SD01729D/06/EN/11.25-00
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Special Documentation
Proline Promass 500

Functional Safety Manual
HART

Endress+Hauser
People for Process Automation

Table of contents

1 Manufacturer declaration

Products Solutions Services

HE_61508_Promass_300_500_de_en_V2018.docx

Herstellererklärung - Manufacturer Declaration Funktionale Sicherheit / Functional Safety (IEC 61508)

Endress+Hauser Flowtec AG, Kägenstrasse 7, 4153 Reinach

erklärt als Hersteller, dass die Durchflussmessgeräte aus der Serie
declares as a manufacturer, that the flow meters of the product line

Proline Promass 300 (8a3b)
Proline Promass 500 (8a5b)
Proline Cubemass 300 (8C3b)
Proline Cubemass 500 (8C5b)

a = A, E, F, H, I, O, P, Q, S, X
b = B, C

in sicherheitsrelevanten Anwendungen SIL 2 (HFT=0) bzw. SIL 3 (HFT=1) nach IEC 61508:2010 eingesetzt werden können.
are suitable for use in safety relevant applications up to SIL 2 (HFT=0) resp. SIL 3 (HFT=1) acc. IEC 61508:2010.

Für einen Einsatz in sicherheitsrelevanten Anwendungen entsprechend IEC 61508 sind die Angaben des Handbuches zur Funktionalen Sicherheit zu beachten. Die Installation muß konform zu diesem Handbuch ausgeführt werden und die Sicherheitshinweise sind zu beachten.
For safety relevant applications according to IEC 61508, we refer to our hand-book named functional safety. The installation has to be conform to our descriptions in our handbook in consideration of our safety instructions.

Die Kenngrößen für die Verwendung des Produktes in sicherheitsrelevanten Anwendungen können dem Handbuch zur Funktionalen Sicherheit entnommen werden.
The characteristics for use of these products in safety relevant applications can be found in the functional safety manual.

Reinach, 29. Juni 2018

Endress+Hauser Flowtec AG

ppa.
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Head of Division Quality Management

i.V.
Dipl.-Ing. Michael Karolzak
Senior Expert Functional Safety

Endress+Hauser
People for Process Automation

A0037141-EN

1.1 Safety-related characteristic values

General	
Device designation and permitted versions	8A5B (Promass A 500) 8A5C (Promass A 500) 8E5B (Promass E 500) 8F5B (Promass F 500) 8H5B (Promass H 500) 8I5B (Promass I 500) 8O5B (Promass O 500) 8P5B (Promass P 500) 8Q5B (Promass Q 500) 8S5B (Promass S 500) 8X5B (Promass X 500)
	Order code for "Output; input 1": ▪ Option BA "4–20 mA HART" ▪ Option BB "4–20 mA + Wireless HART" ▪ Option CA "4–20 mA HART Ex-i passive" ▪ Option CB "4–20 mA Ex-i + Wireless HART" ▪ Option CC "4-20mA HART Ex-i active" Order code for "Output; input 2": All options Order code for "Output; input 3": All options Order code for "Output; input 4": All options Order code for "Additional approval": Option LA "SIL"
Safety-related output signal	4 to 20 mA (output; input 1)
Fault current	≤ 3.6 mA or ≥ 21 mA
Assessed measured variable/ function	Monitoring of mass flow, volume flow or density
Safety function(s)	Min., Max., Range
Device type according to IEC 61508-2	☐ Type A ☑ Type B
Mode of operation	☑ Low Demand Mode ☑ High Demand Mode ☐ Continuous Mode [1)]
Valid hardware version (main electronics)	From delivery date October 1, 2017
Valid firmware version	01.01.zz and higher (HART; from delivery date October 1, 2017)
Safety manual	SD01729D
Type of assessment (only 1 version can be selected)	☑ Complete HW/SW assessment in the context of development including FMEDA and change process according to IEC 61508-2, 3
	☐ Assessment of evidence for proven-in-use HW/SW including FMEDA and change process according to IEC 61508-2, 3

	☐ Analysis of HW/SW field data for evidence of "prior use" according to IEC 61511
	☐ Assessment by FMEDA according to IEC 61508-2 for devices without software
Evaluation by	TÜV SÜD
Test documents	Development documents, test reports, data sheets

1) No continuous mode according to IEC 61508: 2011 (section 3.5.16)

SIL integrity			
Systematic safety integrity		☐ SIL 2 capability	☑ SIL 3 capability
Hardware safety integrity	Single-channel service (HFT = 0)	☑ SIL 2 capability	☐ SIL 3 capability
	Multi-channel service (HFT ≥ 1)	☐ SIL 2 capability	☑ SIL 3 capability

FMEDA [1)]		
Safety function(s)	Min., Max., Range	
Meter Model	**A2**	
	Option BA, BB	Option CA, CB, CC
λ_{DU} [2)]	140 FIT	141 FIT
λ_{DD} [2)]	2354 FIT	2326 FIT
λ_{SU} [2)]	1236 FIT	1201 FIT
λ_{SD} [2)]	2118 FIT	2148 FIT
SFF – Safe Failure Fraction	97.6%	
PFD_{avg} for T_1 = 1 year [3)] (single-channel architecture)	$6.20 \cdot 10^{-4}$	
PFD_{avg} for T_1 = 4 years [3)] (single-channel architecture)	$2.50 \cdot 10^{-3}$	
PFH	$1.40 \cdot 10^{-7}$	
PTC [4)]	Up to 99%	
$MTBF_{tot}$ [5)]	47 years	48 years
Diagnostic test interval [6)]	30 min	

Fault response time [7]	30 s
Recommended test interval T_1	4 years

1) Promass Q ≥ DN 150 → 🖹 7
2) FIT = Failure In Time, number of failures per 10^9 h
3) Valid for averaged ambient temperatures up to 40 °C (104 °F) in accordance with the general standard for devices with SIL capability.
4) PTC = Proof Test Coverage (diagnostic coverage achieved by device failure detection during manual proof testing)
5) This value takes into account all failure types of the electronic components as per Siemens SN29500
6) All diagnostic functions are executed at least once during this time.
7) Maximum time between fault detection and fault response.

FMEDA (Promass Q ≥ DN 150)		
Safety function(s)	Min., Max., Range	
Meter Model	**A2**	
	Option BA, BB	Option CA, CB, CC
λ_{DU} [1]	163	160
λ_{DD} [1]	2595	2640
λ_{SU} [1]	1463	1652
λ_{SD} [1]	2309	2305
SFF – Safe Failure Fraction	97.5 %	
PFD_{avg} for T_1 = 1 year [2] (single-channel architecture)	$7.13 \cdot 10^{-4}$	$7.00 \cdot 10^{-4}$
PFD_{avg} for T_1 = 4 years [2] (single-channel architecture)	$2.85 \cdot 10^{-3}$	$2.80 \cdot 10^{-3}$
PFH	$1.63 \cdot 10^{-7}$	$1.60 \cdot 10^{-7}$
PTC [3]	Up to 99%	
$MTBF_{tot}$ [4]	45 years	40 years
Diagnostic test interval [5]	30 min	
Fault response time [6]	30 s	
Recommended test interval T_1	3 years	

1) FIT = Failure In Time, number of failures per 10^9 h
2) Valid for averaged ambient temperatures up to 40 °C (104 °F) in accordance with the general standard for devices with SIL capability.
3) PTC = Proof Test Coverage (diagnostic coverage achieved by device failure detection during manual proof testing)
4) This value takes into account all failure types of the electronic components as per Siemens SN29500
5) All diagnostic functions are executed at least once during this time.
6) Maximum time between fault detection and fault response.

Note
The measuring instrument has been developed for use in "Low Demand" and "High Demand" mode.

Explanation
☑Our in-house quality management system saves information on safety-related systematic errors that will become known in the future.

2 Certificate

Certificate can be accessed at www.endress.com:

1. Downloads
2. Approvals
3. Type: Functional safety (SIL)
4. Product root: e.g. 8F3B
5. Press the "Search" button

3 About this document

3.1 Document function

This document is part of the Operating Instructions and serves as a reference for application-specific parameters and notes.

General information about functional safety **SIL** is available in the Download Area of the Endress+Hauser website: www.endress.com/SIL.

3.2 Using this document

3.2.1 Information on the document structure

For more information on the arrangment of the parameters, along with a short description, according to the **Operation** menu, **Setup** menu, **Diagnostics** menu and the operating concept: see the Operating Instructions.

3.3 Symbols

3.3.1 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 potentially dangerous situation. Failure to avoid this situation can result in serious or fatal injury.

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

NOTICE
This symbol alerts you to a potentially harmful situation. Failure to avoid this situation can result in damage to the product or something in its vicinity.

3.3.2 Symbols for certain types of information

Symbol	Meaning
	**Permitted** Procedures, processes or actions that are permitted.
	**Preferred** Procedures, processes or actions that are preferred.
	**Forbidden** Procedures, processes or actions that are forbidden.
	**Tip** Indicates additional information.
	Reference to documentation
	Reference to page
	Reference to graphic
	Notice or individual step to be observed
1., 2., 3...	Series of steps
	Result of an individual step
 A0028662	Operation via local display
 A0028663	Operation via operating tool
 A0028665	Write-protected parameter

3.3.3 Symbols in graphics

Symbol	Meaning
1, 2, 3 ...	Item numbers
A, B, C, ...	Views
A-A, B-B, C-C, ...	Sections

3.4 Further applicable 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.

This Special Documentation and other documentation is available:
In the Download Area of the Endress+Hauser Internet site: www.endress.com → Downloads

This documentation is an integral part of the following Operating Instructions:

Measuring instrument	Documentation code
Promass A 500 (8A5B**-...)	BA01526D
Promass A 500 (8A5C**-...)	BA01817D
Promass E 500	BA01528D
Promass F 500	BA01529D
Promass H 500	BA01530D
Promass I 500	BA01531D
Promass O 500	BA01532D
Promass P 500	BA01533D
Promass Q 500	BA01534D
Promass S 500	BA01535D
Promass X 500	BA01536D

3.5 Change history

Version	Changes	Valid as of firmware version
SD01729D/06/xx/11.25	Meter Model "A2"; Meter Model "A1" deleted, structural adjustments, modifications of content	01.06.zz (HART; from delivery date August 2, 2022)
SD01729D/06/xx/10.23	Minor corrections	01.06.zz (HART; from delivery date August 2, 2022)
SD01729D/06/xx/09.22	Promass Q amended, new nominal diameters DN 150, 200, 250	01.06.zz (HART; from delivery date August 2, 2022)
SD01729D/06/xx/08.20	Addition, Device Model A1/A2 & option CC (4 to 20 mA HART Ex-i active)	01.05.zz (HART; from delivery date September 16, 2019)
SD01729D/06/xx/05.18	Proof test modified.	01.01.zz (HART; from delivery date October 1, 2017)

Version	Changes	Valid as of firmware version
SD01729D/06/xx/04.18	Amendment concerning 8A5C (new sensor generation A)	01.01.zz (HART; from delivery date October 1, 2017)
SD01729D/06/xx/02.17	Changes: Operating Instructions for the device	01.01.zz (HART; from delivery date October 1, 2017)
SD01729D/06/xx/01.16	First version	01.00.zz (HART; from delivery date August 2, 2016)

4 Design

4.1 Permitted device types

The information on functional safety contained in this manual relates to the device versions listed below and are valid as of the specified software and hardware version.

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

A modification process according to IEC 61508:2010 is applied for any device modifications.

Any exemptions from possible combinations of features are saved in the Endress+Hauser ordering system.

Valid device versions for safety-related use:

4.1.1 Order codes

Feature	Designation	Option selected
–	Order code	8A5B (Promass A 500) 8A5C (Promass A 500) 8E5B (Promass E 500) 8F5B (Promass F 500) 8H5B (Promass H 500) 8I5B (Promass I 500) 8O5B (Promass O 500) 8P5B (Promass P 500) 8Q5B (Promass Q 500) 8S5B (Promass S 500) 8X5B (Promass X 500)
000	Nominal diameter	All
010	Approval; transmitter; sensor	All
015	Power supply	All
020	Output; input 1 [1)]	▪ Option BA "4–20 mA HART" ▪ Option BB "4–20 mA + Wireless HART" ▪ Option CA "4–20 mA HART Ex-i passive" ▪ Option CB "4~20 mA Ex-i + Wireless HART" ▪ Option CC "4–20 mA HART Ex-i active"
021	Output; input 2	All

Feature	Designation	Option selected
022	Output; input 3	All
023	Output; input 4	All
030	Display; operation	All
035	Integrated ISEM electronics	All
041	Transmitter housing	All
042	Sensor connection housing	All
045	Cable, sensor connection	All
050	Electrical connection	All
060	Measuring tube mat., wetted surface	All
070	Process connection	All
080	Calibration flow	All
480	Meter Model	A2
500	Display operating language	All
520	Sensor option	All
530	Customized parameter configuration	All
540	Application package	All
550 [2)]	Suitability for custody transfer measurement	None
570	Service	All
580	Test, certificate	All
590	Additional approval	LA (= SIL) [3)]
610	Accessory mounted	All
620	Accessory enclosed	All
850	Firmware version	Firmware with SIL capability, e.g. 01.05.zz (HART)
895	Identification	All

1) In devices with several outputs, only current output 1 (terminals 26 and 27) is suitable for safety functions. The other outputs can, if necessary, be connected for non-safety-oriented purposes.
2) Only for devices with approval for custody transfer
3) Additional selection of further approvals is possible.

4.2 Suitability of the measuring instrument

1. Carefully select the nominal diameter of the measuring instrument in accordance with the application's expected flow rates.
   ↳ The maximum flow rate during operation must not exceed the specified maximum value for the sensor.
2. Use Endress+Hauser Applicator to select and dimension products.

4.3 Restrictions

NOTICE

Use the measuring device according to the specifications.

- Pay attention to the medium properties and the environmental conditions.
- Carefully follow instructions pertaining to critical process situations and installation conditions.

Detailed information on:
- Mounting
- Electrical connection
- Medium properties
- Environment
- Process

Operating Instructions → 11

CAUTION

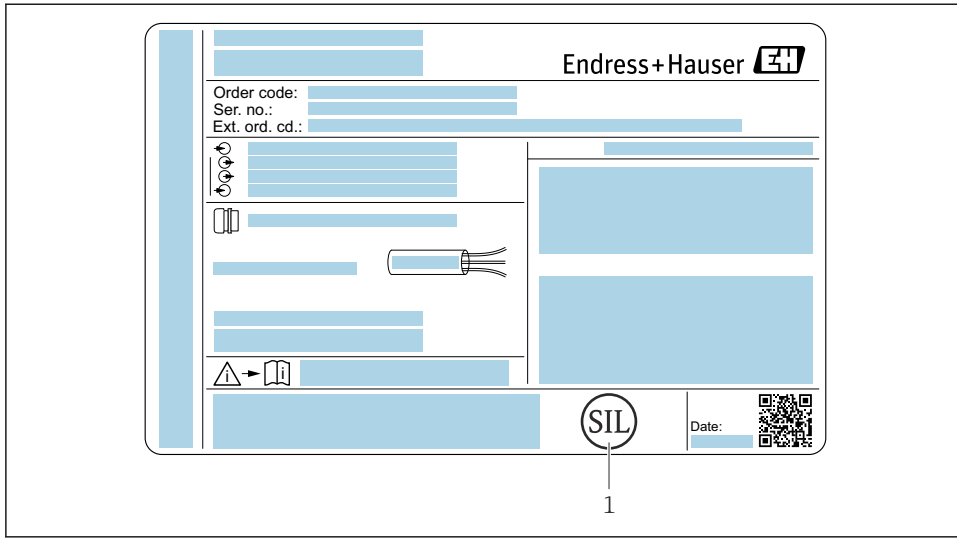
Pay particular attention to the following:

- The measuring instrument may be used only in applications with single-phase media. Two-phase or multiple-phase media must be avoided.
- The measuring instrument must only be used within the technical specifications for process and environmental conditions. If in doubt, please contact your Endress+Hauser Sales Center.
- It is the responsibility of the user to assess the influence of the process conditions and the medium on the measurement result in safety instrumented systems, particularly the occurrence of two-phase mixtures, buildup, abrasion and corrosion, for example, must be avoided.
- In the case of liquids with a low boiling point or liquids in suction lines, it is important to ensure that the pressure does not drop below the vapor pressure and that the liquid does not start to boil.
- Please ensure that there is never any outgassing of the gases naturally contained in many liquids. Sufficiently high system pressure prevents the occurrence of these effects.
- Make sure that cavitation does not occur as it can affect the operating life of the measuring tubes.

Further information on the suitability of the measuring device for safety-related operation is available from your Endress+Hauser sales center.

4.4 Marking

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



1 SIL logo

4.5 Safety function

The measuring device's permitted safety functions are:

- Monitoring of a maximum or minimum mass flow or a mass flow range for liquid or gaseous media
- Monitoring of a maximum or minimum volume flow or a volume flow range for liquid media
  The safety functions are based on the simultaneous, continuous measurement of the mass flow and the density of a liquid.
- Monitoring of a maximum or minimum density or a density range for liquid media

4.5.1 Safety-related output signal

The measuring instrument's safety-related signal is the 4–20 mA analog output signal (output; input 1). All safety measures refer to this signal exclusively.

In addition, the device also communicates via HART® for information purposes and comprises all the HART® features with additional device information. HART® communication is not part of the safety function.

In devices with several outputs, only current output 1 (terminals 26 and 27) is suitable for safety functions. The other outputs can, if necessary, be connected for non-safety-oriented purposes.

The behavior of the output current in the event of an error depends on the setting for the messages.

The safety-related output signal is fed to a downstream automation system where it is monitored for the following:
- Overshooting and/or undershooting of a specified limit value for the flow or the density of the medium
- The occurrence of a fault: e.g. error current (≤ 3.6 mA, ≥ 21 mA), interruption or short-circuit of the signal line

In the event of a fault, it must be ensured that the equipment under control achieves or maintains a safe state.

4.5.2 Redundant configuration of multiple sensors

This section provides additional information regarding the use of homogeneously redundant sensors, e.g. in a 1oo2 or 2oo3 architecture. The failure rates for HFT = 1 must be observed in accordance with: DIN EN 61508-6:2010 Appendix D.

The device meets the requirements for SIL 3 in homogeneously redundant applications (e.g. two identical sensors in series).

If two sensors with an identical design (same type and same nominal diameter) are directly connected to one another flange-to-flange, mutual acoustic interference cannot be entirely ruled out. To fully rule out potential interference, it is recommended to install the sensors at different points of the pipe or to insert a spacer between the two sensors. The spacer must be at least half as long as the sensor.

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

NOTICE

Note the following if a fault is detected in one of the redundantly operated devices during the proof test:

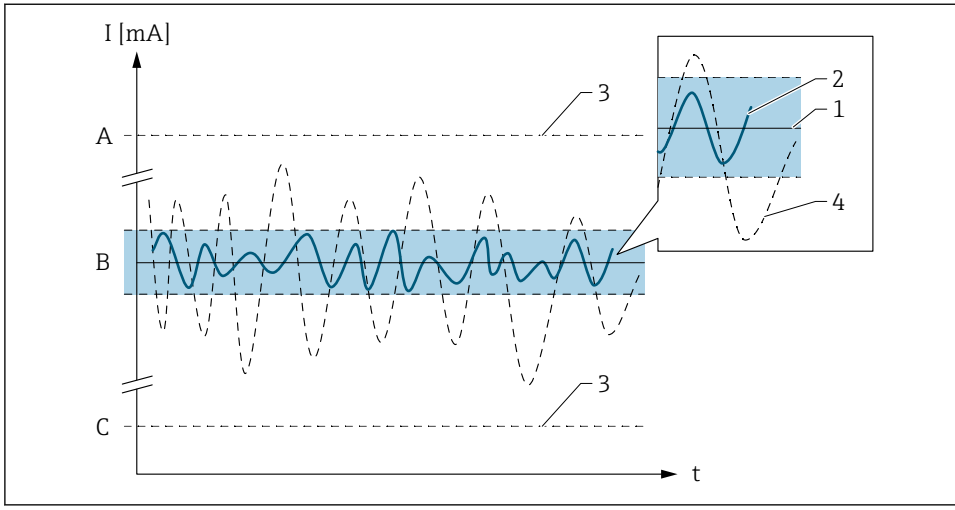
▶ Check the other devices to see if the same fault occurs there.

4.6 Basic conditions for use in safety-related applications

1. The measuring device must be used correctly for the specific application, taking into account the medium properties and ambient conditions.
2. Carefully follow safety instructions pertaining to critical process situations and installation conditions, which can be found in the device documentation.
3. Observe application-specific limits.
4. Do not exceed technical specifications of measuring device.

For detailed information on the technical specifications, see the device documentation → 11.

4.6.1 Random failures in accordance with IEC/EN 61508



1 Safety-related output signal

A HI alarm ≥ 21 mA
B SIL error range
C LO alarm ≤ 3.6 mA

No device error
- No failure
- No impact on the safety-related output signal
- Implications for the safety-related output signal:
  1 – within the specification (see TI, BA, etc.)

λ_S (Safe)
- Safe failure
- No impact on the safety-related output signal: output signal enters the safe state
- Impact on the measurement uncertainty:
  - 2 – Moves within the specified SIL error range B
  - 3 – Has no effect

λ_{DD} (Dangerous detected)
- Dangerous but detectable failure
- Impact on the safety-related output signal: results in a failure mode at the output signal
- Impact on the measurement uncertainty:
  3 – Has no effect

λ_{DU} (Dangerous undetected)
- Dangerous and undetectable failure
- Impact on the safety-related output signal: may be outside the defined error range B
- Impact on the measurement uncertainty:
  4 – May be outside the specified error range

4.6.2 Systematic faults

Systematic faults are faults for which a cause can be clearly identified and which can only be eliminated by modifying the design or the manufacturing process, the method of operation, the operating instructions, or other influencing factors.

Failures caused by systematic faults are always reproducible and can be avoided by taking appropriate measures.

The flexible testing of field devices using Heartbeat Verification can support the detection of systematic faults as part of a proof test → 🖹 32.

Examples:
- Application-related errors: corrosion, abrasion, mechanical stress Possible remedy: carry out Heartbeat Verification
- Faults during installation, commissioning or maintenance: possible remedy: use write protection via hardware DIP switch or software wizard safety mode
- Planning errors: avoid using unsuitable device configuration for the application. Possible remedy: use Endress+Hauser Applicator

4.6.3 Safety measured error

When the measured value is transmitted via the 4–20 mA current output, the measuring instrument's relative measurement error is made up of the contribution of the digitally determined measured value under reference operating conditions, the measurement errors due to process/installation/environmental conditions according to the TI and the accuracy of the analog current output. These contributions, which are listed in the device documentation, apply under reference operating conditions and can depend on the sensor version ordered.

For detailed information on the maximum measured error, see the Technical Information

Power supply to the 4–20 mA current output

Overvoltages at the 4–20 mA current output (passive, output; input 1) - caused by a fault in the supply unit, for example - can result in a leak current in the device's input protection unit. This may lead to falsification of the output signal by more than the specified error or the minimum failure current (3.6 mA) can no longer be set due to the leak current.

► Use a 4–20 mA power supply unit with either voltage limitation or voltage monitoring.

NOTICE

The safety-related connection values depend on the Ex approval.

► Pay attention to the safety-related connection values.

For detailed information on the connection values, see the Safety Instructions.

HART communication

The measuring device also communicates via HART or WirelessHART in the SIL mode. This comprises all the HART features with additional device information.

NOTICE

The measuring device's safety-related signal is the 4–20 mA analog output signal (output; input 1).

All safety measures refer to this signal exclusively.

► Please note the following: .

NOTICE

When the SIL locking code is entered, the device parameters that affect the safety-related output signal are locked and write-protected. It is still possible to read the parameters.

When SIL locking is enabled, restrictions apply on all communication options, such as the service interface (CDI-RJ45), HART protocol and WirelessHART protocol, local display and WLAN.

► Deactivation of the SIL mode → 30.

4.7 Dangerous undetected failures in this scenario

An incorrect output signal that deviates from the value specified in the Operating Instructions but is still in the range of 4 to 20 mA, is considered a dangerous, undetected failure.

Information on measured error→ 18

For detailed information on the maximum measured error, see the Technical Information

4.8 Useful lifetime of electrical components

For the devices described in this manual, there is a useful lifetime of 12 years. The useful lifetime was determined on the basis of a systematic evaluation of all safety-relevant components.

Within this time, and under consideration of the permitted operating conditions (see IEC 61508-2:2010 section 7.4.9.5 note 3), neither a significant change of the safety-related characteristic values for random failures specified in the Declaration of Conformity, nor appreciable wear must be expected.

In accordance with DIN EN 61508-2:2011 section 7.4.9.5, national footnote N3, appropriate measures taken by the manufacturer and operator can extend the useful lifetime.

It is possible to query the date of manufacture based on the serial number via Endress+Hauser Device Viewer. https://www.ch.endress.com/en/product-tools - Device Viewer

For information regarding extending the useful lifetime, contact your Endress+Hauser Service Organisation.

5 Commissioning (installation and configuration)

5.1 Requirements for the 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.
- Are authorized by the plant owner/operator.
- Are familiar with federal/national regulations.
- Before starting work, read and understand the instructions in the manual and supplementary documentation as well as the certificates (depending on the application).
- Follow instructions and comply with basic conditions.

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

5.2 Installation

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

5.3 Commissioning

For detailed information on commissioning, see the Operating Instructions.

Before operating the device in a safety instrumented system, perform a verification using a test sequence, see section → 32

5.4 Operation

For detailed information on the operating options, see the Operating Instructions → 11

5.5 Device configuration for safety-related applications

5.5.1 Measuring point adjustment

The measuring point is calibrated via the operating interfaces. A wizard guides you systematically through all the submenus and parameters that have to be set for configuring the measuring device.

For detailed information on the operating options, see the Operating Instructions
→ 11

For detailed information on configuring the measuring device, see the Operating Instructions and Description of Device Parameters

5.5.2 Device protection

The devices can be protected against external influences as follows:
- Hardware write protection
- Software write protection

The application of these methods is described below.

5.5.3 Device configuration and locking methods

The following operating methods are possible to configure the safety function:

- DTM-based software such as FieldCare or DeviceCare
- Web server
- Operation via display
- EDD-based software such as PDM/FDI/AMS

The safety function can be set in a variety of ways, which are described in detail below:

- Default setting ex works
- Configured on site without the operating menu
- Configuration and locking using the wizard

5.5.4 Default setting ex works

It is a requirement that the customer specified the desired configuration in the order, which was then written to the device during the production process. A function test must be performed on-site by the user before the device may be used in SIL mode. This can be done, for example, by using one of the procedures described for proof testing (see the "Proof testing" section).

To protect against external influences, the device can be locked using hardware write protection (DIP switch (HW lock)).

5.5.5 Configuration and locking using the wizard

By limiting the possibilities during parameter configuration, this method offers added safety against incorrect settings. Recommended for initial commissioning: reset the device as specified in the Operating Instructions. This resets all parameters to defined values (factory settings or customized settings).

To activate the SIL mode, the device must run through a confirmation sequence. While running through this sequence, critical parameters are either set automatically by the device

to standard values or transferred to the local display/operating tool to enable verification of the setting. On completion of parameter configuration, the SIL mode of the device must be enabled with a SIL locking code.

Availability of the SIL mode function

NOTICE

The SIL confirmation sequence is only visible on the local display and in the operating tools for devices with the order code for "Additional approval", option LA "SIL".

- ▶ For this reason, the SIL mode can also only be activated on these measuring devices.
- ▶ If the LA "SIL" option was ordered for the flowmeter ex works, this option is available when the measuring device is delivered to the customer. Access is via the operating interfaces of the measuring device.
- ▶ If the order option cannot be accessed in the measuring device, the function cannot be retrofitted during the life cycle of the device. If you have any questions please contact your Endress+Hauser service or sales organization.

Ways to check function availability in the measuring device:
Using the serial number:
Device viewer [1] → Order code for *"Additional approval"*, option LA *"SIL"*

Detailed information concerning the SIL label:
- Permitted device types → 🖹 12
- SIL marking on the transmitter nameplate → 🖹 14

Overview of the SIL mode

The SIL mode enables the following steps:

1. Makes sure that the preconditions are met.
   ↳ The measuring device checks whether the user has correctly configured a predefined set of parameters for the safety function.
   If the result is positive, the device continues with the activation of the SIL mode.
   If the result is negative, the sequence is not permitted or is aborted, and the device does not continue with the activation of the SIL mode.
2. Automatically switches a predefined set of parameters to the default values specified by the manufacturer.
   ↳ This parameter set ensures that the flowmeter works in the safety mode.
3. Guides the user through the preconfigured parameters for checking.
   ↳ This ensures that the user actively checks all the important pre-settings.
4. Activates write protection for all the relevant parameters in the SIL mode.

All this ensures that the parameter settings that are required for the safety function are configured correctly. (These settings cannot be circumvented either deliberately or by accident.)

1) www.endress.com/deviceviewer

Locking a SIL device

When locking a SIL device, all safety-related parameter settings are shown to the operator individually and must be confirmed explicitly. Parameter settings not permitted in the locked SIL mode are reset to their default values where necessary. A SIL locking code is then entered to lock the device software to ensure that parameters cannot be changed. Non-safety-related parameters remain unchanged.

NOTICE

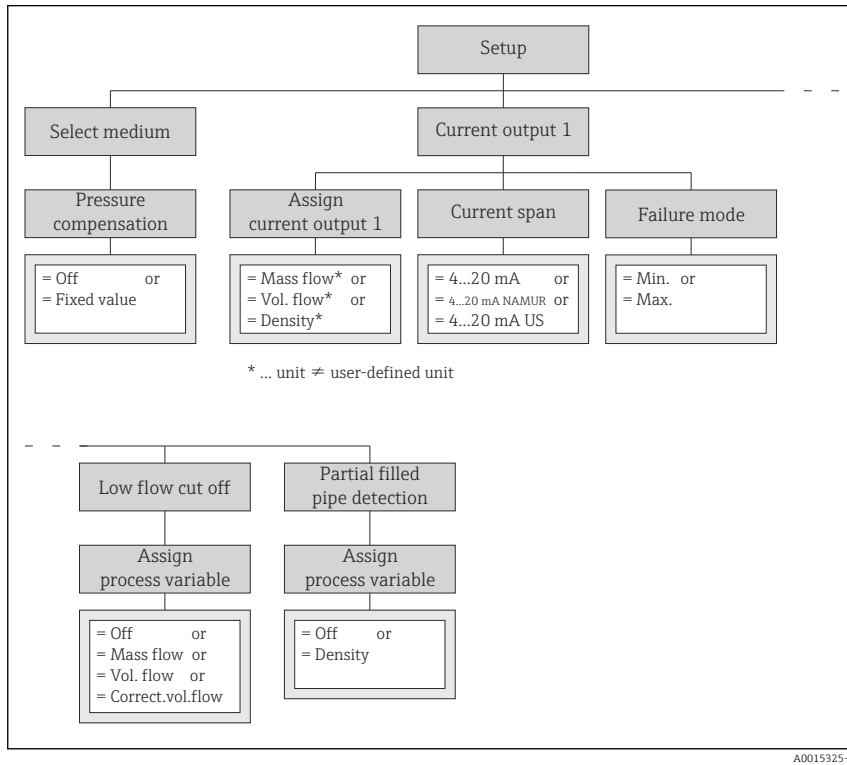
Once the SIL device has been locked, the process-related parameters are write protected, and thereby locked, for security reasons.

It is still possible to read the parameters. When SIL locking is enabled, restrictions apply on all communication options, such as the service interface, HART protocol and WirelessHART protocol, local display and WLAN.

► Follow the specified locking sequence.

1. Check preconditions are met.

↳



2. In the **Setup** menu → **Advanced setup** submenu, select the **SIL confirmation** wizard.
3. Select the **Set write protection** parameter.

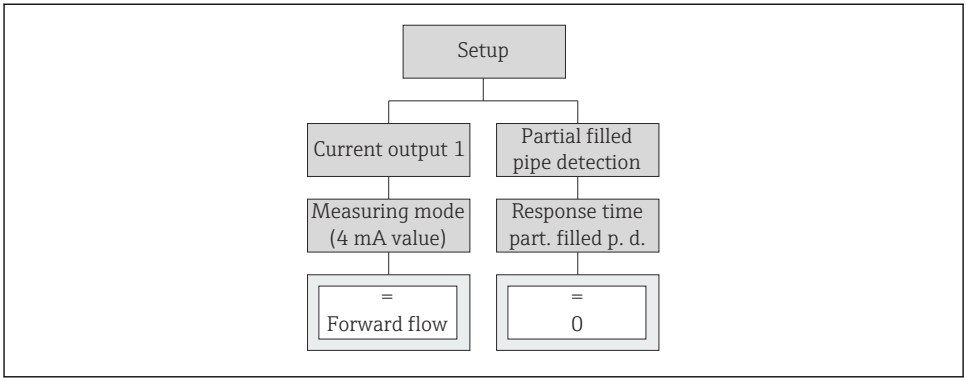
4. Enter the SIL locking code **7452**.
   ↳ The device first checks the preconditions listed under item 1.

NOTICE

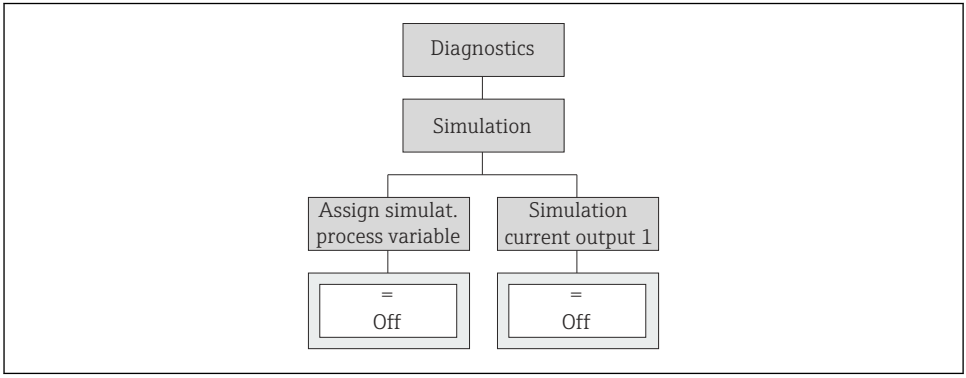
If these preconditions are not met, the message "SIL preparation = failed" appears on the display along with the parameter that failed to meet the preconditions under 1.
The SIL confirmation sequence is not continued.
► Check preconditions.

If the preconditions are met, the message **SIL preparation = finished** appears on the display.

Once the preconditions have been met, the device automatically switches the following parameters to safety-oriented settings:

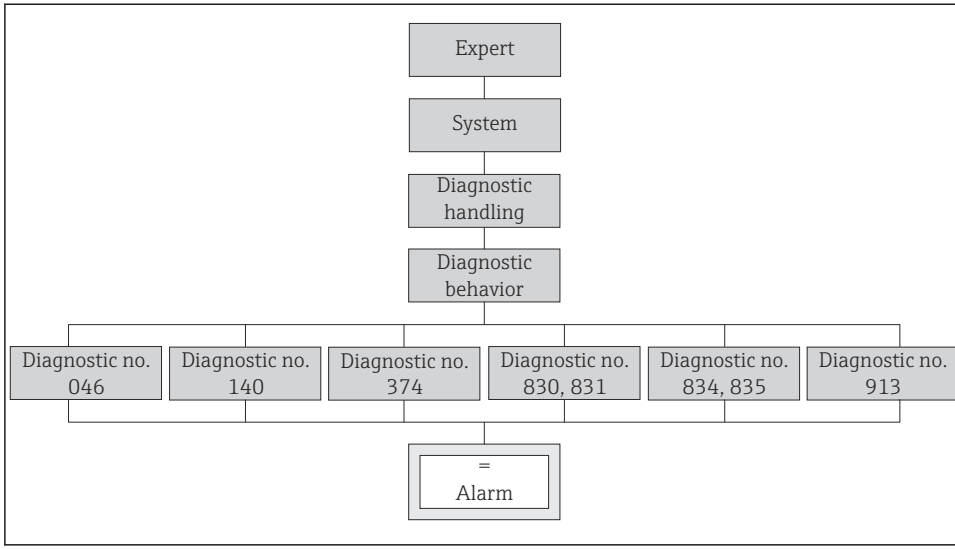


A0015326-EN



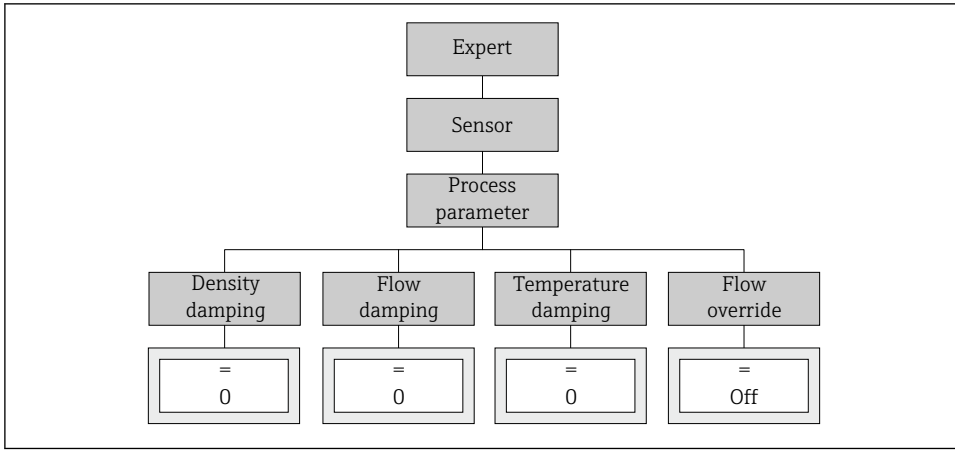
A0015327-EN

The diagnostic behavior is set in such a way that the measuring instrument is set to the safe state when an error occurs. This means that the diagnostic messages listed in the graphic are set to alarm and the current output adopts the configured failsafe mode .

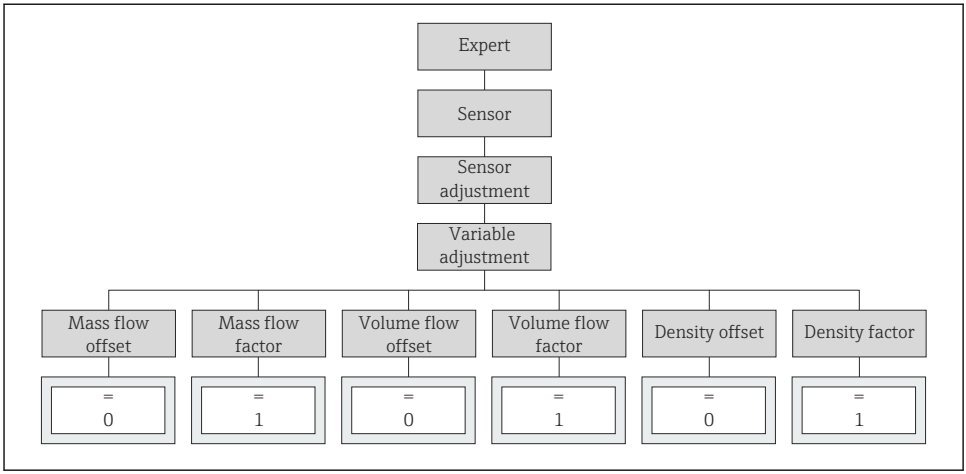


A0031622-EN

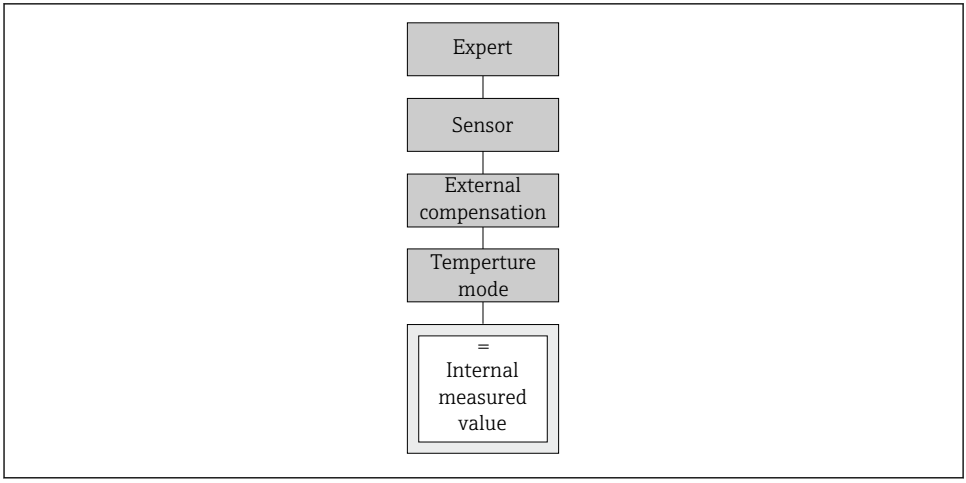
Diagnostic number and event text:
- **046 Sensor limit exceeded** diagnostic message
- **140 Sensor signal** diagnostic message
- **374 Sensor electronics (ISEM) faulty** diagnostic message
- **830 Sensor temperature too high** diagnostic message
- **831 Sensor temperature too low** diagnostic message
- **834 Process temperature too high** diagnostic message
- **835 Process temperature too low** diagnostic message
- **913 Medium unsuitable** diagnostic message



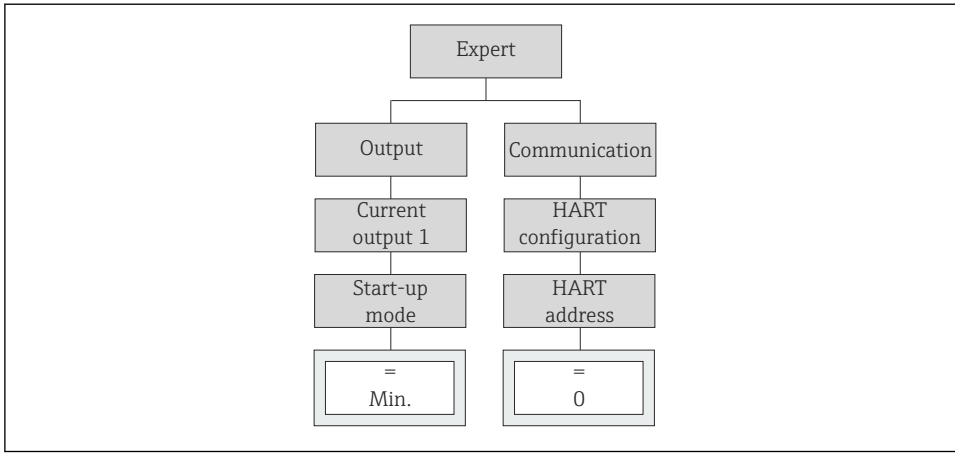
A0043346-EN



A0023070-EN



A0031477-EN



A0015328-EN

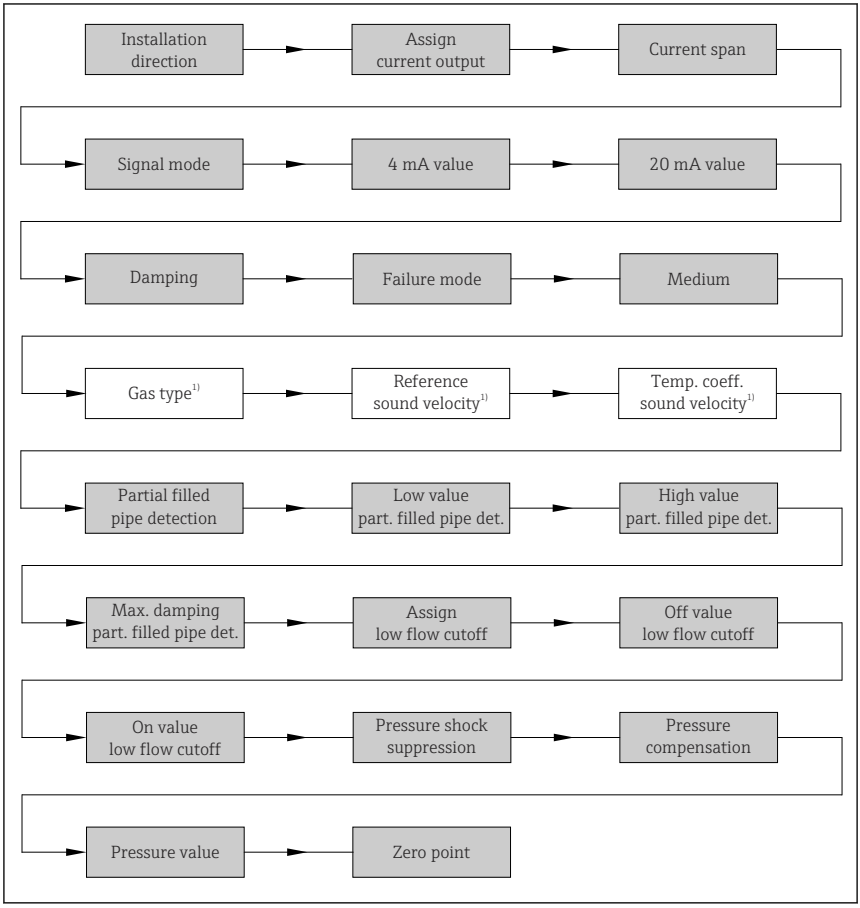
HBSI monitoring

Enables monitoring of the HBSI (Heartbeat Sensor Integrity) parameter. In SIL mode, only the *Continuous HBSI* function is available. The function must be activated before locking the SIL device.

For further information – see "Heartbeat Technology" Special Documentation

To check that values are displayed correctly, the following string appears on the device display or operating tool: **0123456789+-.**

5. The user must confirm that the values are displayed correctly.
   ↳ The device displays the current settings for the following parameters one after another for the user to confirm each of them:



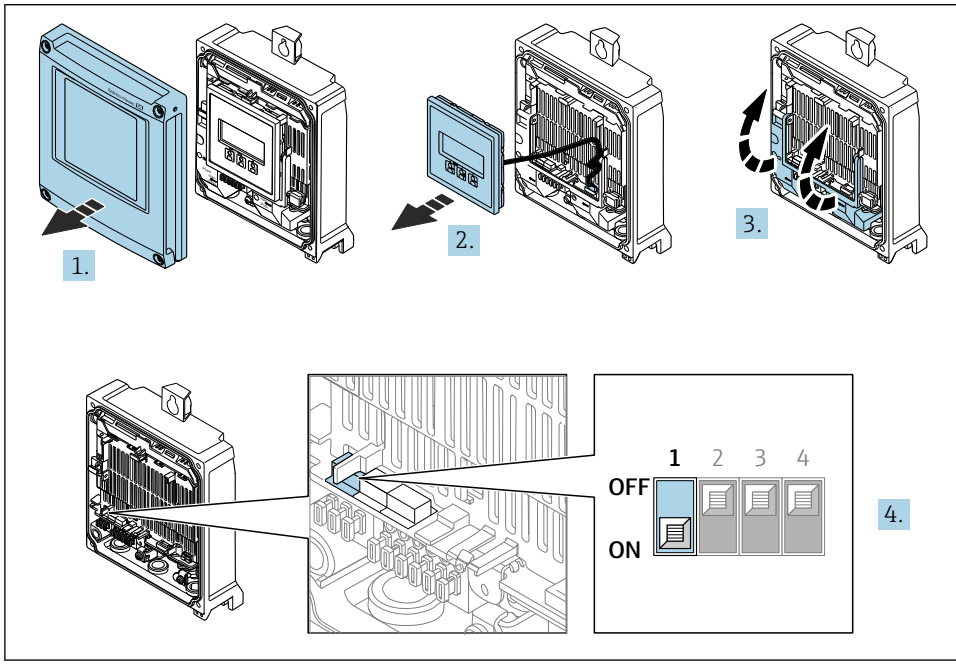
1) This parameter is only displayed under the condition that the "Gas" option is selected in the "Medium" parameter.

For detailed information on the parameters in the graphic, see the Operating Instructions.

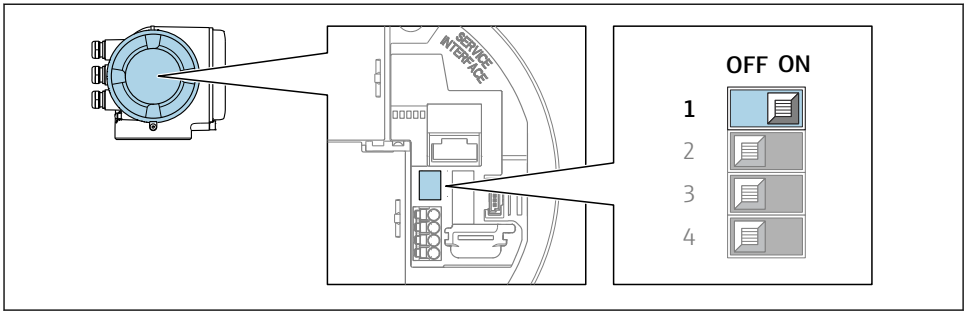
6. At the end of the verification, the SIL locking code **7452** must be entered in the **Set write protection** parameter again to confirm that all the parameter values have been defined correctly.
   ↳ If the SIL locking code has been entered correctly, the message **"End of sequence"** appears on the display.
7. Press the E key to confirm.

The SIL mode is now activated.

Recommendation:



2 *Proline 500 – digital*



3 Proline 500

1. Check the write protection switch (WP) in the connection compartment.
2. If necessary, set this switch to the **ON** position.
   ↳ Hardware write protection enabled.
3. Restart the device on completion of the SIL confirmation sequence.

NOTICE

If the SIL confirmation sequence is aborted before the "End of sequence" message is displayed, the SIL device is not locked. The safety-oriented parameter settings have been made but the SIL device has not been locked.

▶ Perform SIL device locking again.

5.5.6 Unlocking a SIL device

A device in the locked SIL mode is protected against unauthorized operation by means of a SIL locking code and, where applicable, by means of a user-specific release code and a hardware write protection switch. The device must be unlocked in order to change parameters, for proof-tests as well as to reset self-holding diagnostic messages.

NOTICE

Unlocking the device deactivates diagnostic functions, and the device may not be able to carry out its safety function in the unlocked SIL mode.

▶ Therefore, independent measures must be taken to ensure that there is no risk of danger while the SIL device is unlocked.

Unlocking procedure:

1. Check the write protection switch (WP) in the connection compartment.
2. Set this switch to the **OFF** position.
   ↳ Hardware write protection disabled.
3. Enter the user-specific release code if necessary.
4. In the **Setup** menu → **Advanced setup** submenu, select the **Deactivate SIL** wizard.
5. Select the **Reset write protection** parameter.

6. Enter the SIL locking code **7452**.
   ↳ If the SIL locking code has been entered correctly, the message **"End of sequence"** appears on the display.
7. Press the E key to confirm.

The SIL mode is now deactivated.

6 Operation

The behavior during operation and in the event of a fault is described in the Operating Instructions (BA).

6.1 Device behavior during power-up

Once switched on, the device runs through a start-up phase. The current output is set to failure current during this time. This current is ≤ 3.6 mA in the initial seconds of this start-up phase.

After that, depending on the setting of the "Start-up mode" parameter, the current is:
- At the value MIN: ≤ 3.6 mA
- At the value MAX: ≥ 21 mA

No communication with the device is possible via the interfaces during the start-up phase. After the start-up phase the device switches to the normal mode (measuring operation).

6.2 Device behavior when safety function is requested

The device outputs a current value corresponding to the measured value to be monitored. This value must be monitored and processed further in a connected logic unit.

6.3 Safe states

An application error is detected by the device, and the set failure current is output. This state persists until the application error is resolved and the device can again supply a valid measured value at the current output.

Malfunction/description:
If a fault is detected, the transmitter sets the configured alarm current (safe state) at the output:
- I ≤ 3.6 mA (low alarm)
- I ≥ 21 mA (high alarm)

The factory setting is ≤ 3.6 mA (low alarm).

6.4 Device behavior in event of alarms and warnings

The output current on alarm can be set to a value ≤ 3.6 mA or ≥ 21 mA.

In some cases (e.g. a cable open circuit or faults in the current output itself, where it is not possible to set the failure current ≥ 21 mA) output currents of ≤ 3.6 mA occur irrespective of the configured failure current.

In some other cases (e.g. short circuit of cabling), output currents of ≥ 21 mA occur irrespective of the configured failure current.

For alarm monitoring, the downstream automation system must be able to recognize both maximum alarms (≥ 21 mA) and minimum alarms (≤ 3.6 mA).

6.5 Alarm and warning messages

Additional information is provided by the alarm and warning messages output in the form of diagnostic events and associated event texts.

NOTICE

A diagnostic message is displayed even though the diagnostic event is no longer active in the unlocked SIL mode.

When SIL mode is activated, additional diagnostics are activated. If a diagnostic event is pending and the locked SIL mode is deactivated, the diagnostic message remains as long as the error is still present.

- In this case, the device must be disconnected briefly from the power supply.
- When the device is then restarted, a self-check is carried out, and the diagnostics event is reset where applicable.

This behavior occurs in the event of the following diagnostic message:
803 Current loop diagnostic message

After a period of 20 to 30 s, the diagnostic message changes from **803 Current loop** diagnostic message to **⊗F375 I/O- 1 to n communication failed** diagnostic message. If a check run in the device's event logbook confirms the previous **803 Current loop** diagnostic message diagnostic message, the installation must be checked for a cable break.

7 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, and also at appropriate time intervals. This ensures that the functional integrity can be verified within the complete safety instrumented system. The time intervals must be specified by the operator.

⚠ CAUTION

The safety function is not guaranteed during a proof test.
Suitable measures must be taken to guarantee process safety during the test.
- ▶ The safety-related output signal 4 to 20 mA must not be used for the safety instrumented system during testing.
- ▶ Any test that is performed must be documented; the template in the appendix can be used for this purpose → 🖹 55.
- ▶ The operator specifies the test interval and this must be taken into account when determining the probability of failure PFD_{avg} of the sensor system.

If no operator-specific proof testing requirements have been defined, the following is a possible alternative for testing the transmitter depending on the measured variable used for the safety function. The individual proof test coverages (PTC) that can be used for calculation are specified for the test sequences described below.

Flexible testing of field devices
NAMUR Worksheet NA106 "Flexible proof testing of field devices in safety instrumented systems" explains how to optimize testing activities on existing installations. Device verification (Heartbeat Verification) enables documentation of the current device diagnosis or device status as proof of testing. This supports the documentation of proof tests according to IEC 61511-1, section 16.3.3, "Documentation of proof tests and inspections". The Heartbeat Technology developed by Endress+Hauser can be used to implement the "Flexible testing" test strategy of field devices under NA106.

Heartbeat Verification cannot replace a proof test. Test sequences with Heartbeat Verification can support the detection of systematic faults as part of a proof test. In this case, Heartbeat Verification is one step in the proof test sequence.

Heartbeat Technology is a methodological design concept based on IEC 61508:consisting of the Heartbeat Diagnostic, Verification and Monitoring modules.

Heartbeat Verification is based on device-specific test sequences that are performed automatically. Heartbeat Verification also enables the detection of systematic errors in the sensor system (e.g. corrosion/abrasion or formation of buildup in the sensor).

For more information on Heartbeat Technology, see the associated documentation in the Operating Instructions.

If there is a device fault before the test, an alarm is output. The cause of the fault must be rectified before starting the proof test.

Overview of the proof tests:
Proof testing of the device can be performed as follows:
- Test sequence A: Testing with a secondary standard 1 (mass flow, volume flow or density) and current output 1 → PTC = 99%
- Test sequence B: Testing with a secondary standard 1 (density) → PTC = 98 %
- Test sequence C: Testing with a secondary standard 1 (mass flow, volume flow or density) → PTC = 98%
- Test sequence D: Device restart, testing current output 1 with Heartbeat Verification → PTC = 79%

- Test sequence E: verification of current output 1 with Heartbeat Verification → PTC = 44%
- Test sequence F: Device restart, Heartbeat Verification → PTC = 45%
- Test sequence G: Heartbeat Verification

Heartbeat Verification enables additional systematic errors to be detected.

Note the following for the test sequences:
- The individual proof test coverages (PTC) that can be used for calculation are specified in the “Manufacturer declaration” section → 4.
- For a commissioning check, test sequences with a PTC of at least 98% are required.
- The accuracy of the measuring equipment used for checking the current output must meet the transmitter specifications. See test sequence: Testing of current output 1

Proof testing and optimization of subsystems

NAMUR Worksheet NA106 "Flexible proof testing of field devices in safety instrumented systems" explains how to optimize testing activities in safety instrumented systems with regard to interrupting operation while maintaining the necessary safety integrity of the installed safety instrumented systems.

The Heartbeat Technology device can be used to implement the "Flexible testing" test strategy of field devices under NA106.

Device verification (Heartbeat Verification) enables the documentation of the current device diagnostic or the device status as proof of testing. This supports the documentation of proof tests according to IEC 61511-1, Section 16.3.3, "Documentation of proof tests and inspections". Device verification (Heartbeat Verification) is based on device-specific test sequences that are performed automatically. Heartbeat Verification also enables the detection of systematic errors in the sensor system (e.g. corrosion/abrasion or formation of buildup in the sensor).

7.1 Test sequence A (PTC = 99 %)

- Testing with a secondary standard (mass flow, volume flow or density)
- Verification of current output 1
- Inspection and on-site visual check

Preparation

Byassing of safety function of process control system, to prevent accidental activation of the safety function.

▶ Deactivate the locked SIL mode → 30.

7.1.1 Test sequence: Testing with a secondary standard (mass flow, volume flow or density)

The measured values (3 to 5 measuring points) are checked with a secondary standard on an installed device (mobile calibration rig or calibrated reference device) or on a factory calibration rig following device removal.

The measured values of the secondary standard and the device under test (DUT) are compared using one of the following methods:

Comparison by reading off the digital measured value

▶ Compare the digital measured value of the secondary standard against the measured value display of the DUT at the logic subsystem (process control system or safety-related PLC).

Comparison of the measured value by measuring the current

Requirements for the measuring equipment:
- DC current measuring uncertainty ±0.2 %
- DC current resolution 10 µA

1. Measure the current at the DUT using an external, traceably-calibrated ammeter.
2. Measure the current of the DUT at the logic subsystem (process control system or safety-related PLC).

Evaluation of results: Testing with a secondary standard (mass flow, volume flow or density)

The amount of deviation between the measured flow rate and the set point must not exceed the measured error specified for the safety function.

For information on the required measured error for the device, see the "Performance characteristics" section of the Operating Instructions

▶ Follow the information in the section on "Restrictions for use in safety-related applications, information on measured errors" → 🖹 19.

7.1.2 Test sequence: Testing of current output 1

The **Simulation** submenu (Diagnostics → Simulation) enables you to simulate, without a real flow situation, various process variables in the process and the device alarm mode and to verify downstream signal chains (switching valves or closed-control loops).

Performing the test

For proof testing, use only the **Current output simulation** parameter (→ 🖹 37) and the **Value current output** parameter (→ 🖹 37), as these are the only parameters approved for testing the safety-related characteristics.

1. In the **Value current output** parameter, select the defined default values one after the other.
2. Compare current at output 1 with this default value.

Comparing the current values

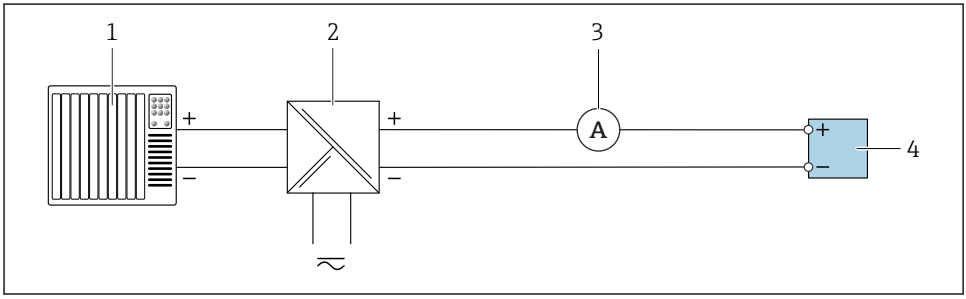
The current values can be compared using one of the following methods:
- Measure the current of the DUT at the logic subsystem (process control system or safety-related PLC).
- Measure the current at the DUT using an external, traceably-calibrated ammeter.

▶ Compare the current values.

Connecting the measuring equipment and external testing

- Connecting the measuring equipment in the measuring circuit
- External check of the passive current output

Requirements for the measuring equipment:
- DC current measuring uncertainty ±0.2 %
- DC current resolution 10 µA



4 *External verification taking the example of a passive current output*

1 Automation system with current input (e.g. PLC)
2 Power supply unit
3 Ammeter
4 Transmitter

1. Connect the ammeter to the transmitter by looping it in series into the circuit.
2. Connect the power supply unit.

Evaluation of results: Testing of current output 1

The amount of deviation between the measured current and the set point must not exceed the measured error specified for the safety function. The deviation should not exceed ±1 % / ±300 µA.

▶ Follow the information in the section on "Restrictions for use in safety-related applications, information on measured errors" → 19.

Parameter overview with brief description

Parameter	Prerequisite	Description	Selection / User entry	Factory setting
Current output 1 to n simulation	–	Switch the simulation of the current output on and off.	On	Off
Current output value	In the **Current output 1 to n simulation** parameter, the **On** option is selected.	Enter the current value for simulation.	▪ 1. Default value: Select 4.0 mA. ▪ 2. Default value: Select 20.0 mA. 3.59 to 22.5 mA	3.59 mA

7.1.3 Test sequence: Inspection and on-site visual check

At the transmitter, check the correct sealing function of all the electronics compartment cover seals and cable entries.

7.1.4 Connecting the test

1. Re-activate the locked SIL mode → 🖹 23.
2. Deactivate bypassing of safety function of process control system.
3. Document results of proof test in accordance with the safety management guidelines applicable to the system.

NOTICE

At least 99 % of dangerous, undetected failures can be detected using the test sequences described (PTC = 0.99). The influence of systematic errors on the safety function is not fully covered by the test. Systematic errors can be caused, for example, by medium properties, operating conditions, buildup or corrosion.

- ▶ 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 protective system.
- ▶ Take measures to reduce systematic errors. For detailed information on the orientation, medium properties and operating conditions, see the "Operating Instructions" → 🖹 11

7.2 Test sequence B (PTC = 98 %)

- Testing with a secondary standard (density)
- Inspection and on-site visual check

Preparation

Byassing of safety function of process control system, to prevent accidental activation of the safety function.

- ▶ Deactivate the locked SIL mode → 🖹 30.

7.2.1 Test sequence: Testing with a secondary standard (density)

Check measured value for density by comparing with a secondary standard. The measuring device is checked consecutively in the empty state and with a medium of known density (e.g. process medium or water).

Check the measured values with a reference value (secondary standard or value from the literature) when the device is installed, or check on a factory calibration rig once the device has been removed. The density measured values determined in each case are compared against the real density of the media.

The reference values are compared against the measured values of the device under test (DUT) using one of the following methods:

Comparison by reading off the digital measured value

- ▶ Compare the digital measured value of the secondary standard against the measured value display of the DUT at the logic subsystem (process control system or safety-related PLC).

Comparison of the measured value by measuring the current

Requirements for the measuring equipment:
- DC current measuring uncertainty ±0.2 %
- DC current resolution 10 µA

1. Measure the current at the DUT using an external, traceably-calibrated ammeter.
2. Measure the current of the DUT at the logic subsystem (process control system or safety-related PLC).

Evaluation of results: Testing with a secondary standard (density)

The amount of deviation between the measured density and the reference value must not exceed the measured error specified for the safety function.

- ▶ Follow the information in the section on "Restrictions for use in safety-related applications, information on measured errors" → 🖹 19.

7.2.2 Test sequence: Inspection and on-site visual check

At the transmitter, check the correct sealing function of all the electronics compartment cover seals and cable entries.

7.2.3 Connecting the test

NOTICE

At least 98 % of dangerous, undetected failures can be detected using the test sequences described (PTC = 0.98). The influence of systematic errors on the safety function is not fully covered by the test. Systematic errors can be caused, for example, by medium properties, operating conditions, buildup or corrosion.

- ▶ 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 protective system.
- ▶ Take measures to reduce systematic errors. For detailed information on the orientation, medium properties and operating conditions, see the "Operating Instructions" → 🖹 11

7.3 Test sequence C (PTC = 98 %)

- Testing with a secondary standard (mass flow or volume flow)
- Inspection and on-site visual check

Preparation

Byassing of safety function of process control system, to prevent accidental activation of the safety function.

▶ Deactivate the locked SIL mode → 30.

7.3.1 Test sequence: Testing with a secondary standard (mass flow or volume flow)

Testing with a secondary standard (mass flow or volume flow): Verification of the measured value for liquid and gaseous mass flow or volume flow by comparing with a secondary standard.

The measured values (3 to 5 measuring points) are checked with a secondary standard on an installed device (mobile calibration rig or calibrated reference device) or on a factory calibration rig following device removal.

The measured values of the secondary standard and the device under test (DUT) are compared using one of the following methods:

Comparison by reading off the digital measured value

▶ Compare the digital measured value of the secondary standard against the measured value display of the DUT at the logic subsystem (process control system or safety-related PLC).

Comparison of the measured value by measuring the current

Requirements for the measuring equipment:
- DC current measuring uncertainty ±0.2 %
- DC current resolution 10 µA

1. Measure the current at the DUT using an external, traceably-calibrated ammeter.
2. Measure the current of the DUT at the logic subsystem (process control system or safety-related PLC).

Evaluation of results: Testing with a secondary standard (mass flow or volume flow)

The amount of deviation between the measured flow rate and the set point must not exceed the measured error specified for the safety function.

For information on the required measured error for the device, see the "Performance characteristics" section of the Operating Instructions

▶ Follow the information in the section on "Restrictions for use in safety-related applications, information on measured errors" → 19.

7.3.2 Test sequence: Inspection and on-site visual check

At the transmitter, check the correct sealing function of all the electronics compartment cover seals and cable entries.

7.3.3 Connecting the test

NOTICE

At least 98 % of dangerous, undetected failures can be detected using the test sequences described (PTC = 0.98). The influence of systematic errors on the safety function is not fully covered by the test. Systematic errors can be caused, for example, by medium properties, operating conditions, buildup or corrosion.

- ▶ 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 protective system.
- ▶ Take measures to reduce systematic errors. For detailed information on the orientation, medium properties and operating conditions, see the "Operating Instructions" → 🖹 11

7.4 Test sequence D (PTC = 79 %)

- Device restart
- Verification of current output 1
- Heartbeat Verification
- Inspection and on-site visual check

Detection of additional systematic errors with Heartbeat Verification: influence of the process on the device (e.g. corrosion/abrasion or formation of buildup in the sensor).

Preparation

Byassing of safety function of process control system, to prevent accidental activation of the safety function.

- ▶ Deactivate the locked SIL mode → 🖹 30.

7.4.1 Test sequence: Device restart

The device restart resets every parameter whose data are in the volatile memory (RAM) to the factory setting (e.g. measured value data). The device configuration remains unchanged.

The device can be restarted using one of the following methods:
- Disconnecting and reconnecting the terminal voltage.
- In the **Device reset** parameter, select the **Restart device** option.
  Setup → Advanced setup → Administration

- ▶ Restart the device.

NOTICE

Wrong option selected in the "Reset device" parameter.
If the "To factory defaults" or "To delivery settings" option is selected, the device configuration is reset and the device must be reconfigured!
- ▶ In the **Device reset** parameter, select only the **Restart device** option.

Evaluation of results: Device restart

▶ Test restart of device.

↳ After a successful startup, the local display switches automatically from the startup display to the operational display. If the device restarts and no diagnostic message is displayed, this step has been completed successfully.
If nothing appears on the local display or a diagnostic message is displayed, refer to the "Diagnostics and troubleshooting" section of the "Operating Instructions" → 🖹 11

7.4.2 Test sequence: Testing of current output 1

Alternative to method listed below for verifying current output 1 can be used for the extended Heartbeat Verification. This can be found in the special documentation for "Application package Heartbeat Verification + Monitoring HART", section "Extended verification"→ 🖹 11.

The **Simulation** submenu (Diagnostics → Simulation) enables you to simulate, without a real flow situation, various process variables in the process and the device alarm mode and to verify downstream signal chains (switching valves or closed-control loops).

Performing the test

For proof testing, use only the **Current output simulation** parameter (→ 🖹 37) and the **Value current output** parameter (→ 🖹 37), as these are the only parameters approved for testing the safety-related characteristics.

1. In the **Value current output** parameter, select the defined default values one after the other.
2. Compare current at output 1 with this default value.

Comparing the current values

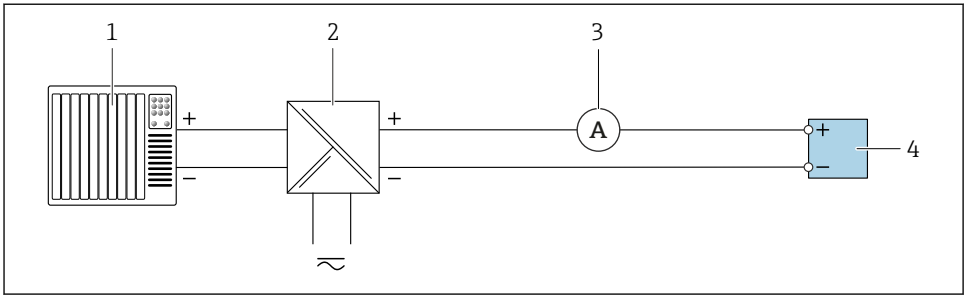
The current values can be compared using one of the following methods:
- Measure the current of the DUT at the logic subsystem (process control system or safety-related PLC).
- Measure the current at the DUT using an external, traceably-calibrated ammeter.

▶ Compare the current values.

Connecting the measuring equipment and external testing

- Connecting the measuring equipment in the measuring circuit
- External check of the passive current output

Requirements for the measuring equipment:
- DC current measuring uncertainty ±0.2 %
- DC current resolution 10 µA



5 *External verification taking the example of a passive current output*

1 Automation system with current input (e.g. PLC)
2 Power supply unit
3 Ammeter
4 Transmitter

1. Connect the ammeter to the transmitter by looping it in series into the circuit.
2. Connect the power supply unit.

Evaluation of results: Testing of current output 1

The amount of deviation between the measured current and the set point must not exceed the measured error specified for the safety function. The deviation should not exceed ±1 % / ±300 µA.

► Follow the information in the section on "Restrictions for use in safety-related applications, information on measured errors" → 19.

Parameter overview with brief description

Parameter	Prerequisite	Description	Selection / User entry	Factory setting
Current output 1 to n simulation	–	Switch the simulation of the current output on and off.	On	Off
Current output value	In the **Current output 1 to n simulation** parameter, the **On** option is selected.	Enter the current value for simulation.	▪ 1. Default value: Select 4.0 mA. ▪ 2. Default value: Select 20.0 mA. 3.59 to 22.5 mA	3.59 mA

7.4.3 Test sequence: Heartbeat Verification

1. Select Heartbeat Verification (standard).
2. Initiate Heartbeat Verification.

3. Verification is performed automatically in the device: see the "Standard verification" section of the "Special Documentation for Heartbeat Technology" .

Acceptance criteria: Heartbeat Verification

1. Check whether the result of the verification is **Passed** or **Failed**.
   ↳ The test is completed successfully if the result of the Heartbeat Verification is **Passed**.
2. To document the test, print the verification report. Device diagnostics or device status as proof of testing.

The following systematic errors can be detected:
- Corrosion and abrasion in the sensor pipes
- Hard buildup in the sensor pipes

7.4.4 Test sequence: Inspection and on-site visual check

At the transmitter, check the correct sealing function of all the electronics compartment cover seals and cable entries.

7.4.5 Concluding the test

1. Re-activate the locked SIL mode → 23.
2. Deactivate bypassing of safety function of process control system.
3. Document results of proof test in accordance with the safety management guidelines applicable to the system.

Depending on the device version, at least the following proportion of dangerous, undetected failures can be detected with the described test sequences:
- Promass Q ≥ DN 150: PTC = 76%
- Promass 500 – digital: PTC = 77%
- All others: PTC = 79 %

NOTICE

The influence of systematic errors on the safety function is not fully covered by the test. Systematic errors can be caused, for example, by medium properties, operating conditions, buildup or corrosion.

- ▶ 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 protective system.
- ▶ Take measures to reduce systematic errors. For detailed information on the orientation, medium properties and operating conditions, see the "Operating Instructions" → 11

7.5 Test sequence E (PTC = 44 %)

- Device restart
- Verification of current output 1
- Heartbeat Verification
- Inspection and on-site visual check

Detection of additional systematic errors with Heartbeat Verification: influence of the process on the device (e.g. corrosion/abrasion or formation of buildup in the sensor).

Preparation

Byassing of safety function of process control system, to prevent accidental activation of the safety function.

▶ Deactivate the locked SIL mode → 30.

7.5.1 Test sequence: Device restart

The device restart resets every parameter whose data are in the volatile memory (RAM) to the factory setting (e.g. measured value data). The device configuration remains unchanged.

The device can be restarted using one of the following methods:
- Disconnecting and reconnecting the terminal voltage.
- In the **Device reset** parameter, select the **Restart device** option.
  Setup → Advanced setup → Administration

▶ Restart the device.

NOTICE

Wrong option selected in the "Reset device" parameter.
If the "To factory defaults" or "To delivery settings" option is selected, the device configuration is reset and the device must be reconfigured!
▶ In the **Device reset** parameter, select only the **Restart device** option.

Evaluation of results: Device restart

▶ Test restart of device.
  ↳ After a successful startup, the local display switches automatically from the startup display to the operational display. If the device restarts and no diagnostic message is displayed, this step has been completed successfully.
  If nothing appears on the local display or a diagnostic message is displayed, refer to the "Diagnostics and troubleshooting" section of the "Operating Instructions" → 11

7.5.2 Test sequence: Testing of current output 1

Alternative to method listed below for verifying current output 1 can be used for the extended Heartbeat Verification. This can be found in the special documentation for "Application package Heartbeat Verification + Monitoring HART", section "Extended verification"→ 11.

The **Simulation** submenu (Diagnostics → Simulation) enables you to simulate, without a real flow situation, various process variables in the process and the device alarm mode and to verify downstream signal chains (switching valves or closed-control loops).

Performing the test

For proof testing, use only the **Current output simulation** parameter (→ 37) and the **Value current output** parameter (→ 37), as these are the only parameters approved for testing the safety-related characteristics.

1. In the **Value current output** parameter, select the defined default values one after the other.
2. Compare current at output 1 with this default value.

Comparing the current values

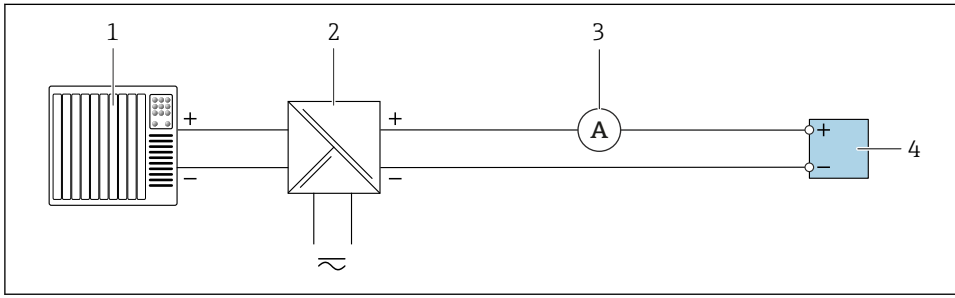
The current values can be compared using one of the following methods:
- Measure the current of the DUT at the logic subsystem (process control system or safety-related PLC).
- Measure the current at the DUT using an external, traceably-calibrated ammeter.

▶ Compare the current values.

Connecting the measuring equipment and external testing

- Connecting the measuring equipment in the measuring circuit
- External check of the passive current output

Requirements for the measuring equipment:
- DC current measuring uncertainty ±0.2 %
- DC current resolution 10 µA



6 *External verification taking the example of a passive current output*

1 *Automation system with current input (e.g. PLC)*
2 *Power supply unit*
3 *Ammeter*
4 *Transmitter*

1. Connect the ammeter to the transmitter by looping it in series into the circuit.
2. Connect the power supply unit.

Evaluation of results: Testing of current output 1

The amount of deviation between the measured current and the set point must not exceed the measured error specified for the safety function. The deviation should not exceed ±1 % / ±300 µA.

- Follow the information in the section on "Restrictions for use in safety-related applications, information on measured errors" → 19.

Parameter overview with brief description

Parameter	Prerequisite	Description	Selection / User entry	Factory setting
Current output 1 to n simulation	–	Switch the simulation of the current output on and off.	On	Off
Current output value	In the **Current output 1 to n simulation** parameter, the **On** option is selected.	Enter the current value for simulation.	▪ 1. Default value: Select 4.0 mA. ▪ 2. Default value: Select 20.0 mA. 3.59 to 22.5 mA	3.59 mA

7.5.3 Test sequence: Heartbeat Verification

1. Select Heartbeat Verification (standard).
2. Initiate Heartbeat Verification.
3. Verification is performed automatically in the device: see the "Standard verification" section of the "Special Documentation for Heartbeat Technology" .

Acceptance criteria: Heartbeat Verification

1. Check whether the result of the verification is **Passed** or **Failed**.
   ↳ The test is completed successfully if the result of the Heartbeat Verification is **Passed**.
2. To document the test, print the verification report. Device diagnostics or device status as proof of testing.

The following systematic errors can be detected:
- Corrosion and abrasion in the sensor pipes
- Hard buildup in the sensor pipes

7.5.4 Test sequence: Inspection and on-site visual check

At the transmitter, check the correct sealing function of all the electronics compartment cover seals and cable entries.

7.5.5 Concluding the test

1. Re-activate the locked SIL mode → 23.

2. Deactivate bypassing of safety function of process control system.
3. Document results of proof test in accordance with the safety management guidelines applicable to the system.

Depending on the device version, at least the following proportion of dangerous, undetected failures can be detected with the described test sequences:
- Device model A2: PTC = 37%
- Promass Q ≥ DN 150: PTC = 30%

NOTICE

The influence of systematic errors on the safety function is not fully covered by the test. Systematic errors can be caused, for example, by medium properties, operating conditions, buildup or corrosion.

- ▶ 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 protective system.
- ▶ Take measures to reduce systematic errors. For detailed information on the orientation, medium properties and operating conditions, see the "Operating Instructions" → 🖹 11

7.6 Test sequence F (PTC = 45 %)

- Device restart
- Heartbeat Verification
- Inspection and on-site visual check

Detection of additional systematic errors with Heartbeat Verification: influence of the process on the device (e.g. corrosion/abrasion or formation of buildup in the sensor).

Preparation

Byassing of safety function of process control system, to prevent accidental activation of the safety function.

- ▶ Deactivate the locked SIL mode → 🖹 30.

7.6.1 Test sequence: Device restart

The device restart resets every parameter whose data are in the volatile memory (RAM) to the factory setting (e.g. measured value data). The device configuration remains unchanged.

The device can be restarted using one of the following methods:
- Disconnecting and reconnecting the terminal voltage.
- In the **Device reset** parameter, select the **Restart device** option.
  Setup → Advanced setup → Administration

- ▶ Restart the device.

NOTICE

Wrong option selected in the "Reset device" parameter.

If the "To factory defaults" or "To delivery settings" option is selected, the device configuration is reset and the device must be reconfigured!

- ▶ In the **Device reset** parameter, select only the **Restart device** option.

Evaluation of results: Device restart

- ▶ Test restart of device.
  - ↳ After a successful startup, the local display switches automatically from the startup display to the operational display. If the device restarts and no diagnostic message is displayed, this step has been completed successfully.
    If nothing appears on the local display or a diagnostic message is displayed, refer to the "Diagnostics and troubleshooting" section of the "Operating Instructions" → 📄 11

7.6.2 Test sequence: Heartbeat Verification

1. Select Heartbeat Verification (standard).
2. Initiate Heartbeat Verification.
3. Verification is performed automatically in the device: see the "Standard verification" section of the "Special Documentation for Heartbeat Technology" .

Acceptance criteria: Heartbeat Verification

1. Check whether the result of the verification is **Passed** or **Failed**.
   - ↳ The test is completed successfully if the result of the Heartbeat Verification is **Passed**.
2. To document the test, print the verification report. Device diagnostics or device status as proof of testing.

The following systematic errors can be detected:
- Corrosion and abrasion in the sensor pipes
- Hard buildup in the sensor pipes

7.6.3 Test sequence: Inspection and on-site visual check

At the transmitter, check the correct sealing function of all the electronics compartment cover seals and cable entries.

7.6.4 Concluding the test

1. Re-activate the locked SIL mode → 📄 23.
2. Deactivate bypassing of safety function of process control system.
3. Document results of proof test in accordance with the safety management guidelines applicable to the system.

Depending on the device version, at least the following proportion of dangerous, undetected failures can be detected with the described test sequences:
- Device model A2: PTC = 41%
- Promass Q ≥ DN 150: PTC = 45%

NOTICE

The influence of systematic errors on the safety function is not fully covered by the test. Systematic errors can be caused, for example, by medium properties, operating conditions, buildup or corrosion.

- ▶ 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 protective system.
- ▶ Take measures to reduce systematic errors. For detailed information on the orientation, medium properties and operating conditions, see the "Operating Instructions" → 11

7.7 Test sequence G Systematic fault detection

- Heartbeat Verification
- Inspection and on-site visual check

Detection of additional systematic errors with Heartbeat Verification: influence of the process on the device (e.g. corrosion/abrasion or formation of buildup in the sensor).

Preparation

Byassing of safety function of process control system, to prevent accidental activation of the safety function.

- ▶ Deactivate the locked SIL mode → 30.

7.7.1 Test sequence: Heartbeat Verification

1. Select Heartbeat Verification (standard).
2. Initiate Heartbeat Verification.
3. Verification is performed automatically in the device: see the "Standard verification" section of the "Special Documentation for Heartbeat Technology" .

Acceptance criteria: Heartbeat Verification

1. Check whether the result of the verification is **Passed** or **Failed**.
   - ↳ The test is completed successfully if the result of the Heartbeat Verification is **Passed**.
2. To document the test, print the verification report. Device diagnostics or device status as proof of testing.

The following systematic errors can be detected:
- Corrosion and abrasion in the sensor pipes
- Hard buildup in the sensor pipes

7.7.2 Test sequence: Inspection and on-site visual check

At the transmitter, check the correct sealing function of all the electronics compartment cover seals and cable entries.

7.7.3 Concluding the test

1. Re-activate the locked SIL mode → 23.

2. Deactivate bypassing of safety function of process control system.
3. Document results of proof test in accordance with the safety management guidelines applicable to the system.

NOTICE

None of the dangerous random errors (PTC = 0.36) can be detected with the test sequences described. However, systematic errors can be detected. The influence of systematic errors on the safety function is not fully covered by the test. Systematic errors can be caused, for example, by medium properties, operating conditions, buildup or corrosion.

- ▶ 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 protective system.
- ▶ Take measures to reduce systematic errors. For detailed information on the orientation, medium properties and operating conditions, see the "Operating Instructions" → 11

7.8 Verification criterion

If one of the test criteria from the test sequences described above is not satisfied, 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}).
- The impact of systematic errors on the safety function is partially covered by this test and must be assessed separately.
- Systematic errors can be caused, for example, by substance properties, operating conditions, buildup or corrosion.
- As part of the visual inspection, for example, ensure that all of the seals and cable entries provide adequate sealing.

8 Repair and fault handling

8.1 Maintenance

For detailed information on maintenance, see the Operating Instructions.

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

8.2 Repair

Repair means restoring functional integrity by replacing defective components.

Only original Endress+Hauser spare parts may be used for this purpose.

We recommend that you document the repair. This includes documenting the:
- Serial number of the device
- Date of the repair
- Type of repair
- Person who performed the repair

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

For detailed information on returns, see the Operating Instructions.

8.2.1 Replacing device components

The following components may be replaced by the customer's technical staff if genuine spare parts are used and the appropriate installation instructions are followed:
- Sensor
- Transmitter without a sensor
- Display module
- Power unit
- Main electronics module
- Sensor electronics module (ISEM)
- I/O modules
- Terminals
- Connection compartment cover
- Electronics compartment cover
- Seal sets for electronics compartment cover
- Securing clamps for electronics compartment cover
- Cable glands

Installation Instructions: see the Download Area under www.endress.com.

The replaced component must be sent to Endress+Hauser for the purpose of fault analysis if the device has been operated in a protective system and a device error cannot be ruled out. In this case, always enclose the "Declaration of Hazardous Material and Decontamination" with the note "Used as SIL device in protection system" when returning the defective device. Please refer to the "Return" section in the Operating Instructions .

8.3 Modification

Modifications are changes to devices with SIL capability approved by Endress+Hauser for sales.
- ▶ Modifications to SIL devices by the user are not permitted as they can impair the functional safety of the device.
- ▶ Modifications to SIL devices onsite at the user's plant are possible following approval by the Endress+Hauser manufacturing center.

- Modifications to SIL devices must be performed by personnel authorized to do so by Endress+Hauser.
- Only original Endress+Hauser spare parts may be used for modifications.
- All modifications must be documented in the Endress+Hauser Device Viewer (www.endress.com/deviceviewer).
- All modifications require a change nameplate or replacement of the original nameplate.

A proof test must always be performed after every modification.

8.4 Taking out of service

The requirements of IEC 61508-1:2010 Section 7.17 must be observed when taking the device out of service.

8.5 Disposal

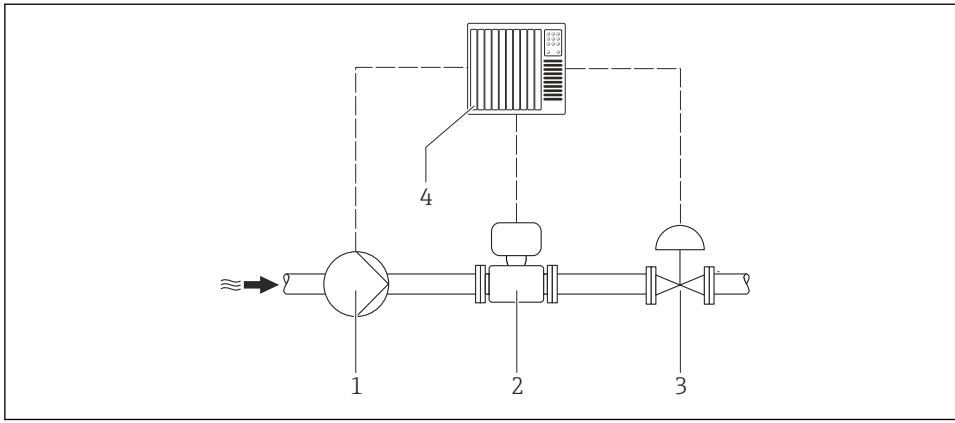
For detailed information on the device disposal, see the Operating Instructions → 11

9 Appendix

9.1 Structure of the measuring system

9.1.1 System components

An example of the devices in the measuring system is shown in the following graphic.



7 *System components*

1 Pump
2 Measuring device
3 Valve
4 Automation system

An analog signal (4–20 mA) proportional to the flow or density is generated in the transmitter. This is sent to a downstream automation system where it is monitored to determine whether it falls below or exceeds a specified limit value. The safety function (mass flow, volume flow or density monitoring) is implemented in this way.

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

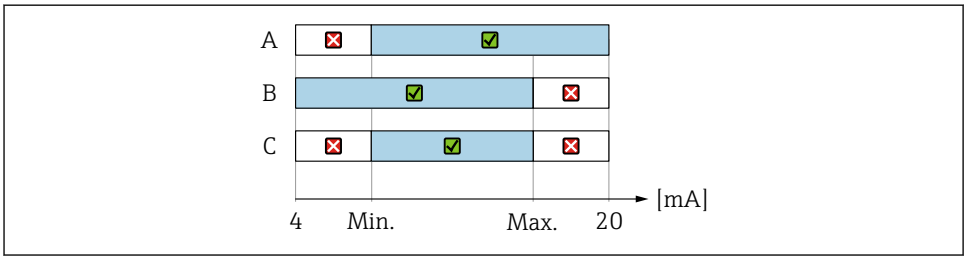
9.1.2 Description of use as a safeguard

The measuring device can be used in protective systems to monitor the following (Min., Max. and range):
- Volume flow
- Mass flow
- Density

NOTICE

The device must be correctly mounted to guarantee safe operation.
► Observe the mounting instructions.

For detailed information on mounting, see the Operating Instructions



8 Monitoring options in safeguards

A Min. alarm
B Max. alarm
C Range monitoring

= *Safety function is triggered*
= *Permitted operating status*

9.2 Commissioning or proof test report

9.2.1 Test report – Page 1

Prüfprotokoll – Seite 1

Geräteinformation
Anlage
Messstellen / TAG-Nr.
Seriennummer
Informationen zur Prüfung
Datum / Uhrzeit
Durchgeführt von:

Prüfablauf	PTC

Prüfungsergebnis	
Bestanden:	**Nicht bestanden**

Bemerkungen

Firma / Ansprechpartner:
Ausführender:

Datum **Unterschrift** **Unterschrift Ausführender**

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9.2.2 Test report – Page 2

Prüfprotokoll – Seite 2

Geräteinformation
Anlage
Messstellen / TAG-Nr.
Seriennummer
Informationen zur Prüfung
Datum / Uhrzeit

Sicherheitsfunktion - Grenzwertüberwachung	
☐ Min	☐ Max

Teil Prüfabläufe	Soll	Ist	Teil-Ergebnis ✓	✗

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9.2.3 Parameter settings for the SIL mode

Parameter-Einstellungen für den SIL-Mode

Parametername	Werkseinstellung	Eingestellter Wert	Geprüft
Freigabecode eingeben	0		
Anfang Messbereich (4mA)	0		
Sensortyp			
Druckkompensation	= Aus		
Zuordnung Stromausgang 1	= Massefluss		
Strombereich	= 4...20 mA		
Fehlerverhalten	= Min.		
Schleichmengenunterdrückung	= Aus		
Überwachung teilgefülltes Rohr	= Aus		
Messmodus (4 mA-Wert)*	= Förderricht.		
Ansprechzeit teilgefülltes Rohr*	= 0		
Zuordnung Simul. Prozessgr.*	= Aus		
Simulation Stromausgang 1*	= Aus		
Diagnosenr. 046; 140; 274; 374; 830; 831; 834; 835; 913*	= Alarm		

* Das Gerät schaltet nach Erfüllung der Vorbedingungen selbsttätig diese Parameter auf sicherheitsgerichtete Einstellungen.

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9.3 Verification or calibration

The SIL mode must be disabled in order to verify the measuring point with Heartbeat Technology or calibrate the measuring point.

NOTICE

To use the device in a safety function again following a verification or calibration, the configuration of the measuring point must be checked and the SIL mode must be enabled again.

▶ Activate the SIL mode → 🖹 23.

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