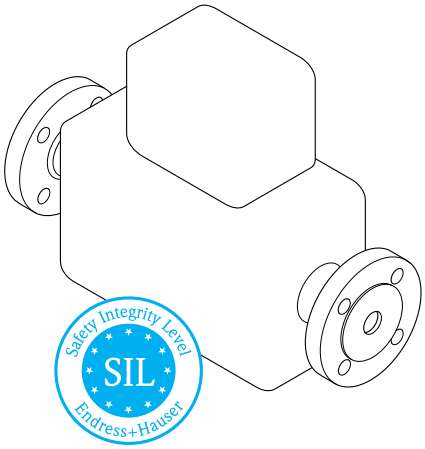
SD00147D/06/EN/12.26-00
71757642
2026-02-09

Special Documentation
Proline Promass 200

Functional Safety Manual



Endress+Hauser
People for Process Automation

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Declaration of Conformity

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Endress+Hauser
People for Process Automation

Declaration of Conformity

Functional Safety according to IEC 61508:2010
Supplement 1 / NE130 Form B.1

Endress+Hauser Flowtec AG, Kägenstrasse 7, CH-4153 Reinach

declares as manufacturer, that the Flowmeter

Promass 200

is suitable for the use in safety-instrumented systems according to IEC61508:2010.

In safety instrumented systems according IEC 61508 and IEC 61511, the instructions of the Safety Manual have to be followed.

Reinach, 29 . Mai. 2015

Endress+Hauser Flowtec AG

Marcel Ziltener
Direktor Controlling

i.V.
Michael Karolzak
Project Manager Functional Safety

Safety-related characteristic values

General			
Device designation and permitted versions	8A2B**-... (Promass A 200) 8E2B**-... (Promass E 200) 8E2C**-... (Promass E 200) 8F2B**-... (Promass F 200)		
	Order code for "Output": ▪ Option **A** "4-20mA HART" ▪ Option **B** "4-20mA HART, pul./freq./switch output" ▪ Option **C** "4-20mA HART, 4-20mA" Order code for "Additional approval": Option **LA** "SIL"		
Safety-related output signal	4 to 20 mA		
Failure 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	
Operating mode	☑ Low Demand Mode	☑ High Demand Mode	☐ Continuous Mode [1]
Valid hardware version (main electronics)	From delivery date March 1, 2014		
Valid firmware version	01.04.zz and higher (HART; from delivery date June 1, 2015)		
Safety manual	SD00147D		
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		
Assessment by (including report no. + FMEDA data source)	TÜV Rheinland Industrie Service GmbH – Certificate No. 968/EZ 504.01/12		
Test documents	Development documents, test reports, data sheets		
SIL integrity			
Systematic safety integrity		☐ SIL 2 capable	☑ SIL 3 capable
Hardware safety integrity	Single-channel service (HFT = 0)	☑ SIL 2 capable	☐ SIL 3 capable
	Multi-channel service (HFT ≥ 1)	☐ SIL 2 capable	☑ SIL 3 capable
FMEDA			
Safety function(s)	Min., Max., Range		
	Option **A**, **B**	Option **C**	
λ_{DU} [2]	89 FIT	73 FIT	
λ_{DD} [2]	1168 FIT	1010 FIT	
λ_{SU} [2]	1105 FIT	1720 FIT	
λ_{SD} [2]	1374 FIT	1374 FIT	
SFF - Safe Failure Fraction	97 %	98 %	
PFD_{avg} for T_1 = 1 year [3] (single-channel architecture)	$3.9 \cdot 10^{-4}$	$3.2 \cdot 10^{-4}$	
PFD_{avg} for T_1 = 5 years [3] (single-channel architecture)	$1.9 \cdot 10^{-3}$	$1.6 \cdot 10^{-3}$	
PFH	$4.5 \cdot 10^{-8}$	$3.7 \cdot 10^{-8}$	
PTC [4]	Up to 98 %		

$MTBF_{tot}$ [5]	47 years	40 years
Diagnostic test interval [6]	30 min	
Fault response time [7]	30 s	
Process safety [8]	50 h	
Recommended test interval T_1	5 years	
$MTTF_d$ [9]	89 years	105 years
Note		
The measuring device 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.		

1) No continuous operation as per IEC 61508: 2011 (section 3.5.16)
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 general standard for devices with SIL capabilities.
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 carried out at least once during this time.
7) Maximum time between fault detection and fault response.
8) The process safety is the diagnostics test interval * 100 (calculation as per IEC 61508).
9) $MTTF_d$ according to ISO 13849/IEC 62061 also includes soft errors (sporadic bit errors in data memories).

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

About this document

Document function

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

- General information about functional safety: **SIL**
- General information about SIL is available:
  In the Downloads area of the Endress+Hauser website: www.endress.com/SIL

Using this document

Information on the document structure

Additional information regarding:
- The arrangement of the parameters, along with a short description, according to the **Operation** menu, **Setup** menu, **Diagnostics** menu: Operating Instructions
- Operating concept: Operating Instructions

Symbols

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.

Symbols for certain types of information

Symbol	Meaning
	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 a step
	Operation via local display

Symbol	Meaning
	Operation via operating tool
	Write-protected parameter

Symbols in graphics

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

Supplementary device 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

Standard documentation

Operating Instructions

Measuring device	Documentation code
Promass 8A2B**-...	BA01821D
Promass 8E2B**–...	BA01027D
Promass 8E2C**–...	BA01638D
Promass 8F2B**–...	BA01112D

Description of Device Parameters

Measuring device	Documentation code
Promass 200	GP01010D

Technical Information

Measuring device	Documentation code
Promass 8A2B**-...	TI01380D
Promass 8E2B**–...	TI01009D
Promass 8E2C**–...	TI01300D
Promass 8F2B**–...	TI01060D

Supplementary device-dependent documentation

Safety instructions

Contents	Documentation code
ATEX/IECEx Ex i	XA00144D
ATEX/IECEx Ex d	XA00143D
ATEX/IECEx Ex nA	XA00145D

Contents	Documentation code
cCSAus IS	XA00151D
cCSAus XP	XA00152D
INMETRO Ex i	XA01300D
INMETRO Ex d	XA01305D
INMETRO Ex nA	XA01306D
NEPSI Ex i	XA00156D
NEPSI Ex d	XA00155D
NEPSI Ex nA	XA00157D

Special Documentation

Contents	Documentation code
Information on the Pressure Equipment Directive	SD01614D
Display and operating module FHX50	SD01007F

Installation Instructions

Contents	Comment
Installation Instructions for spare part sets and accessories	For an overview of the accessories available for order, see the Operating Instructions for the device

Permitted devices types

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

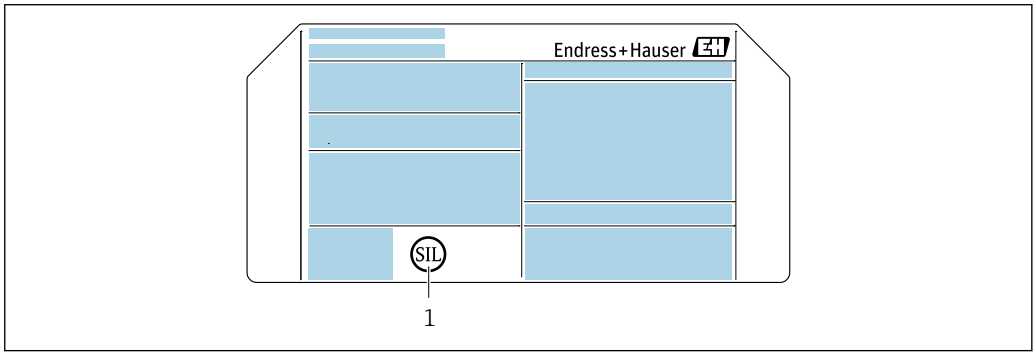
Feature	Designation	Option selected
–	Order code	8A2B**-... (Promass A 200) 8E2B**-... (Promass E 200) 8E2C**-... (Promass E 200) 8F2B**-... (Promass F 200)
000	Nominal diameter	A: DN 1 to 4 (1/24 to 1/8") E: DN 8 to 50 (3/8 to 2") F: DN 8 to 80 (3/8 to 3")
010	Approval	All
020	Output; input [1)]	Option **A** "4-20mA HART" Option **B** "4-20mA HART, pul./freq./switch output" Option **C** "4-20mA HART, 4-20mA"
030	Display; operation	All
040	Housing	All
050	Electrical connection	All
060	Measuring tube mat., wetted surface	All
070	Process connection	All
080	Calibration flow	All
500	Display operating language	All

Feature	Designation	Option selected
520 [2]	Sensor option	All
540	Application package	All
570	Service	All
580	Test, certificate	All
590	Additional approval	Option **LA** "SIL" [3]
600 [4]	Sensor option	All
610	Accessory mounted	All
620	Accessory enclosed	All
850	Firmware version	Firmware with SIL capability, e.g. 01.04.zz (HART)
895	Marking	All

1) In devices with 2 outputs, only current output 1 (terminals 1 and 2) is suitable for safety functions. Output 2 (terminals 3 and 4) can be connected for non-safety related purposes where needed.
2) Valid for 8A2B, 8E2C and 8F2B
3) An additional selection of any further versions is possible.
4) Valid for 8E2B

- Valid hardware version (main electronics): from delivery date March 1, 2014
- Valid firmware version: 01.04.zz and higher (HART; from delivery date June 1, 2015)

SIL label on the transmitter nameplate



1 SIL logo

Safety function

Definition of the 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 or gaseous media
- Monitoring of a maximum or minimum density or a density range for liquid media

The safety functions are based on the simultaneous, continuous measurement of the mass flow and the density of a liquid.

Safety-related output signal

The measuring device's safety-related signal is the 4–20 mA analog output signal. All safety measures refer to this signal exclusively.

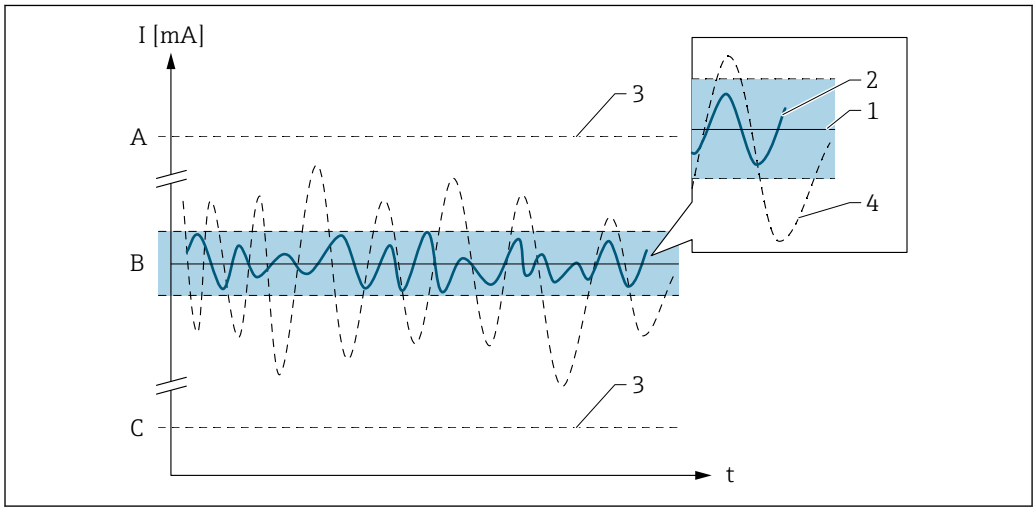
In devices with 2 outputs (*order code for "Output, input", option B "4-20mA HART, pulse/frequency/switch output" or option C "4-20mA HART, 4-20mA"*) only current output 1 (terminals 1 and 2) is suitable for safety functions. Output 2 (terminals 3 and 4) can be connected for non-safety related purposes where needed.

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. failure current (≤ 3.6 mA, ≥ 21 mA), interruption or short-circuit of the signal line

The safety-related errors are broken down in accordance with IEC/EN 61508 into different categories and implications for the safety-related output signal.

Safety related error	Explanation	Item no.→ 🖹 10	Implication for safety-related output signal
No device error	Safe: No error	1	Within specification
λ_{SD}	Safe detected: Safe, detectable failure present	3	Device assumes a signal on alarm
λ_{SU}	Safe undetected: Safe, undetectable failure present	2	Is within the specified tolerance range
λ_{DD}	Dangerous detected: Dangerous but detectable failure present (diagnosis in device)	3	Device assumes a signal on alarm
λ_{DU}	Dangerous undetected: Dangerous, undetectable failure present	4	May be outside the specified tolerance range



A Failure current ≥ 21 mA
B Measuring uncertainty in accordance with Technical Information
C Failure current ≤ 3.6 mA

Restrictions 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.

Information on the safety-related signal → 🖹 9

For detailed information on the technical specifications, see the device documentation → 🖹 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→ 13

For detailed information on the maximum measured error, see the Operating Instructions.
→ 7

Useful lifetime of electric components

The established failure rates of electrical components apply for a useful lifetime of 12 years as per IEC 61508-2: 2010, section 7.4.9.5, note 3.

The device's year of manufacture is coded in the first character of the serial number (→ table below).

Example: serial number **E**5ABBF02000 → year of manufacture 2011

ASCII character	Meaning	ASCII character	Meaning	ASCII character	Meaning
D	2010	K	2015	R	2020
E	2011	L	2016	S	2021
F	2012	M	2017	T	2022
H	2013	N	2018	V	2023
J	2014	P	2019	W	2024

Suitability of the measuring device

1. Carefully select the nominal diameter of the measuring device 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. In safety-related applications, it is advisable to select the limit value for monitoring a minimum flow such that this limit is at least twice the smallest specified flow that can still be measured, with the actual medium and the selected nominal diameter.
   ↳ For further information, see the Technical Information. → 🖹 7
3. In safety-related applications, it is also advisable to select a limit value for monitoring the minimum flow that is not less than 5 % of the specified maximum value of the sensor.

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:
- Installation
- Electrical connection
- Medium properties
- Environment
- Process

Operating Instructions and Technical Information → 🖹 7

⚠ CAUTION

Pay particular attention to the following:

- ▶ It is essential to avoid the occurrence of entrained air, cavitation or two-phase mixtures in the measuring tube which can result in a higher measuring uncertainty.
- ▶ 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.
- ▶ If gaseous media are used, turbulences can occur at high flow velocity rates, e.g. if valves are half-closed. This can cause the measured values to fluctuate.
- ▶ Avoid applications that cause buildup, corrosion or abrasion in the measuring tube.

No special measures need to be taken into consideration for single-phase, liquid media with properties similar to water.

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

Information on measured errors

When the measured value is transmitted via the 4–20 mA current output, the measuring device's relative measured error is made up of the contribution of the digitally determined measured value 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. If process or ambient conditions are different, there are additional contributions, e.g. temperature or pressure, which are also listed.

For further information on calculating the measured error, see the Technical Information. → 7

Guidelines for minimal measured errors:

1. In the event of high process pressure:
   Set the typical process pressure in the measuring device.
2. If measuring the mass flow or volume flow:
   Experience shows that zero point adjustment is advisable only in special cases:
   - To achieve maximum measuring accuracy even with low flow rates
     Under extreme process or operating conditions, e. g. very high process temperatures or very high viscosity of fluid
3. The volume flow is calculated in the device from the mass flow and density. For minimum measured error for the measured volume flow:
   Perform field density calibration under process conditions.
4. Limit value monitoring: Depending on the process dynamics, the current value of the unfiltered 4–20 mA output signal can temporarily exceed the specified error range.
   The device can optionally provide damping of the current output via a parameter that only affects the measured value output.
   - Device-internal diagnostics or the outputting of a failure current (≤ 3.6 mA , ≥ 21 mA) are not affected by this damping.

Power supply to the 4–20 mA current output

Overvoltages at the 4–20 mA current output - 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.→ 7

HART communication

The measuring device also communicates via HART 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.
All safety measures refer to this signal exclusively.

- Please note the following: → 9.

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), HART protocol and local display.

- Deactivation of the SIL mode → 20.

Use in protective systems

Device behavior during operation

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.

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).

Behavior of device during operation

The device outputs a current value which corresponds to the measured value to be monitored. This value must be monitored and processed further in an attached automation system.

Device behavior in safety function demand mode

Depending on the setting of the **Failure mode** parameter, the current is as follows in demand mode:
- For **Min.** option: ≤ 3.6 mA
- For **Max.** option: ≥ 21 mA

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).

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 (e. g. by unplugging the terminals).
- ▶ 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 case of the following diagnostic messages:
803 Current loop diagnostic message

Parameter configuration for safety-related applications

Calibration of the measuring point

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.→ 7

After the operating language has been selected, the following can be configured:
- Selection and configuration of the medium
- Configuration of the current outputs
- Configuration of the pulse/frequency output and switch output
- Configuration of the local display
- Configuration of the output behavior
- Configuration of the low flow cutoff
- Configuration of the partial filled pipe detection

For the further configuration of the measuring device in special applications, a wide range of other configuration parameters are available via the **Diagnostics** menu and **Expert** menu.

For detailed information on configuring the measuring device, see the Operating Instructions and Description of Device Parameters → 🖹 7

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:
W@M Device viewer [1] → Order code for *"Additional approval"*, option LA *"SIL"*

Detailed information concerning the SIL label:
- Permitted device types
- SIL label on the transmitter nameplate → 🖹 9

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.)

Locking a SIL device

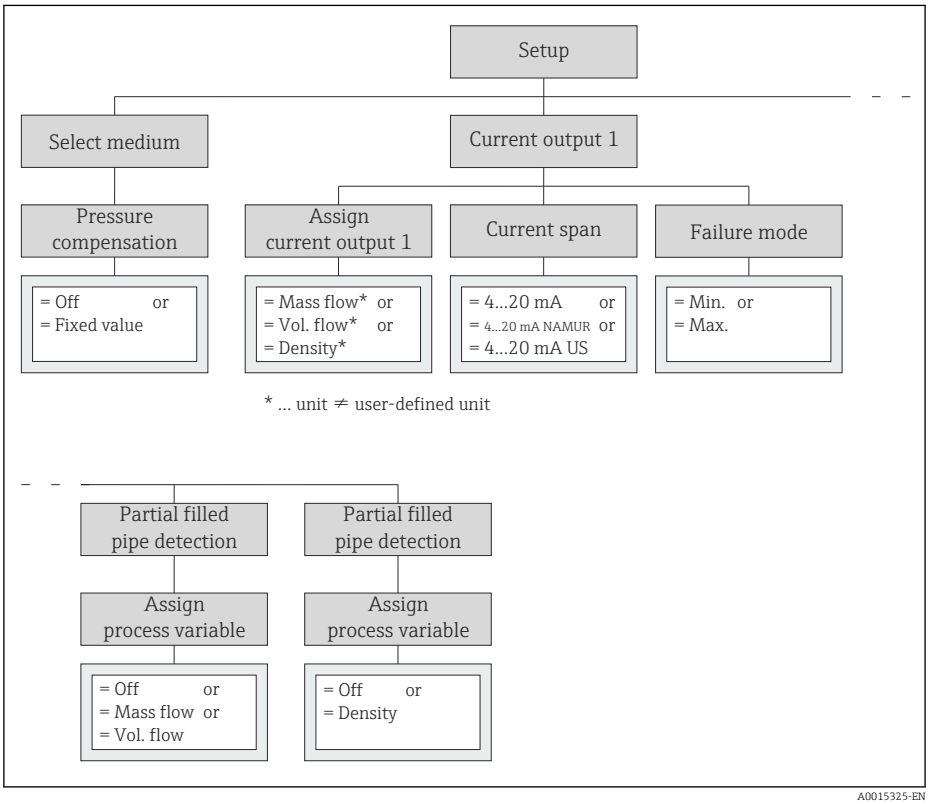
When locking a SIL device, all safety-related parameter settings are shown to the operator individually and must be confirmed explicitly. Parameter settings not permitted in the locked SIL mode are reset to their default values where necessary. A SIL locking code is then entered to lock the device software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

1) www.endress.com/deviceviewer

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 local display.
► Follow the specified locking sequence.

1. Ensure preconditions are met.
   ↳



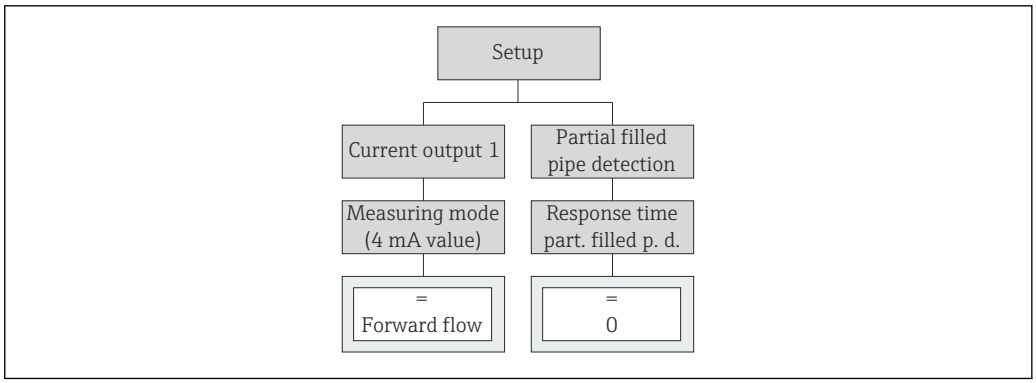
2. In the **Setup** menu → **Advanced setup** submenu, select the **SIL confirmation** wizard.
3. Select **Set write protection** parameter.
4. Enter the SIL locking code **7452**.
   ↳ The device first checks the preconditions listed under item 1.

NOTICE

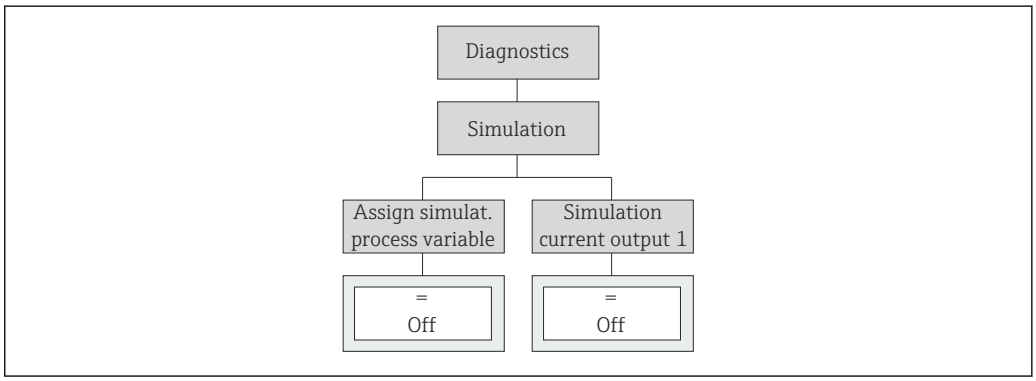
If these preconditions are not met, the message "SIL preparation = failed" appears on the display along with the parameter that failed to meet the preconditions under 1.
The SIL confirmation sequence is not continued.
► Check preconditions.

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:

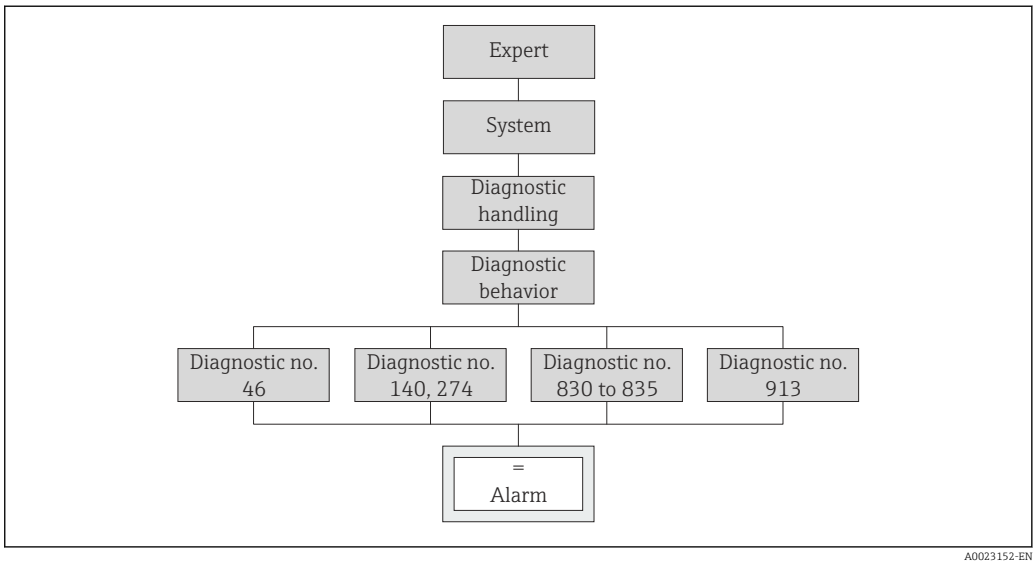


A0015326-EN



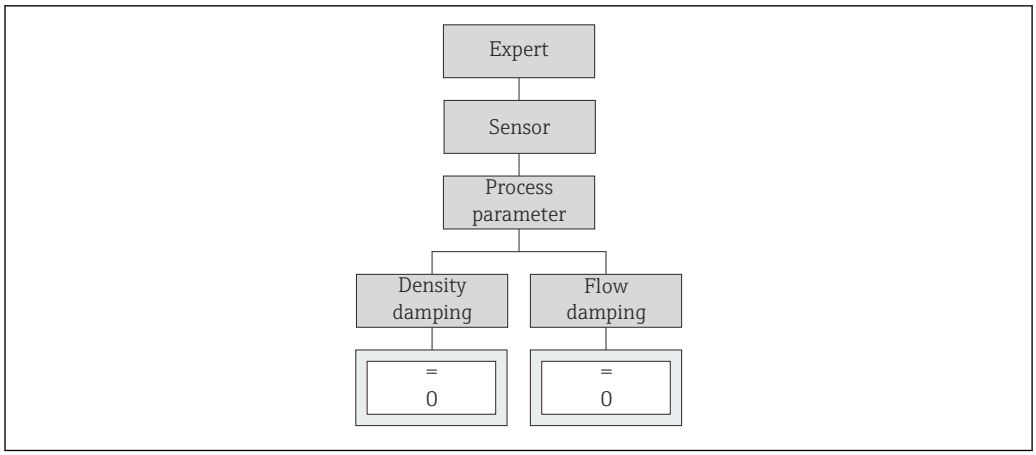
A0015327-EN

The diagnostic behavior is set in such a way that the measuring device 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 → 🖹 14.

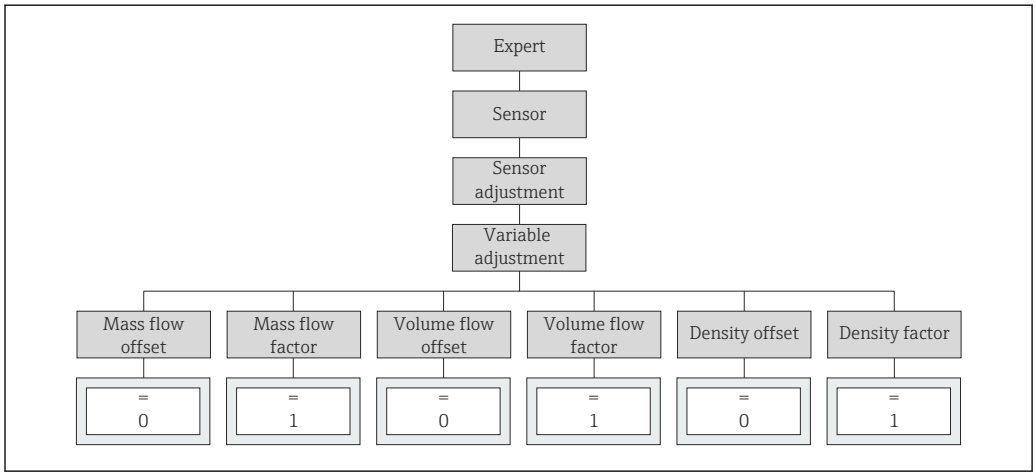


A0023152-EN

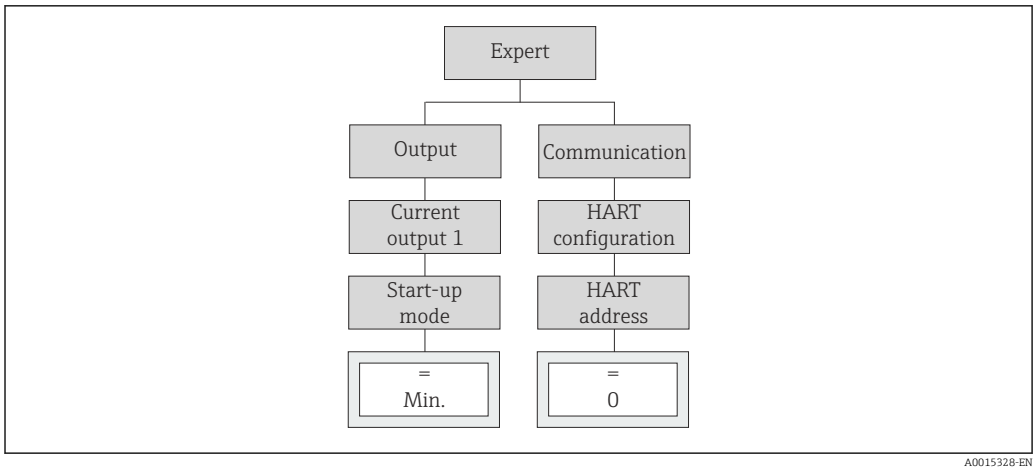
- **046 Sensor limit exceeded** diagnostic message
- **140 Sensor signal** diagnostic message
- **274 Main electronic failure** diagnostic message
- **830 Sensor temperature too high** diagnostic message
- **831 Sensor temperature too low** diagnostic message
- **832 Electronic temperature too high** diagnostic message
- **833 Electronic temperature too low** diagnostic message
- **834 Process temperature too high** diagnostic message
- **835 Process temperature too low** diagnostic message
- **913 Medium unsuitable** diagnostic message



A0023068-EN



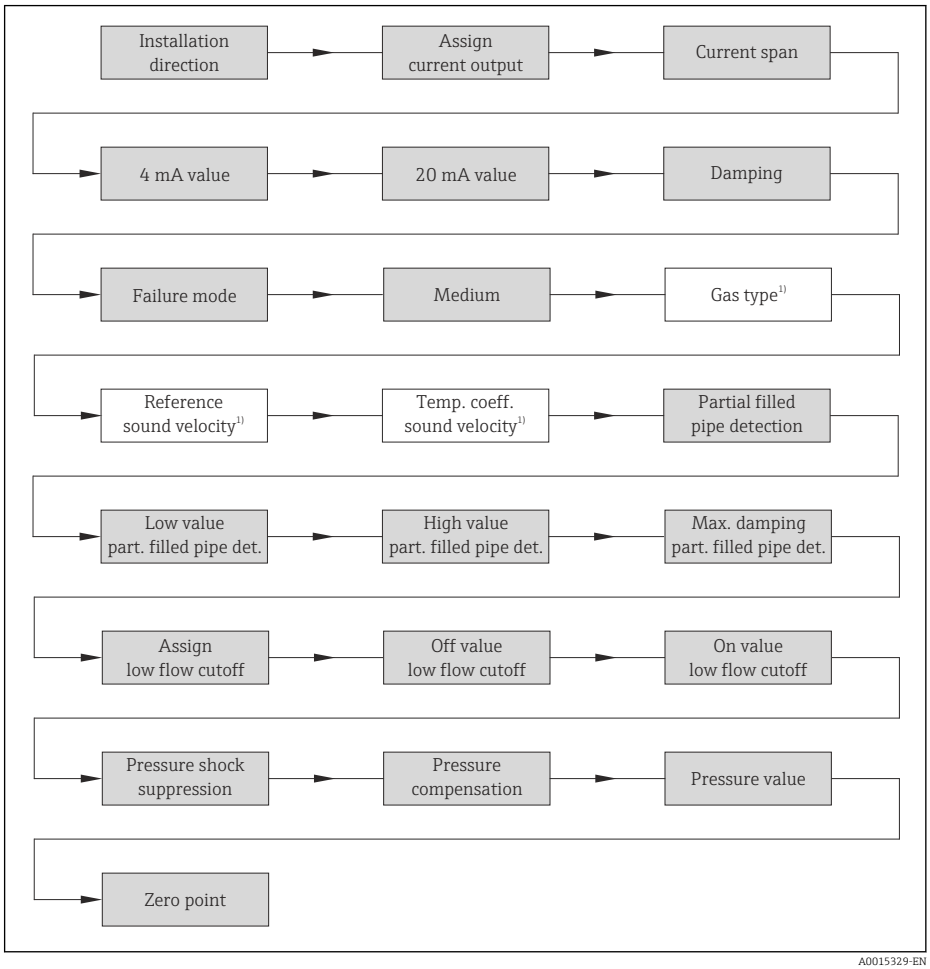
A0023070-EN



A0015328-EN

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 if the "Gas" option is selected in the "Medium" parameter.

For detailed information on the parameters in the graphic, see the Operating Instructions.→ 7

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:

1. Check the write protection switch (WP) in the connection compartment.
2. Set this switch to the **ON** position where necessary.
   ↳ 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.

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 where necessary.
   ↳ 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 **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.

Proof-testing

NOTICE

The safety function is not guaranteed during a proof test.
Nevertheless, process safety must be guaranteed during proof testing.
- ▶ The safety-related output signal 4 to 20 mA may not be used for the protective system.
- ▶ Take alternative monitoring measures if necessary.

Proof-testing the safety function of the entire system

1. Check the functional integrity of the safety function at appropriate intervals.
2. The operator specifies the testing interval and this must be taken into account when determining the probability of failure PFD_{avg} of the sensor system.
   ↳ In the case of a single-channel system architecture, the average probability of failure (PFD_{avg}) of the sensor is derived from the proof-test interval T_i, the failure rate for dangerous undetected failures λ_{du}, the proof test coverage PTC and the assumed mission time by close approximation as follows:

$$PFD_{avg} \approx \lambda_{du} \times (PTC/2 \times T_i + (1 - PTC) / 2 \times MT)$$

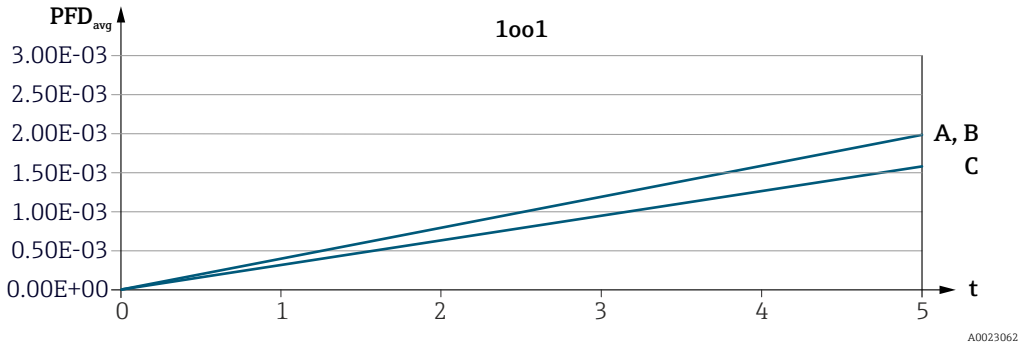
A0023571

MT Mission time
PTC Proof test coverage
Ti Test interval

3. The operator also specifies the procedure for proof-testing.
   ↳ **NOTE!**
   In accordance with IEC 61511, an independent proof test of the subsystems→ 🖹 22, e.g. sensor, is permitted as an alternative to testing the safety function of the entire system.

Average probability of failure and mission time

PFD_{avg} for a single-channel system:



t	*Mission time in years*
A, B, C	*Output versions*
PFD_{avg}	*Average probability of dangerous failure on demand*
1oo1	*Single-channel architecture*

Proof testing the sensor subsystem

If there are no operator-specific requirements for the proof test, the following alternatives are available for testing the sensor subsystem [2] depending on the "mass flow/volume flow" or "density" measured variable used for the safety function.

PTC [1]	Proof-testing	
	Device restart and testing of current output 1	→ 23
98 %	Testing with a secondary standard (volume flow and mass flow)	→ 26
98 %	Testing with a secondary standard (density)	→ 27
99 %	Testing with a secondary standard and testing of current output 1	→ 28

1) Proof Test Coverage

Other recommendations

It is advisable to perform a visual inspection on site.

- As part of the visual inspection of the transmitter, ensure that all of the electronics compartment cover seals and cable entries are providing adequate sealing.

NOTICE

The safety function is not guaranteed during a proof test.

Nevertheless, process safety must be guaranteed during proof testing.

- The safety-related output signal 4 to 20 mA may not be used for the protective system.
- Take alternative monitoring measures if necessary.

2) Under IEC 61508 the sensor is synonymous with the entire flowmeter.

Device restart and testing of current output 1

- Part 1 - Device restart
- Part 2 - Testing of current output 1

Preparation

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

▶ Deactivate the locked SIL mode → 20.

Test sequence - Part 1: 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.
- Selecting the **Restart device** option in the **Device reset** parameter.
  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.

Evaluating the results - Part 1: 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 if a diagnostic message is displayed, refer to the section on "Diagnostics and troubleshooting" in the Operating Instructions for the device.

Test step - Part 2 - Testing of current output 1

The **Simulation** submenu (→ 23) (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 **Simulation current output** parameter (→ 24) and the **Value current output** parameter (→ 25), as these are the only parameters approved for testing the safety-related characteristics.

1. In the **Value current output** parameter (→ 25), select the defined default values one after the other.
2. Compare current at output 1 with this default value.

Comparing the current values

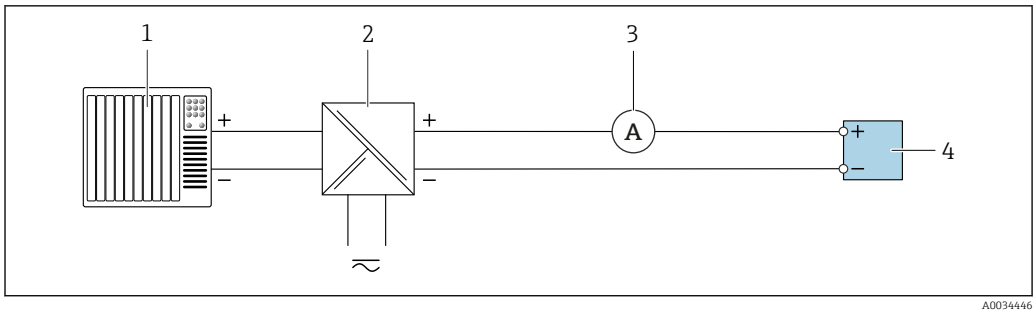
The current values can be compared using one of the following methods:
- Measure the current of the DUT at the logic subsystem (process control system or safety-related PLC).
- Measure the current at the DUT using an external, traceably-calibrated ammeter.

▶ Compare the current values.

Connecting the measuring equipment and external testing

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

Requirements for the measuring equipment:
- DC current measuring uncertainty ±0.2 %
- DC current resolution10 µA



1 *External verification of 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 - Part 2: 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.

► Note data relating to measured error→ 13.

Connecting the test

1. Re-activate the locked SIL mode→ 15.
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

With the test sequences described, at least of the undetected dangerous failures 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, build-up 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.

Simulation current output 1 to n

Navigation Diagnostics → Simulation → Simulation current output 1 to n (0354–1 to n)

Description Use this function to switch simulation of the current output on and off. The display alternates between the measured value and a diagnostic message of the "Function check" category (C) while simulation is in progress.

Selection On

Additional information

Description

The desired simulation value is defined in the **Value current output 1 to n** parameter.

Selection

- Off
  Current simulation is switched off. The device is in normal measuring mode or another process variable is being simulated.
- On
  Current simulation is active.

Value current output 1 to n

Navigation

Diagnostics → Simulation → Value current output 1 to n (0355–1 to n)

Prerequisite

In the **Simulation current output 1 to n** parameter, the **On** option is selected.

Description

Use this function to enter a current value for the simulation. In this way, users can verify the correct adjustment of the current output and the correct function of downstream switching units.

User entry

- 1. Default value: Select 4.0 mA.
- 2. Default value: Select 20.0 mA.

Additional information

Dependency

The input range is dependent on the option selected in the **Current span** parameter.

Testing with a secondary standard (mass flow or volume flow)

Check measured value for liquid and gaseous mass or volume flow by comparing with a secondary standard

Test sequence

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 resolution10 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 the results

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

- ▶ Carefully follow the information in the section on "Restrictions for use in safety-related applications – information on measured errors" → 10.

NOTICE

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

Detailed information on:
- Installation position
- Medium properties
- Operating conditions

Operating Instructions→ 7

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).

I. Test sequence:

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:

a. 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).

b. Comparison of the measured value by measuring the current

1. Measure the current at the DUT using an external, traceably-calibrated ammeter.
   ↳ Note: measuring equipment requirements:
   - DC current measuring uncertainty ±0.2 %
   - DC current resolution 10 µA
2. Measure the current of the DUT at the logic subsystem (process control system or safety-related PLC).

II. Assessment of the results:

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" → 📄 10.

NOTICE

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

Detailed information on:
- Installation position
- Medium properties
- Operating conditions

Operating Instructions→ 📄 7

Testing with a secondary standard and testing of current output 1

- Part 1: Testing with a secondary standard
- Part 2 - Testing of current output 1

Preparation

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

► Deactivate the locked SIL mode → 🖹 20.

Test sequence - Part 1: Testing 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 resolution10 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 - Part 1: Testing with a secondary standard

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

► Carefully follow the information in the section on "Restrictions for use in safety-related applications – information on measured errors" → 🖹 10.

Test step - Part 2 - Testing of current output 1

The **Simulation** submenu (→ 🖹 23) (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 **Simulation current output** parameter (→ 🖹 24) and the **Value current output** parameter (→ 🖹 25), as these are the only parameters approved for testing the safety-related characteristics.

1. In the **Value current output** parameter (→ 🖹 25), select the defined default values one after the other.
2. Compare current at output 1 with this default value.

Comparing the current values

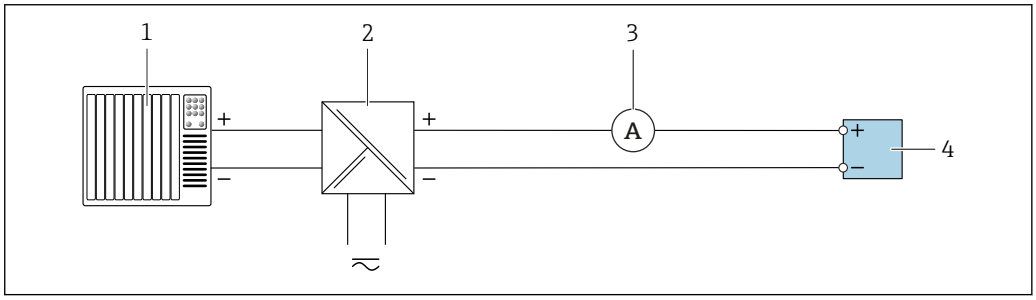
The current values can be compared using one of the following methods:
- Measure the current of the DUT at the logic subsystem (process control system or safety-related PLC).
- Measure the current at the DUT using an external, traceably-calibrated ammeter.

► Compare the current values.

Connecting the measuring equipment and external testing

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

Requirements for the measuring equipment:
- DC current measuring uncertainty ±0.2 %
- DC current resolution10 µA



2 *External verification of 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 - Part 2: 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.

► Note data relating to measured error→ 13.

Connecting the test

1. Re-activate the locked SIL mode→ 15.
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 are detected using these test sequences (PTC = 0.99). The influence of systematic errors on the safety function is not fully covered by the test. Systematic faults can be caused, for example, by medium properties, operating conditions, build-up 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.

Detailed information on:
- Installation position
- Medium properties
- Operating conditions

Operating Instructions→ 7

Simulation current output 1 to n

Navigation Diagnostics → Simulation → Simulation current output 1 to n (0354–1 to n)

Description Use this function to switch simulation of the current output on and off. The display alternates between the measured value and a diagnostic message of the "Function check" category (C) while simulation is in progress.

Selection On

Additional information

Description

The desired simulation value is defined in the **Value current output 1 to n** parameter.

Selection

- Off
  Current simulation is switched off. The device is in normal measuring mode or another process variable is being simulated.
- On
  Current simulation is active.

Value current output 1 to n

Navigation Diagnostics → Simulation → Value current output 1 to n (0355–1 to n)

Prerequisite In the **Simulation current output 1 to n** parameter, the **On** option is selected.

Description Use this function to enter a current value for the simulation. In this way, users can verify the correct adjustment of the current output and the correct function of downstream switching units.

User entry

- 1. Default value: Select 4.0 mA.
- 2. Default value: Select 20.0 mA.

Additional information

Dependency

The input range is dependent on the option selected in the **Current span** parameter.

Heartbeat Technology

Heartbeat Technology continuously diagnoses whether failures have occurred. The scope of the diagnostics in the SIL mode corresponds to the SFF.

Heartbeat Technology also allows operators to create documented proof that diagnostic checks have been carried out and thereby supports the documentation of proof testing in accordance with IEC 61511-1, Section 16.3.3, "Documentation of proof testing and inspections".

NOTICE

The SIL mode needs to be disabled temporarily in order to perform heartbeat verification.

- On completion of the verification, the SIL mode must be enabled again .

The **Heartbeat Verification** application package is available as an order option and can be retrofitted on all measuring devices.

Please contact your Endress+Hauser service or sales organization to retrofit the device.

Life cycle

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.

Installation

Installation and electrical connection

Detailed information on:

- Installation
- Electrical connection
- Medium properties
- Environment
- Process

Operating Instructions and Technical Information → 7

Installation position

For detailed information on the orientation, see the Operating Instructions. → 7

Commissioning

For detailed information on commissioning, see the Operating Instructions. → 7

Operation

For detailed information on the operating options, see the Operating Instructions.→ 7

Maintenance

For detailed information on maintenance, see the Operating Instructions. → 7

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

Repair

Repair means restoring functional integrity by replacing defective components. Components of the same type must be used for this purpose. It is recommended to document the repair. This includes specifying the device serial number, the repair date, the type of repair and the individual who performed the repair.

For detailed information on returns, see the Operating Instructions. → 7

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:
- Calibrated sensor component
- Transmitter without a sensor
- Display module
- Main electronics module
- I/O-Module
- Terminals for I/O modules
- Electronics compartment cover
- Seal sets for electronics compartment cover
- Securing clamps for electronics compartment cover
- Pressure compensation vent
- Cable glands

Installation Instructions: see the Download Area at 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 also refer to the "Return" section in the Operating Instructions. → 7.

Modification

Modifications are changes to devices with SIL capability already delivered or installed.
- ▶ Modifications to devices with SIL capability are usually performed in the Endress+Hauser manufacturing center.
- ▶ Modifications to devices with SIL capability onsite at the user's plant are possible following approval by the Endress+Hauser manufacturing center. In this case, the modifications must be performed and documented by an Endress+Hauser service technician.
- ▶ Modifications to devices with SIL capability by the user are not permitted.

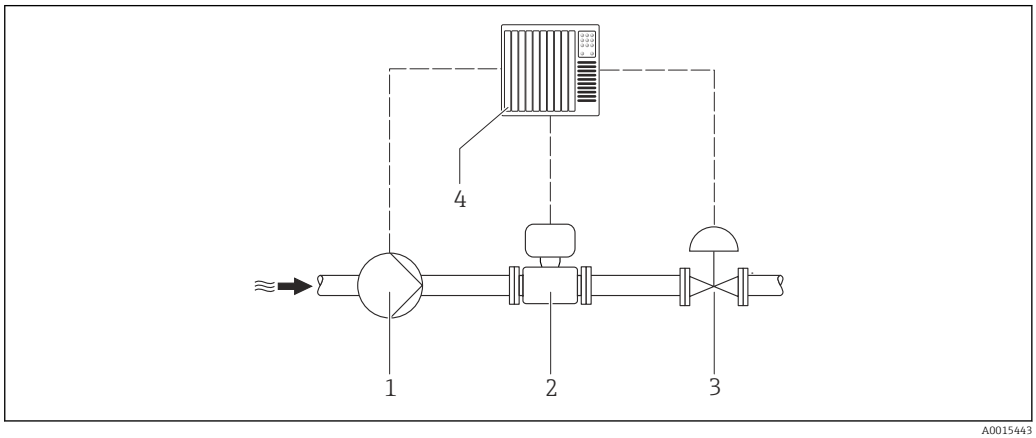
Decommissioning

For detailed information on decommissioning, see the Operating Instructions for the device → 7

Appendix

Structure of the measuring system

System components



3 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.

Description of use of protective system

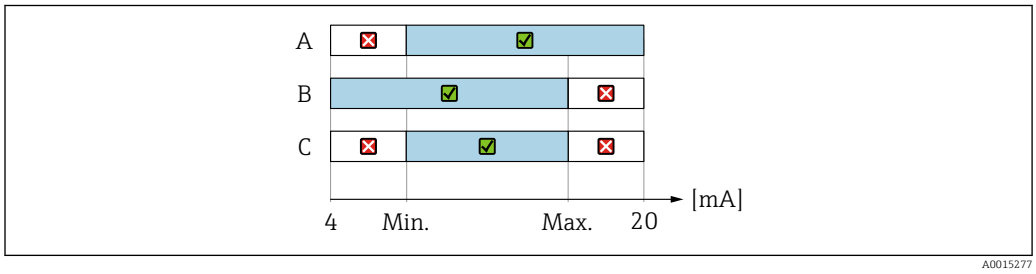
The measuring device can be used in protective systems to monitor the following (Min., Max. and range):
- Volume flow
- Mass flow
- Density

NOTICE

The device must be correctly mounted to guarantee safe operation.

▶ Observe the mounting instructions.

For detailed information on mounting, see the Operating Instructions → 7



4 *Monitoring options in protective systems*

A Min. alarm
B Max. alarm
C Range monitoring

= *Safety function is triggered*

= *Permitted operating status*

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.

▶ Activation of the SIL mode → 15.

Notes on the redundant use of multiple sensors

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

The common cause factors β and β_D indicated below are minimum values for the device. These must be used when designing the sensor subsystem:
- Minimum value β for homogeneously redundant use: 2 %
- Minimum value β_D for homogeneously redundant use: 1 %

The device meets the requirements for SIL 3 in homogeneously redundant applications.

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.

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.

Version history

Version	Changes	Valid as of firmware version
SD00147D/06/xx/11.19	New certificate	01.04.zz (HART; from delivery date June 1, 2015)
SD00147D/06/xx/10.18	Proof test modified.	01.04.zz (HART; from delivery date June 1, 2015)
SD00147D/06/xx/09.18	Amendment concerning 8A2B (new sensor generation A)	01.04.zz (HART; from delivery date June 1, 2015)
SD00147D/06/xx/08.16	Amendment concerning 8E2C (new sensor generation E)	01.04.zz (HART; from delivery date June 1, 2015)
SD00147D/06/xx/06.15	Low flow cut off can be configured in the SIL mode and integral part of the SIL confirmation sequence	01.04.zz (HART; from delivery date June 1, 2015)
SD00147D/06/xx/05.14	Diagnostic message S912 "Fluid not homogeneous" does not force a switchover to an alarm in the SIL mode (adjustment of the safety-related characteristic quantities)	01.03.zz (HART; from delivery date March 1, 2014)
SD00147D/06/xx/03.14	–	01.02.zz (HART; from delivery date July 1, 2012)
SD00147D/06/xx/02.12	–	01.02.zz (HART; from delivery date July 1, 2012)
SD00147D/06/xx/01.11	First version	01.01.zz (HART; from delivery date July 1, 2011)

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