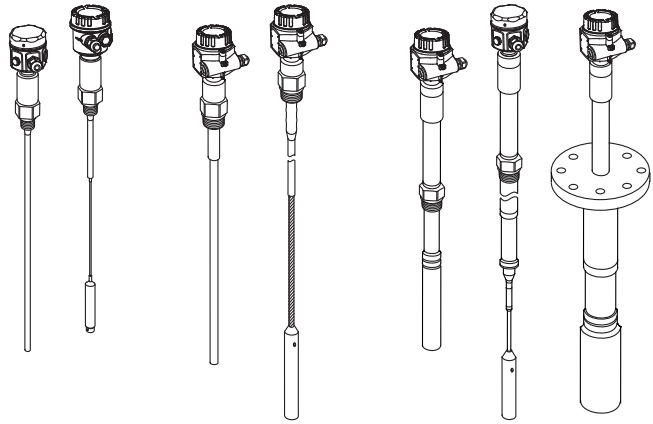
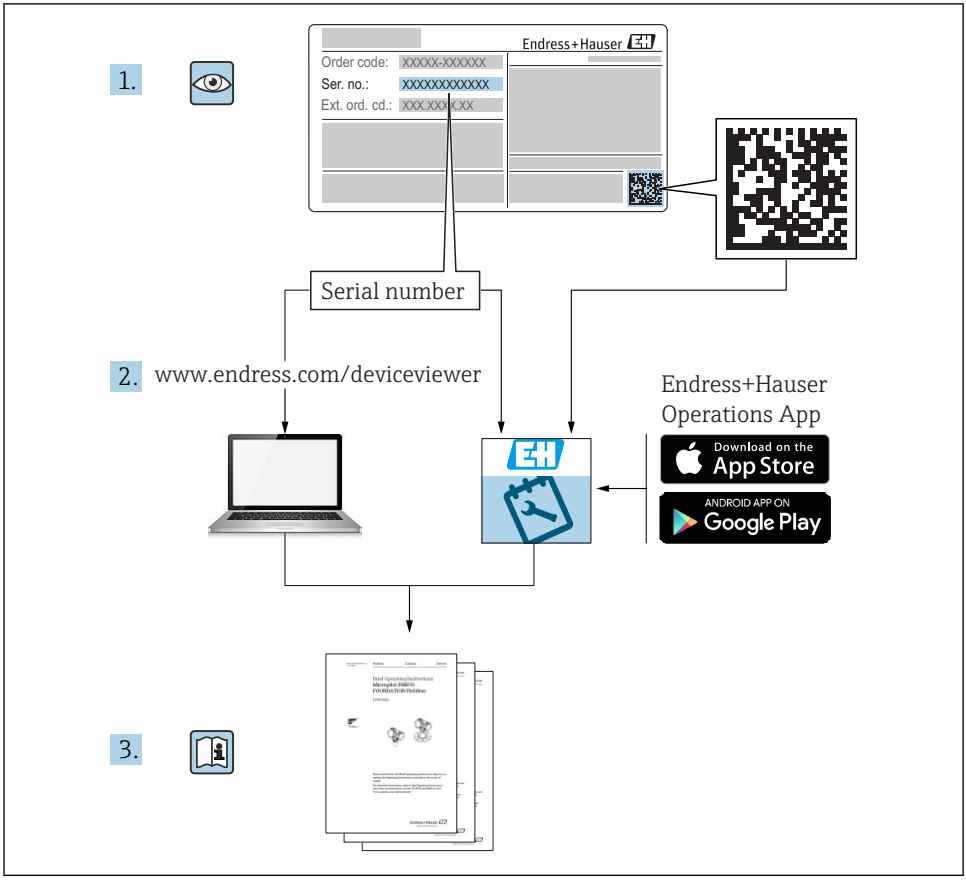
SD00278F/00/EN/14.20
71469961
2020-03-31

02.00.zz (Device firmware)

Special Documentation
Liquicap M FTI51/52; Solicap M FTI55/56; Solicap S FTI77

Capacitance level measurement for liquids




1.
Endress+Hauser
Order code: XXXXX-XXXXXX
Ser. no.: XXXXXXXXXXXX
Ext. ord. cd.: XXX.XXX-XXX
Serial number
2.
www.endress.com/deviceviewer
Endress+Hauser
Operations App
Download on the App Store
ANDROID APP ON Google Play
3.

A0023555

Table of contents

1 Declaration of Conformity

SIL_00344_02.20

Endress+Hauser
People for Process Automation

Declaration of Conformity

Functional Safety according to IEC 61508
Based on NE 130 Form B.1

Endress+Hauser SE+Co. KG, Hauptstraße 1, 79689 Maulburg

being the manufacturer, declares that the product

Liquicap M FTI51/52, Solicap M FTI55/56, Solicap S FTI77
+ electronic insert FEI55

is suitable for the use in safety-instrumented systems according to IEC 61508. The instructions of the corresponding functional safety manual must be followed.

This declaration of compliance is exclusively valid for the customer listed in the cover letter of the respective Endress+Hauser sales center and for the listed products and accessories in delivery status.

Maulburg, 5-February-2020
Endress+Hauser SE+Co. KG

i. V.
Manfred Hammer
Dept. Man. Technology
Quality Management / FSM
Research & Development

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A0041858

1.1 Safety-related characteristic values

SIL_00344_02.20

Endress+Hauser
People for Process Automation

General				
Device designation and permissible types	Liquicap M, Solicap M/S + electronic insert FEI55			
	VKM100 = F			
Safety-related output signal	8/16 mA			
Fault signal	≤ 3,6 mA ; ≥ 21 mA			
Process variable/function	Level switch for liquids or bulk solids			
Safety function(s)	Overfill protection or operating maximum/minimum detection*			
Device type acc. to IEC 61508-2	☐ Type A		☒ Type B	
Operating mode	☒ Low Demand Mode	☐ High Demand Mode	☐ Continuous Mode	
Valid hardware version	02.00.ww (ww: any double number)			
Valid software version	02.00.zz (zz: any double number)			
Safety manual	SD00278F			
Type of evalulation (check only one box)	☒	Complete HW/SW evaluation parallel to development incl. FMEDA and change request acc. to IEC 61508-2, 3		
	☐	Evaluation of "proven in use" performance for HW/SW incl. FMEDA and change request acc. to IEC 61508-2, 3		
	☐	Evaluation of HW/SW field data to verify „prior use" acc. to IEC 61511		
	☐	Evaluation by FMEDA acc. to IEC 61508-2 for devices w/o software		
Evaluation through – report/certificate no.	TÜV Nord Test Report 3525 9869 Registered 44 799 13761309			
Test documents	Development documents	Test reports	Data sheets	
SIL - Integrity				
Systematic safety integrity		☐ SIL 2 capable	☒ SIL 3 capable	
Hardware safety integrity	Single channel use (HFT = 0)	☒ SIL 2 capable	☐ SIL 3 capable	
	Multi channel use (HFT ≥ 1)	☐ SIL 2 capable	☒ SIL 3 capable	

FMEDA			
Safety function	MIN *	MAX	
λ_{DU} [1),2)]	45 FIT	36 FIT	
λ_{DD} [1),2)]	363 FIT	221 FIT	
λ_{SU} [1),2)]	68 FIT	103 FIT	
λ_{SD} [1),2)]	5 FIT	120 FIT	
SFF	91 %	93 %	
PFD_{avg} (T_1 = 1 year) [2)] (single channel architecture)	1.97×10^{-4}	1.58×10^{-4}	
λ_{total} [1,2)]	481 FIT	480 FIT	
Diagnostic test interval [4)]	2 min	2 min	
Fault reaction time [5)]	1 s	1 s	

Comments

* Minimum detection (MIN) only with fully insulated probe (VKM040 = 1)

Declaration

☒ Our internal company quality management system ensures information on safety-related systematic faults which become evident in the future

[1)] FIT = Failure In Time, number of failures per 10^9 h
[2)] Valid for average ambient temperature up to +40 °C (+104 °F)
For continuous operation at ambient temperature close to +60 °C (+140 °F), a factor of 2.1 should be applied
[3)] PTC = Proof Test Coverage
[4)] All diagnostic functions are performed at least once within the diagnostic test interval
[5)] Maximum time between error recognition and error response

2/2

A0041859

2 About this document

2.1 Document function

This supplementary Safety Manual applies in addition to the Operating Instructions, Technical Information and ATEX Safety Instructions. The supplementary device documentation must be observed during installation, commissioning and operation. The requirements specific to the protection function are described in this Safety Manual.

General information on functional safety (SIL) is available at:
- www.endress.com/SIL
- CP01008Z, Brochure "Functional Safety – SIL, Safety Instrumented Systems in the Process Industry"

2.2 Symbols used

2.2.1 Safety symbols

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

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

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

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

2.2.2 Symbols for certain types of information and graphics

Tip
Indicates additional information

Reference to documentation

Reference to graphic

▶
Notice or individual step to be observed

1., 2., 3.
Series of steps

Result of a step

1, 2, 3, ...
Item numbers

A, B, C, ...
Views

Hazardous area
Indicates the hazardous area

Safe area (non-hazardous area)
Indicates the non-hazardous area

2.3 Documentation

For an overview of the scope of the associated Technical Documentation, refer to the following:
- *W@M Device Viewer* (www.endress.com/deviceviewer): Enter the serial number from nameplate
- *Endress+Hauser Operations App*: Enter the serial number from the nameplate or scan the 2D matrix code (QR code) on the nameplate

The following documentation types are available in the Downloads section of the Endress+Hauser website (www.endress.com/downloads):

2.3.1 Further applicable documents

Liquicap M FTI51, FTI52
- TI00417F
- BA00299F

Solicap M FTI55, FTI56
- TI00418F
- BA00300F

Solicap S FTI77
- TI00433F
- BA00381F

2.3.2 Technical Information (TI)

Planning aid
The document contains all the technical data on the device and provides an overview of the accessories and other products that can be ordered for the device.

2.3.3 Brief Operating Instructions (KA)

Guide that takes you quickly to the 1st measured value
The Brief Operating Instructions contain all the essential information from incoming acceptance to initial commissioning.

2.3.4 Operating Instructions (BA)

Your reference guide
These Operating Instructions contain all the information that is required in various phases of the life cycle of the device: from product identification, incoming acceptance and storage, to

mounting, connection, operation and commissioning through to troubleshooting, maintenance and disposal.

2.3.5 Safety Instructions (XA)

Depending on the approval, the following Safety Instructions (XA) are supplied with the device. They are an integral part of the Operating Instructions.

The nameplate indicates the Safety Instructions (XA) that are relevant to the device.

3 Design

3.1 Permitted device types

The details pertaining to functional safety in this manual relate to the device versions listed below and are valid as of the specified firmware and hardware versions.

Unless otherwise specified, all subsequent versions can also be used for safety functions.

A modification process according to IEC 61508 is applied for device changes.

Valid device versions for safety-related use:

3.1.1 Order codes FTI51-

Feature: 010 "Approval"
Version: all

Feature: 020 "Inactive length L3"
Version: all

Feature: 030 "Active length L1; insulation"
Version: all

Feature: 040 "Insulation"
- 1; fully insulated
  For MIN and MAX safety
- 2; ...mm L2, partially insulated (must be at least 25 shorter than L1)
  For MAX safety
- 3; ...inch L2, partially insulated (must be at least 1 inch shorter than L1)
  For MAX safety

Feature: 050 "Process connection"
Version: all

Feature: 060 "Electronics; output"
Version: 5; FEI55; 8/16 mA, 11 to 36 V_{DC}

Feature: 070 "Housing"
Version: all

Feature: 080 "Cable entry"
Version: all

Feature: 090 "Probe design"
Version: 1; compact

Feature: 100 "Additional options"
Version: F; SIL Declaration of Conformity

Feature: 995 "Marking"
Version: all

3.1.2 Order codes FTI52-

Feature: 010 "Approval"
Version: all

Feature: 020 "Inactive length L3"
Version: all

Feature: 030 "Active length L1; insulation"
Version: all

Feature: 040 "Insulation"
Version: all

Feature: 050 "Process connection"
Version: all

Feature: 060 "Electronics; output"
Version: 5; FEI55; 8/16 mA, 11 to 36 V_{DC}

Feature: 070 "Housing"
Version: all

Feature: 080 "Cable entry"
Version: all

Feature: 090 "Probe design"
Version: 1; compact

Feature: 100 "Additional options"
Version: F; SIL Declaration of Conformity

Feature: 995 "Marking"
Version: all

3.1.3 Order codes FTI55-

Feature: 010 "Approval"
Version: all

Feature: 020 "Inactive length L3"
Version: all

Feature: 030 "Active length L1; insulation"
Version: all

Feature: 040 "Insulation"
- 1; fully insulated PE, max. 80 °C (175 °F)
  For MIN and MAX safety
- 2; 75 mm L2, partially insulated PPS max. 180 °C (Ex max. 150 °C (300 °F))
  For MAX safety
- 3; 3 in L2, partially insulated PPS max. 180 °C (Ex max. 150 °C (300 °F))
  For MAX safety

Feature: 050 "Process connection"
Version: all

Feature: 060 "Electronics; output"
Version: 5; FEI55; 8/16 mA, 11 to 36 V_{DC}

Feature: 070 "Housing"
Version: all

Feature: 080 "Cable entry"
Version: all

Feature: 090 "Probe design"
Version: 1; compact

Feature: 100 "Additional options"
Version: F; SIL Declaration of Conformity

Feature: 995 "Marking"
Version: all

3.1.4 Order codes FTI56-

Feature: 010 "Approval"
Version: all

Feature: 020 "Inactive length L3"
Version: all

Feature: 030 "Active length L1; tensioning weight"
- A, B, C, D
  L1 max. 10 000 mm
- H, K, M, N
  L1 max. 393 in

Feature: 040 "Cable insulation"
- 1; fully insulated PA, max. 120 °C (250 °F)
  For MIN and MAX safety
- 2; 500 mm L2, partially insulated PPS max. 180 °C (Ex max. 150 °C (300 °F))
  For MAX safety

Feature: 050 "Process connection"
Version: all

Feature: 060 "Electronics; output"
Version: 5; FEI55; 8/16 mA, 11 to 36 V_{DC}

Feature: 070 "Housing"
Version: all

Feature: 080 "Cable entry"
Version: all

Feature: 090 "Probe design"
Version: 1; compact

Feature: 100 "Additional options"
Version: F; SIL Declaration of Conformity

Feature: 995 "Marking"
Version: all

3.1.5 Order codes FTI77-

Feature: 010 "Approval"
Version: all

Feature: 015 "Application"
Version: all

Feature: 020 "Inactive length L3"
Version: all

Feature: 030 "Active length L1"
- CR, CS, DR, DS
  L1 max. 10 000 mm
- GR, GS, HR, HS
  L1 max. 393 in

Feature: 050 "Process connection"
Version: all

Feature: 060 "Electronics; output"
Version: 5; FEI55; 8/16 mA, 11 to 36 V_{DC}

Feature: 070 "Housing"
Version: all

Feature: 080 "Cable entry"
Version: all

Feature: 090 "Probe design"
Version: 1; compact

Feature: 100 "Additional options"
Version: F; SIL Declaration of Conformity

Feature: 995 "Marking"
Version: all

3.2 Identification marking

SIL-certified devices are marked with the SIL logo Ⓢ on the nameplate.

3.3 Safety function

The device's safety functions are:
- Minimum point level detection (dry running protection, MIN detection)
- Maximum point level detection (overfill prevention, MAX detection)

Activation of the safety function

For applications in liquids or bulk solids

▶ Lock the device after calibration

For examples of the measuring arrangement, see **Section 10.1 Structure of the measuring system**.

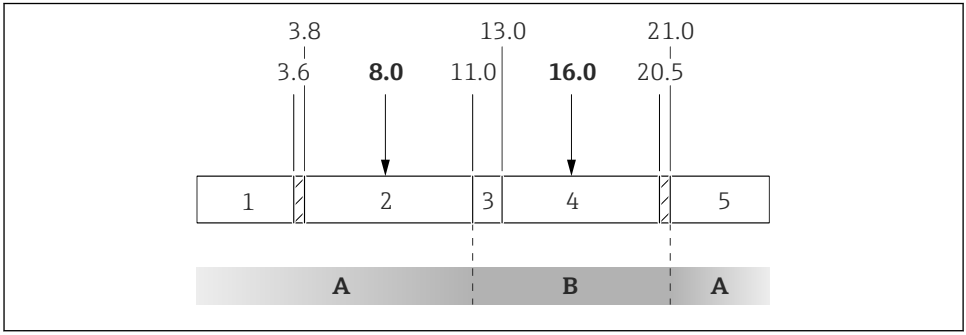
3.4 Basic conditions for use in safety-related applications

The measuring system must be used correctly for the specific application, taking into account the medium properties and ambient conditions. Carefully follow instructions pertaining to critical process situations and installation conditions from the Operating Instructions. The application-specific limits must be observed. The specifications in the Operating Instructions and the Technical Information must not be exceeded.

3.4.1 Safety-related signal

The safety-related signal is the switch signal: 8/16 mA. All safety measures refer to this output exclusively.

3.4.2 Current output



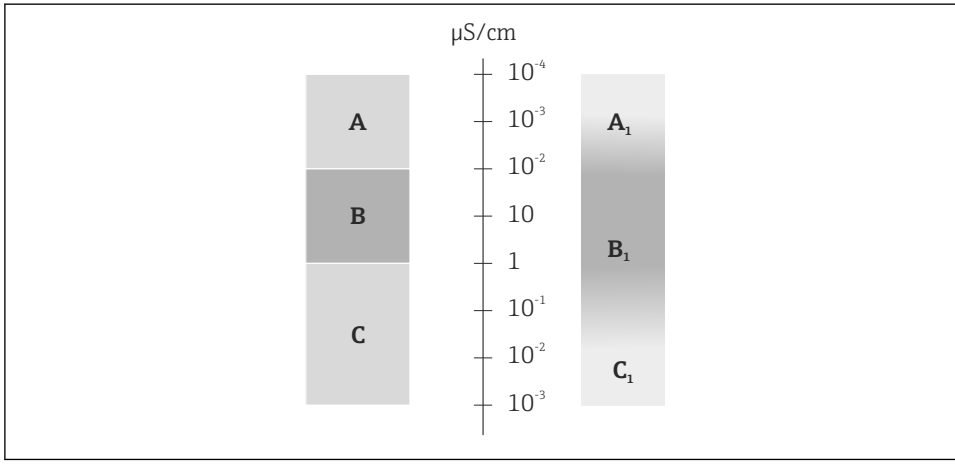
A0026320

1 Engineering unit: mA

A Safe state
B Potentially dangerous range
1 Signal on alarm, lower current range (NE43)
2 Demand mode (nominal)
3 Switching range of the isolation amplifier to be guaranteed (12 ±1 mA)
4 Good state (nominal)
5 Signal on alarm, upper current range (NE43)

3.4.3 Restrictions for use in safety-related applications

The following restrictions also apply to safety-related use:
- In the event of the buildup of conductive deposits, observe the commissioning measures.
- Heavy buildup (≥100 g/m) is not permitted in applications with vibrations/oscillations.
- Check the resistance of parts in contact with the medium with regard to corrosion and diffusion.
- Only compact versions are permitted.
  Separate versions are not permitted due to the additional cable capacitance.
- Overview of the permitted device types and device versions for the MIN or MAX safety modes.
- The relative dielectric constant ε_r (relative permittivity) of the medium must be ≥2.5 or the change in capacitance between empty and full calibration must be ≥10 pF.



2 *Conductivity [µS/cm]*

A *The accuracy is independent of the conductivity and the ε_r*

A_1 *Examples: Water-based liquids, aqueous solutions of salts, acids, alkalis, aqueous dispersions and emulsions, wastewater, electrolytes, beverages*

B *The accuracy depends on the ε_r and the conductivity of the medium. Measurement not recommended, therefore select another measuring principle*

B_1 *Example: Hydrocarbons with higher water content, demineralized water*

C *The accuracy depends on the ε_r*

C_1 *Example: Hydrocarbons with water content below 0.1 %, petroleums, oils, solvents*

Dangerous undetected failures in this scenario

An incorrect output signal that deviates from the real measured value by more than 2 %, but is still at 8 mA, or at 16 mA depending on the configuration, is considered a dangerous, undetected failure.

3.4.4 Notes on the redundant use of multiple sensors for SIL 3

This section provides additional information regarding the use of homogeneously redundant sensors e.g. in a 1oo2 or 2oo3 architecture.

The device meets the requirements for SIL 3 in homogeneously redundant applications. The following common cause factors β and β_D can be used for the design.
- β for homogeneously redundant use: 5 %
- β_D for homogeneously redundant use: 2%

The system-specific analysis can produce other values depending on the specific installation and use of additional components.

3.5 Useful lifetime of electric components

The established failure rates of electrical components apply within the useful lifetime as per IEC 61508-2:2010 section 7.4.9.5 note 3.

According to DIN EN 61508-2:2011 section 7.4.9.5 (national footnote N3) appropriate measures taken by the operator can extend the useful lifetime.

4 Commissioning (installation and configuration)

4.1 Requirements for personnel

The personnel for installation, commissioning, diagnostics and maintenance must fulfill the following requirements:
- ▶ Trained, qualified specialists must have a relevant qualification for this specific function and task.
- ▶ Personnel must be authorized by the plant owner/operator.
- ▶ Be familiar with federal/national regulations.
- ▶ Before starting work: personnel must read and understand the instructions in the manual and supplementary documentation as well as the certificates (depending on the application).
- ▶ Personnel must follow instructions and comply with general policies.

The operating personnel must fulfill the following requirements:
- ▶ Personnel are instructed and authorized according to the requirements of the task by the facility's owner-operator.
- ▶ Personnel follow the instructions in this manual.

4.2 Installation

The mounting and wiring of the device and the permitted orientations are described in the Operating Instructions pertaining to the device.

4.3 Commissioning

The device is commissioned using the Commissioning Wizard. The commissioning procedure is described in the Operating Instructions pertaining to the device.

Prior to operating the device in a safety instrumented system, verification must be performed by carrying out a test sequence as described in **Section 6 Proof testing**.

4.4 Operation

The operation of the device is described in the Operating Instructions pertaining to the device.

4.5 Parameter configuration for safety-related applications

4.5.1 Adjustment of the measuring point

The adjustment of the measuring point is described in the relevant Operating Instructions.

4.5.2 Configuration methods

The configuration of the device is described in the relevant Operating Instructions.

1. Carry out the device configuration as described in the Operating Instructions
2. On completion of the configuration, set the device to the SIL mode
   ↳ The device is locked automatically
3. Perform a proof test after every new configuration

Unlocking a SIL device

The procedure for unlocking the device is described in the relevant Operating Instructions.

5 Operation

5.1 Device behavior during power-up

The behavior of the device when switched on is described in the relevant Operating Instructions.

5.2 Device behavior in safety function demand mode

The behavior of the device in safety function demand mode is described in the relevant Operating Instructions.

5.3 Behavior of device in the event of an alarm and warnings

5.3.1 Failure current

The failure current is permanently set to a value of ≤3.6 mA.

In some cases (e.g. signal cable short-circuit) in which it is not possible to set the failure current ≤3.6 mA, the signal on alarm "Upper current range (NE43)" is output.

5.4 Alarm and warning messages

In addition, an LED flashes red cyclically to signal an error.

This signaling system provides additional diagnostic information and is not part of the safety-related output signal.

6 Proof testing

The functional integrity of the device in the SIL mode must be verified during commissioning, when changes are made to safety-related parameters, as well as at appropriate time intervals. The operator must determine the time intervals.

⚠ CAUTION

The safety function is not guaranteed during a proof test.

- ▶ Suitable measures must be taken to guarantee process safety during the test.

The individual proof test coverages (PTC) that can be used for calculation are specified for the proof tests described below.

Proof testing of the device can be performed as follows:

- Approach the level in the original vessel (test sequence A)
- Remove the device and immerse it in a medium with comparable properties (test sequence B)
- Device self-test and level simulation (test sequence C)
  No change of level in the vessel is necessary for this sequence.

Note the following for the test sequences:

- Test sequence C is not permitted for a commissioning test.
- The transmitter can be tested without a sensor using an appropriate sensor simulator (resistance decade, reference voltage source, etc.)
- The accuracy of the measuring device used must meet the transmitter specifications.
- If both transmitter input channels are used, the test for the second sensor must be repeated accordingly.
- A three-point calibration must be performed when customized linearization (e.g. with CvD coefficients) is used. In addition, the Upper sensor limit and Lower sensor limit must be checked.

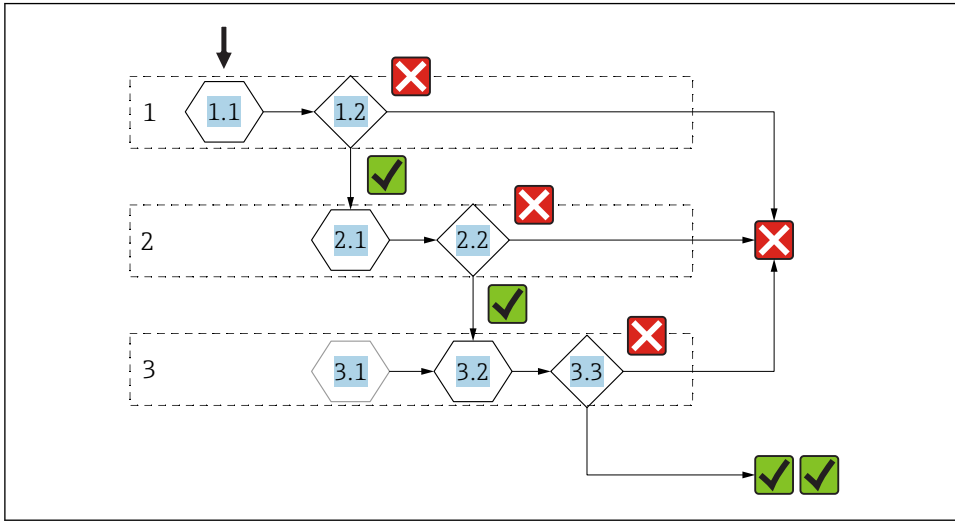
Recommendation: Check the probe rod for bending and other signs of substantial application of force!

NOTICE

Ensuring correct device sealing!

- ▶ You must also check and ensure that all cover seals and cable entries are sealing correctly.

6.1 Basic test sequence



3 *Basic test sequence*

1.1 Status OK
1.2 Output signal for status OK?
2.1 Establish demand mode
2.2 Output signal for demand mode?
3.1 Re-install the sensor that was removed (optional)
3.2 Establish status OK
3.3 Output signal for status OK?

6.2 Test sequence A, MIN detection

Approach the level

Preparation

1. Connect a suitable device to the current output (recommended accuracy more than ±0.1 mA).
2. Determine point level detection (see appropriate Operating Instructions).

Step 1

▶ Check the current at terminal 1.
↳ The current must be between 15.2 to 16.8 mA.

If the current is outside the specified tolerance, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Step 2

1. Lower the level so that the demand mode is expected.
2. Check the current at terminal 1.
   ↳ After a response time of approx. 0.3 to 5 s, the current must be between 7.5 to 8.5 mA.

If the current is outside the specified tolerance, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Step 3

1. Raise the level so that the good state is expected.
2. Check the current at terminal 1.
   ↳ After a response time of approx. 0.3 to 5 s, the current must be between 15.2 to 16.8 mA.

If the current is outside the specified tolerance, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

6.3 Test sequence A, MAX detection

Approach the level

Preparation

1. Connect a suitable device to the current output (recommended accuracy more than ±0.1 mA).
2. Determine point level detection (see appropriate Operating Instructions).

Step 1

- ▶ Check the current at terminal 1.
  ↳ The current must be between 15.2 to 16.8 mA.

If the current is outside the specified tolerance, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Step 2

1. Raise the level so that the demand mode is expected.
2. Check the current at terminal 1.
   ↳ After a response time of approx. 0.3 to 5 s, the current must be between 7.5 to 8.5 mA.

If the current is outside the specified tolerance, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Step 3

1. Lower the level so that the good state is expected.
2. Check the current at terminal 1.
   ↳ After a response time of approx. 0.3 to 5 s, the current must be between 15.2 to 16.8 mA.

If the current is outside the specified tolerance, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

6.4 Test sequence B, MIN detection

Remove and immerse in a medium of identical conductivity or dielectric constant

Preparation

1. Prepare a test vessel with a medium (conductivity ≥100 µS/cm) and a suitable counterelectrode. For installation instructions, refer to the Operating Instructions).
2. Remove the device and mount it in the test vessel. Connect the functional ground!
3. Connect a suitable device to the current output (recommended accuracy more than ±0.1 mA).
4. Determine point level detection (MIN or MAX safety, see appropriate Operating Instructions).

Step 1

1. If necessary, raise the level so that the good state is expected.
2. Check the current at terminal 1.
   ↳ After a response time of approx. 0.3 to 5 s, the current must be between 15.2 to 16.8 mA.

If the current is outside the specified tolerance, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Step 2

1. Raise the level so that the demand mode is expected.
2. Check the current at terminal 1.
   ↳ After a response time of approx. 0.3 to 5 s, the current must be between 7.5 to 8.5 mA.

If the current is outside the specified tolerance, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Step 3

1. Lower the level so that the good state is expected.

2. Check the current at terminal 1.
   ↳ After a response time of approx. 0.3 to 5 s, the current must be between 15.2 to 16.8 mA.

If the current is outside the specified tolerance, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

6.5 Test sequence B, MAX detection

Remove and immerse in a medium of identical conductivity or dielectric constant

Preparation

1. Prepare a test vessel with a medium (conductivity ≥100 µS/cm) and a suitable counterelectrode. For installation instructions, refer to the Operating Instructions).
2. Remove the device and mount it in the test vessel. Connect the functional ground!
3. Connect a suitable device to the current output (recommended accuracy more than ±0.1 mA).
4. Determine point level detection (MIN or MAX safety, see appropriate Operating Instructions).

Step 1

1. Lower the level if necessary so that the good state is expected.
2. Check the current at terminal 1.
   ↳ After a response time of approx. 0.3 to 5 s, the current must be between 15.2 to 16.8 mA.

If the current is outside the specified tolerance, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Step 2

1. Raise the level so that the demand mode is expected.
2. Check the current at terminal 1.
   ↳ After a response time of approx. 0.3 to 5 s, the current must be between 7.5 to 8.5 mA.

If the current is outside the specified tolerance, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Step 3

1. Lower the level so that the good state is expected.

2. Check the current at terminal 1.
   ↳ After a response time of approx. 0.3 to 5 s, the current must be between 15.2 to 16.8 mA.

If the current is outside the specified tolerance, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

6.6 Test sequence C, MIN and MAX detection

Preparation

1. Connect a suitable device to the current output (recommended accuracy more than ±0.1 mA).
2. Determine point level detection (MIN or MAX safety, see appropriate Operating Instructions).

Step 1

▶ Check the current at terminal 1.
   ↳ The current must be between 15.2 to 16.8 mA.

If the current is outside the specified tolerance, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Step 2

1. Turn the function switch to position 6. Then press the "-" and "+" keys simultaneously for 2 seconds. When LED 5 starts flashing, this indicates that proof testing has commenced.
2. Check the current at terminal 1.
   ↳ After 10 s (plus a response time of approx. 10 s), the current must be between 7.5 to 8.5 mA

If the current is outside the specified tolerance, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

Step 3

1. Turn the function switch back to position 1.
2. Check the current at terminal 1.
   ↳ After a response time of approx. 0.3 to 5 s, the current must be between 15.2 to 16.8 mA.

If the current is outside the specified tolerance, a fault has occurred in the safety path. The proof test has not been passed and must be aborted.

This test sequence does not test the probe rod and the electrical coupling of the probe. Take a proof test coverage of 35 % into consideration.

6.7 Verification criterion

If one of the test criteria from the test sequences described above is not fulfilled, the device may no longer be used as part of a safety instrumented system.

- The purpose of proof-testing is to detect dangerous undetected device failures (λ_{DU}).
- This test does not cover the impact of systematic faults on the safety function, which must be assessed separately.
- Systematic faults can be caused, for example, by process material properties, operating conditions, build-up or corrosion.
- As part of the visual inspection, for example, ensure that all of the seals and cable entries provide adequate sealing and that the device is not visibly damaged.

7 Maintenance

Maintenance instructions and instructions regarding recalibration may be found in the Operating Instructions pertaining to the device.

Alternative monitoring measures must be taken to ensure process safety during configuration, proof-testing and maintenance work on the device.

8 Repair

Repair means restoring functional integrity by replacing defective components.

Components may be repaired/replaced by the customer's technical staff if **genuine spare parts** from Endress+Hauser are used (they can be ordered by the end user) and the appropriate installation instructions are followed.

A proof test must always be performed after every repair

Spare parts are grouped into logical kits with the associated replacement instructions.

Document the repair with the following information:

- Serial number of the device
- Date of the repair
- Type of repair
- Person who performed the repair

Installation Instructions are supplied with the orginal spare part and can also be accessed in the Download Area at www.endress.com

Return the replaced component to Endress+Hauser for fault analysis.

When returning the defective component, always enclose the "Declaration of Hazardous Material and Decontamination" with the note "Used as SIL device in a safety instrumented system.

For information on device returns, please see:
http://www.endress.com/support/return-material

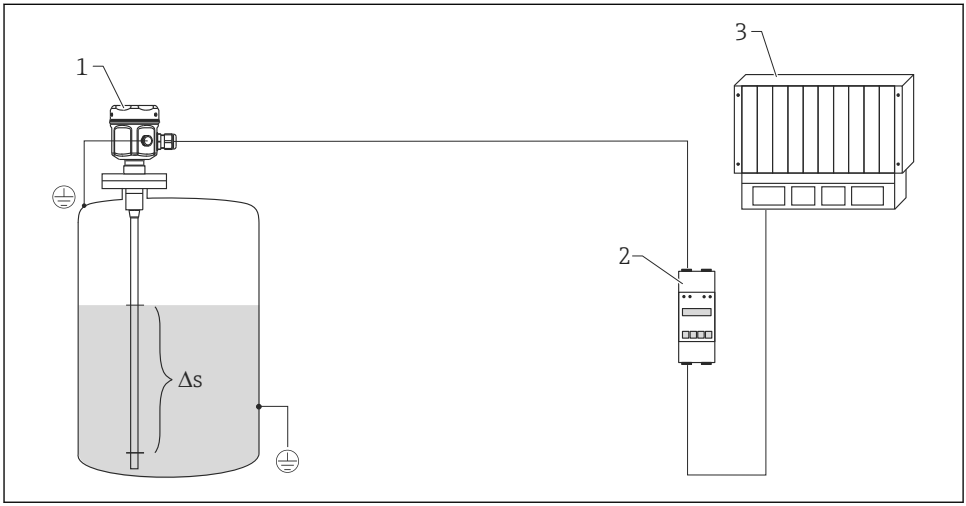
9 Disposal

If required by the Directive 2012/19/EU on waste electrical and electronic equipment (WEEE), our products are marked with the depicted symbol in order to minimize the disposal of WEEE as unsorted municipal waste. Such products may not be disposed of as unsorted municipal waste and can be returned to Endress+Hauser for disposal at conditions stipulated in our General Terms and Conditions or as individually agreed.

10 Appendix

10.1 Structure of the measuring system

10.1.1 System components



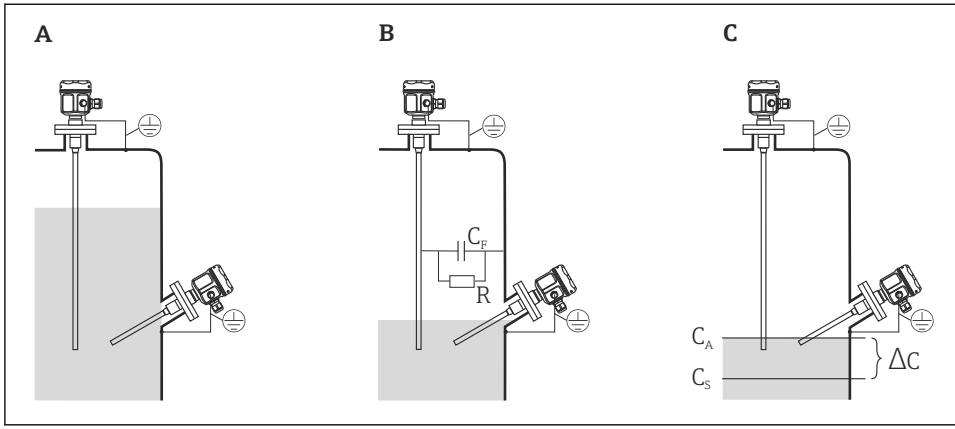
4 *Example: remote operation via HART protocol*

1 Liquicap M, Solicap M, Solicap S with electronic insert FEI55
2 Active barrier (optional)
3 PLC (or similar)

A switch signal (8/16 mA) that depends on the level is generated in the transmitter. This signal is sent to a downstream logic unit (e.g. PLC, limit signal transmitter, etc.) where it is monitored to determine whether it is below or above a specified limit value.

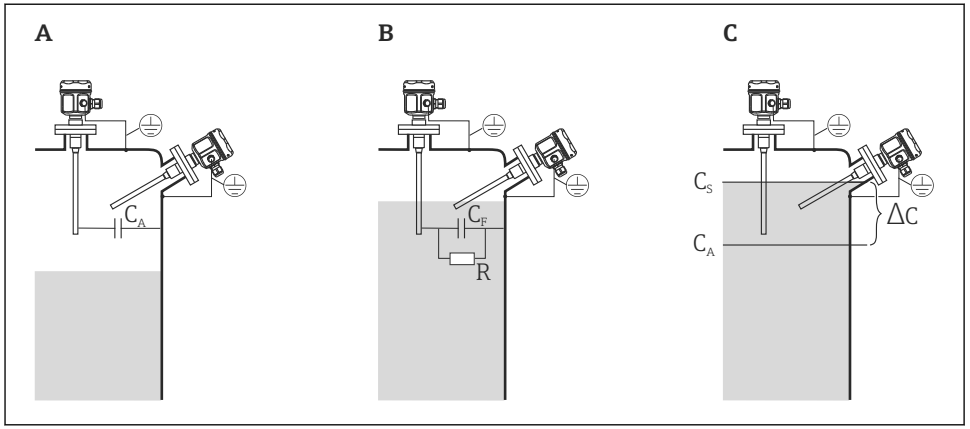
For fault monitoring, the logic unit must recognize both high alarms (≥ 21 mA) and low alarms (≤ 3.6 mA).

10.1.2 Description of application as a safety instrumented system



5 Typical measuring arrangement for minimum point level detection in safety instrumented systems

A Covered
B Covered (switch point not yet reached)
C Free (switch point reached)
R Conductivity of bulk solids
C_F Capacitance of bulk solids
C_A Initial capacitance (probe covered)
C_S Switching capacitance
ΔC Change in capacitance



6 *Typical measuring arrangement for maximum point level detection in safety instrumented systems*

A Free
B Covered (switch point not yet reached)
C Covered (switch point reached)
R Conductivity of bulk solids
C_F Capacitance of bulk solids
C_A Initial capacitance (probe free)
C_S Switching capacitance
ΔC Change in capacitance

The installation conditions for various measurements are described in the Technical Information for the device.

Correct installation is a prerequisite for safe operation of the device.

Measurement function

The principle of capacitance point level detection is based on the change in capacitance of a capacitor as a result of the probe being covered by bulk solids or liquid. The probe and vessel wall (conductive material) form an electric capacitor. When the probe is in air, a certain low initial capacitance is measured. When the vessel is filled, the capacitance of the capacitor increases as more of the probe is covered.

The limit switch switches when the switching capacitance specified in the calibration:
- is undershot in the minimum detection mode
- is exceeded in the maximum detection mode

10.2 Commissioning or proof test report

The following device-specific test report acts as a print/master template and can be replaced or supplemented any time by the SmartBlue app or the customer's own SIL reporting and testing system.

10.2.1 Test Report - Page 1 -

Device information
Facility
Measuring points/TAG No.
Device type/order code
Serial number

Verification information
Date/time
Performed by

Verification result	
Overall result	
☐ Passed	☐ Failed

Comments

Company/contact person
Tester

Date Signature Signature of tester

10.2.2 Test Report - Page 2 -

Device information
Facility
Measuring points/TAG No.
Serial number

Safety function - operation mode	
☐ MIN detection	☐ MAX detection

Commissioning parameters
Test medium, conductivity and ε_r if necessary
Measuring range [pF]
Switching delay [s]
Empty/full calibration
Switchpoint adjustment [pF]

Commissioning or proof testing
☐ Test sequence A, MIN detection
☐ Test sequence A, MAX detection
☐ Test sequence B, MIN detection
☐ Test sequence B, MAX detection
☐ Test sequence C, simulation with "Self-test" function switch

Terminal 1, check current				
Test step	**Target**	**Actual value**	**Result** ☑	☒
Step 1	15.2 to 16.8 mA			
Step 2	7.5 to 8.5 mA			
Step 3	15.2 to 16.8 mA			

10.3 Version history

SD00278F
- Version: 10.08
- Valid as of firmware version:
  "02.00.00"
- Valid as of hardware version:
  "02.00"
- Changes:
  First version

SD00278F
- Version: 13.15
- Valid as of firmware version:
  "02.00.00"
- Valid as of hardware version:
  "02.00"
- Changes:
  "Proof testing" section added

SD00278F
- Version: 14.20
- Valid as of firmware version:
  "02.00.00"
- Valid as of hardware version:
  "02.00"
- Changes:
  Certificate update, Declaration of Conformity adapted to new certificate, changes to structure

www.addresses.endress.com

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