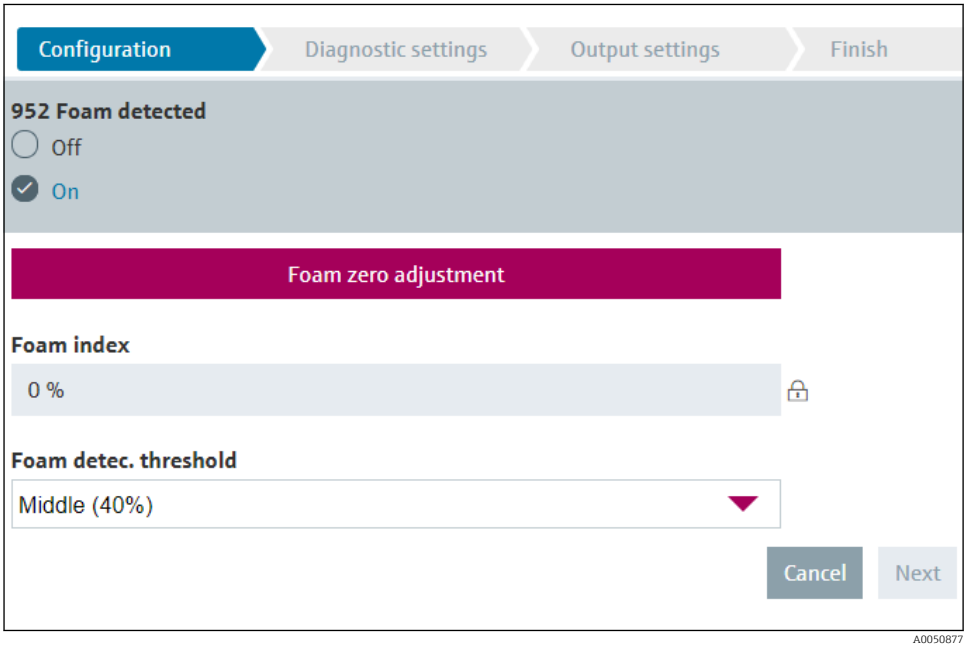
- Measurement in liquids
- Reliable detection of foam on the medium

5.2.2 Foam detection initialization

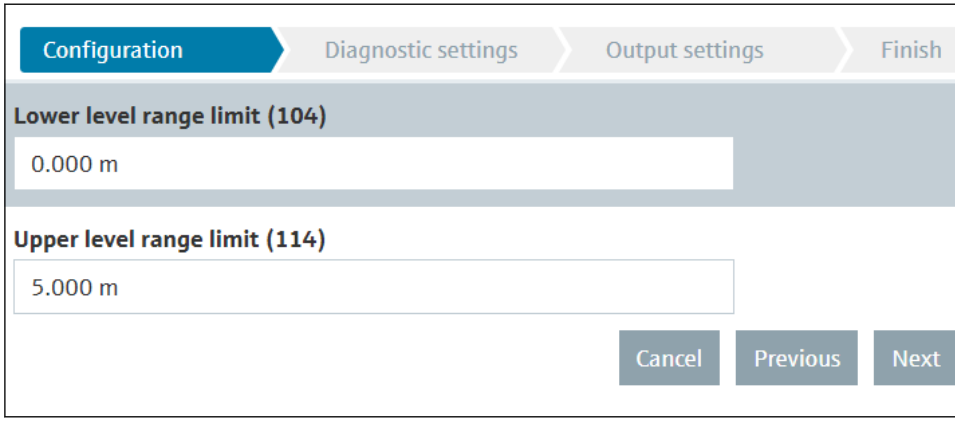
Foam detection wizard is only available for Medium type= Liquid.

Guidance → Heartbeat Technology → Heartbeat Verification → Foam detection

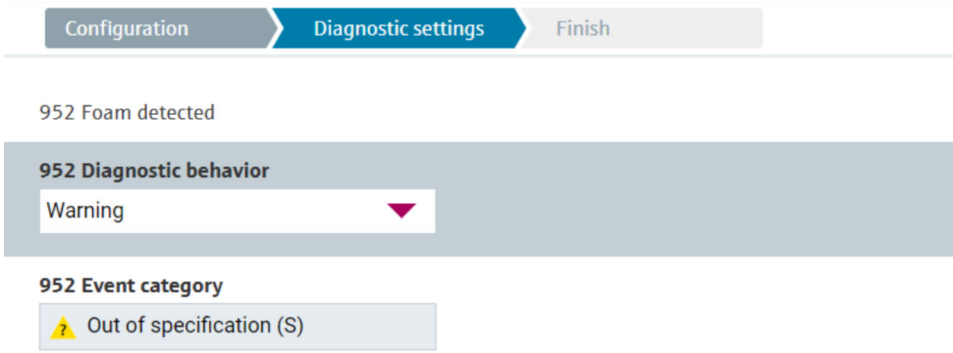
Foam detection should only be initialized with little or no foam.



2 *Screenshot - Values and entries provided as examples*



3 *Screenshot - Values and entries provided as examples*



4 *Screenshot - Values and entries provided as examples*

952 Diagnostic behavior
Determines how the detected Foam detection result is to be communicated:
- **Logbook entry only** option: Message not communicated via the fieldbus and display
- **Warning** option: Warning message is output via the fieldbus and display (Factory settings)
- **Alarm** option: Alarm message is output via the fieldbus and display

Once the permissible conditions are restored, the message is no longer available in the device and on the display.

5.3 "Build-up detection" wizard

This wizard configures the build-up detection.

Basic idea:
The build-up detection can, for example, be linked to a compressed-air system to clean the antenna.
With the build-up monitoring the maintenance cycles can be optimized.

Preparation:
The build-up monitoring initialization should only be done without or less build-up.

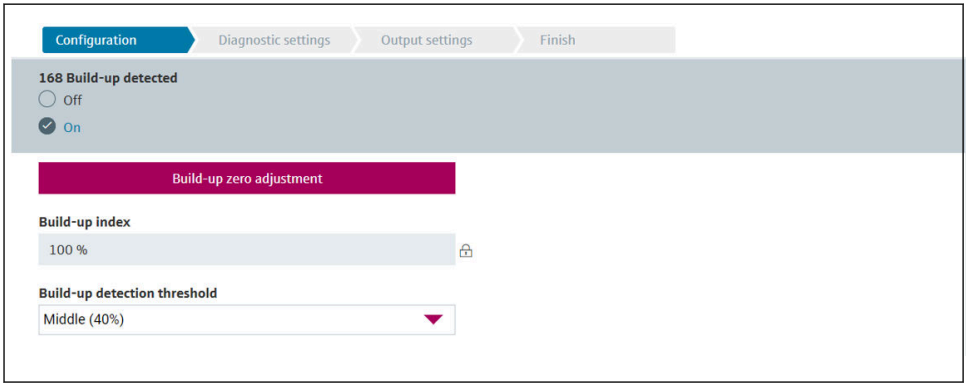
5.3.1 Areas of application

- Reliable measurement in liquids and solids
- Detection of buildup on the antenna, enables optimization of maintenance cycles

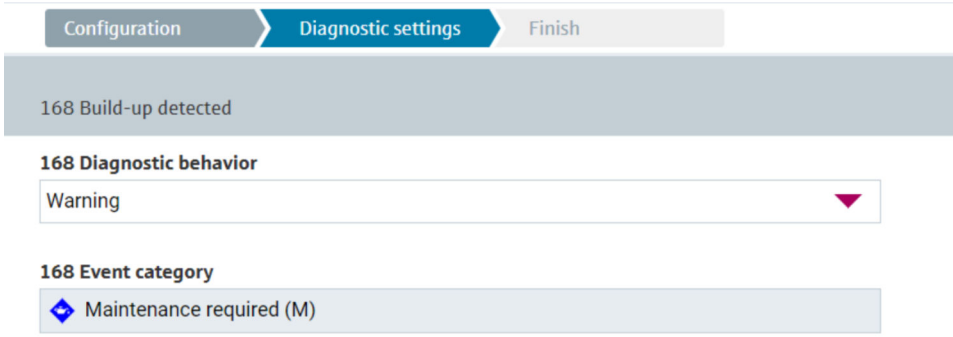
5.3.2 Build-up detection initialization

Guidance → Heartbeat Technology → Heartbeat Verification → Build-up detection

Build-up detection should only be initialized with little or no buildup.



5 *Screenshot - Values and entries provided as examples*



6 Screenshot - Values and entries provided as examples

" 168 Diagnostic behavior" parameter
Determines how the detected Build-up detection result is to be communicated:
- **Logbook entry only** option: Message not communicated via the fieldbus and display
- **Warning** option: Warning message is output via the fieldbus and display (Factory settings)
- **Alarm** option: Alarm message is output via the fieldbus and display

Once the permissible conditions are restored, the message is no longer available in the device and on the display.

www.addresses.endress.com

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