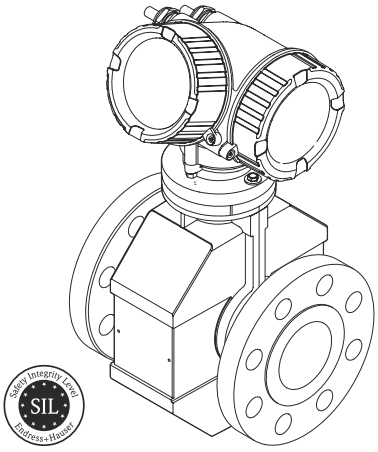
Special Documentation
Proline Promag 200

Functional Safety Manual



Electromagnetic flowmeter with two-wire technology and 4–20 mA output signal

Application

Monitoring of maximum and/or minimum flow in systems which are required to comply with the particular safety circuit requirements of IEC 61508.

The measuring device fulfills the requirements concerning:
- Functional safety as per IEC 61508
- Explosion protection (depending on the version)
- Electromagnetic compatibility as per IEC 61326-3-2 and NAMUR recommendation NE 21
- Electrical safety as per IEC 61010-1

Your benefits

- Use for volume flow monitoring up to SIL 2 (single-channel architecture) or SIL 3 (multi-channel architecture with homogeneous redundancy) - independently assessed and certified by TÜV in accordance with IEC 61508
- Measurement is virtually independent of the process properties
- Permanent self-monitoring
- Easy installation and commissioning
- Integrated proof-testing
- Heartbeat verification for the documentation of diagnostic checks in accordance with IEC 61511

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

Promag 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, 09. Juni. 2015

Endress+Hauser Flowtec AG

ppa.
Dr.-Ing. Christian Jarms
Head of Quality Management

i.V.
Dipl.-Ing. Michael Karolzak
Project Manager Functional Safety

Safety-related characteristic values

General			
Device designation and permitted versions	5H2B (Promag H 200) 5P2B (Promag P 200)		
	Order code for "Output": ▪ Option **A** "4-20mA HART" ▪ Option **B** "4-20mA HART, pul./freq./switch output" Order code for "Additional approval": Option **LA** "SIL"		
Safety-related output signal	4 to 20 mA		
Error current	≤ 3.6 mA or ≥ 21 mA		
Assessed measured variable/function	Volume flow monitoring		
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 April 1 2015		
Valid firmware version	01.01.zz and higher (HART; from delivery date April 1 2015)		
Safety manual	SD01451D		
Type of assessment (only one version can be selected)	☑	Complete HW/SW assessment in the context of development including FMEDA and change process according to 61508-2, 3	
	☐	Assessment of evidence for proven-in-use HW/SW including FMEDA and change process according to 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/FSP 1135.00/15		
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		
λ_{DU} [2]	156 FIT		
λ_{DD} [2]	1574 FIT		
λ_{SU} [2]	608 FIT		
λ_{SD} [2]	1051 FIT		
SFF - Safe Failure Fraction	95 %		
PFD_{avg} for T_1 = 1 year [3] (single-channel architecture)	$6.81 \cdot 10^{-4}$		
PFD_{avg} for T_1 = 3 years [3] (single-channel architecture)	$2.04 \cdot 10^{-3}$		
PFH	$1.56 \cdot 10^{-7} \cdot 1/h$		
PTC [4]	Up to 98 %		
$MTBF_{tot}$ [5]	33.7 years		
Diagnostic test interval [6]	30 min		

Fault response time [7]	30 s
Process safety [8]	50 h
Recommended test interval T_1	3 years
$MTTF_d$ [9]	66 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 according to 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).
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 time is the diagnostic test interval * 100 (calculation according to IEC 61508).
9) $MTTF_d$ according to ISO 13849/IEC 62061 also includes soft errors (sporadic bit errors in data memories).

Useful lifetime of electric components

The established failure rates of electric 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 no. E5ABBF02000 → 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

SIL certificate

Certificate

Product Safety
Functional Safety

TÜVRheinland CERTIFIED

www.tuv.com
ID 0600000000

Nr./No.: 968/FSP 1135.00/15

Prüfgegenstand **Product tested**	Messgerät für die sichere Messung von Volumendurchfluss Meter for the safe measurement of volume flow	**Zertifikats-inhaber** **Certificate holder**	Endress + Hauser Flowtec AG Kägenstraße 7 4153 Reinach BL 1 Switzerland
Typbezeichnung **Type designation**	Promag 200 with the IO-Modul "IO211 Ex-i, 212 Ex-d" (Option A, B)		
Prüfgrundlagen **Codes and standards**	IEC 61508 Parts 1-7:2010		
Bestimmungsgemäße Verwendung **Intended application**	Das Messgerät erfüllt die Anforderungen der Prüfgrundlagen (HW Sicherheitsintegrität SIL 2 und systematische Sicherheitsintegrität SIL 3 nach IEC 61508) für die Sicherheitsfunktion Messung von Volumendurchfluss am Stromausgang 1 (4-20mA). Es kann in Anwendungen bis SIL 2 (HFT=0) bzw. SIL 3 (HFT=1) nach IEC 61508 eingesetzt werden. In der Betriebsart mit hoher Anforderungsrate und in einer HFT=0 Struktur ist die sichere Verwendung des Gerätes auf eine Anforderungsrate der Sicherheitsfunktion von ≤ 1/50 h beschränkt. Details siehe Rückseite des Zertifikates. The measurement device complies with the requirements of the relevant standards (HW Safety Integrity SIL 2 and Systematic Safety Integrity SIL 3 acc. to IEC 61508) for the safety function measurement of volume flow rate at current output 1 (4-20mA). It can be used in applications up to SIL 2 (HFT=0) resp. SIL 3 (HFT=1) acc. to IEC 61508. In high demand mode and HFT=0 architecture the safe use of the device is limited to a demand rate of the safety function ≤ 1/50 h. Details see backside of certificate.		
Besondere Bedingungen **Specific requirements**	Die Hinweise in der zugehörigen Installations- und Betriebsanleitung sind zu beachten. The instructions of the associated Installation and Operating Manual shall be considered.		

Gültig bis / Valid until 2020-05-29

Der Ausstellung dieses Zertifikates liegt eine Prüfung zugrunde, deren Ergebnisse im Bericht Nr. 968/FSP 1135.00/15 vom 29.05.2015 dokumentiert sind.
Dieses Zertifikat ist nur gültig für Erzeugnisse, die mit dem Prüfgegenstand übereinstimmen. Es wird ungültig bei jeglicher Änderung der Prüfgrundlagen für den angegebenen Verwendungszweck.
The issue of this certificate is based upon an examination, whose results are documented in Report No. 968/FSP 1135.00/15 dated 2015-05-29.
This certificate is valid only for products which are identical with the product tested. It becomes invalid at any change of the codes and standards forming the basis of testing for the intended application.

TÜV Rheinland Industrie Service GmbH
Bereich Automation
Funktionale Sicherheit
Am Grauen Stein, 51105 Köln

Köln, 2015-05-29

Certification Body for FS-Products

Dipl.-Ing. Heinz Gall

www.fs-products.com
www.tuv.com

TÜVRheinland®
Precisely Right.

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A0026814

Document information

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 Download Area of the Endress+Hauser Internet site: www.de.endress.com/SIL

Using this document

Information on the document structure

For information on the arrangement of the parameters in accordance with the menu structure **Operation** menu, **Setup** menu, **Diagnostics** menu along with a short description, see the Operating Instructions for the device.

For information about the operating philosophy, see the "Operating philosophy" chapter in the device's Operating Instructions

Symbols used

Safety symbols

Symbol	Meaning
DANGER	**DANGER!** This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.
WARNING	**WARNING!** This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.
CAUTION	**CAUTION!** This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.
NOTICE	**NOTE!** 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 Refers to the corresponding device documentation.
	Reference to page Refers to the corresponding page number.
	Reference to graphic Refers to the corresponding graphic number and page number.
	Operation via local display Indicates navigation to the parameter via the local display.
	Operation via operating tool Indicates navigation to the parameter via the operating tool.
	Write-protected parameter Indicates a parameter that can be locked against changes by entering a user-specific code.

Symbols in graphics

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

Supplementary documentation

For an overview of the scope of the associated Technical Documentation, refer to the following:
- The CD-ROM provided for the device (depending on the device version, the CD-ROM might not be part of the delivery!)
- The *W@M Device Viewer* : Enter the serial number from the nameplate (www.endress.com/deviceviewer)
- The *Endress+Hauser Operations App*: Enter the serial number from the nameplate or scan the 2-D matrix code (QR code) on the nameplate.

Standard documentation

Operating Instructions

Measuring device	Documentation code
Promag H 200	BA01110D
Promag P 200	BA01111D

Description of Device Parameters

Measuring device	Documentation code
Promag 200	GP01026D

Technical Information

Measuring device	Documentation code
Promag H 200	TI01061D
Promag P 200	TI01062D

Supplementary device-dependent documentation

Safety Instructions

Contents	Documentation code
ATEX/IECEx Ex d[ia], Ex tb	XA01015D
ATEX/IECEx Ex ia, Ex tb	XA01016D
ATEX/IECEx Ex nA, Ex ic	XA01017D
cCSAus XP (Ex d)	XA01018D
cCSAus IS (Ex i)	XA01019D
NEPSI Ex d	XA01179D
NEPSI Ex i	XA01178D
NEPSI Ex nA, Ex ic	XA01180D
INMETRO Ex d	XA01309D
INMETRO Ex i	XA01310D
INMETRO Ex nA	XA01311D

Special Documentation

Contents	Documentation code
Information on the Pressure Equipment Directive	SD01056D
Heartbeat Technology	SD01452D

Installation Instructions

Contents	Documentation code
Installation Instructions for spare part sets	Overview of accessories available for order: Operating Instructions for the device

Permitted devices types

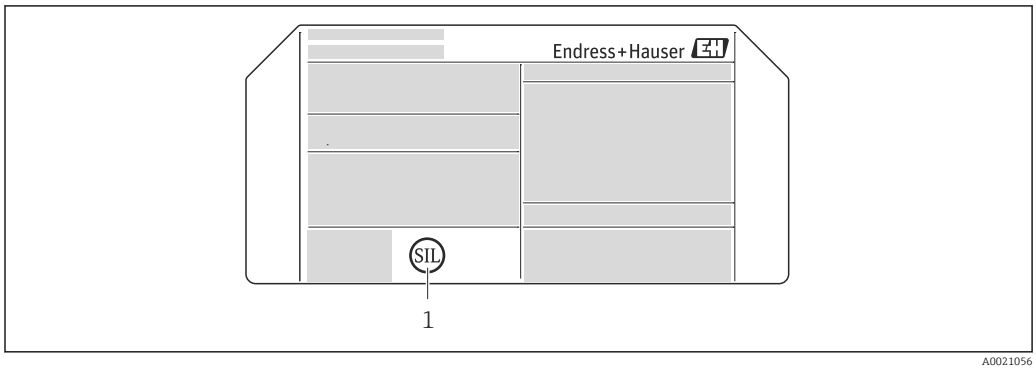
The details pertaining to functional safety in this manual relate to the device versions listed below and are valid as of the specified software and hardware versions. Unless otherwise specified, all subsequent versions can also be used for safety functions. A modification process according to IEC 61508 is applied for any device modifications.

Feature	Designation	Selected option
–	Order code	5H2B (Promag H 200) 5P2B (Promag P 200)
000	Nominal diameter	H: DN 2 to 25 (1/12 to 1") P: DN 15 to 200 (½ to 8")
010	Approval	All
020	Output [1]	Option **A** "4-20mA HART" Option **B** "4-20mA HART, pul./freq./switch output"
030	Display; operation	All
040	Housing	All
050	Electrical connection	All
060	Lining	All
070	Process connection	All
075	Electrodes	All
080	Calibration flow	All
500	Display operating language	All
520	Sensor option	All
530	Customer-specific configuration	All
540	Application package	All
570	Service	All
580	Test, certificate	All
590	Additional approval	LA (= SIL) [2]
610	Accessories mounted	All
620	Accessories enclosed	All
850	Firmware version	Firmware with SIL capabilities, e.g. 01.01.zz (HART)
895	Tagging	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) Additional selection of further approvals is possible.

- Valid hardware version (main electronics): From delivery date April 1 2015
- Valid firmware version: 01.01.zz and higher (HART; from delivery date April 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 volume flow for liquid media
- Monitoring of a volume flow range for liquid media

Safety-related output signal

The measuring device's safety-related signal is the 4 to 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"* → 🖹 11) 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 volume flow
- The occurrence of a fault, e.g. error current (≤ 3.6 mA, ≥ 21 mA), interruption or short-circuit of the signal line

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.

For detailed information about the measured error, refer to the "Information on measured errors" section → 🖹 13

For detailed information about the maximum measured error, see the Operating Instructions for the device → 🖹 9

Restrictions for use in safety-related applications

Do not exceed the values specified in the device documentation: see the "Supplementary documentation" section → 🖹 9.

Suitability of the measuring device

Carefully select the nominal diameter of the measuring device in accordance with the application's expected flow rates.

For detailed information on selecting the nominal diameter, see the Technical Information for the device → 🖹 9

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.

For detailed information about the installation and electrical connection, as well as information about the medium properties, the environment and the process, see the Operating Instructions and Technical Information for the device → 🖹 9

⚠ CAUTION

For liquids that readily boil or in the case of suction lines:

- Ensure that the vapor pressure is not undershot 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.
- In order to guarantee correct measurement, ensure that no cavitation occurs.
- Avoid applications that cause buildup, corrosion or abrasion.

Detailed 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 detailed information on calculating the measured error, see the Technical Information for the device → 🖹 9

Guidelines for minimal measured errors:
Limit value monitoring: Depending on the process dynamics, the current value of the unfiltered 4–20 mA output signal can temporarily exceed the specified tolerance 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 an error current (≤ 3.6 mA, ≥ 21 mA) are not affected by this damping.

Power supply for the 4–20 mA interface

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

Therefore, it is necessary to 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, see the section on "Safety-related values" in the Technical Information → 🖹 9

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 to 20 mA analog output signal.
All safety measures refer to this signal exclusively.

- Pay attention to information in the "Safety-related output signal" section → 🖹 12.

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), the HART protocol and the onsite display.

- Deactivation of the SIL mode .

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 error current during this time. This current is ≤ 3.6 mA in the initial seconds of this start-up phase.

No communication is possible via the service interface (CDI) or via the HART protocol 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 response in the event of alarms or 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 the error current ≥ 21 mA cannot be set) output currents of ≤ 3.6 mA occur irrespective of the configured error current.

In some other cases, (e.g. short-circuit of the line) output currents of ≥ 21 mA occur irrespective of the configured error 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

The alarm and warning messages output on the device display or in the operating tool in the form of diagnostic events and the associated event text are additional information.

For an overview of the diagnostic events, see the Operating Instructions → 9

NOTICE

When SIL mode is activated, additional diagnostics are activated.
If a diagnostic event occurs and the locked SIL mode is deactivated, the error message remains while the error persists, even if the diagnostic event is no longer active in the unlocked state.
- ▶ 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.

Parameter configuration for safety-related applications

Configuration of the measuring point

Either the device display or an operating tool (e.g. FieldCare) is used to carry out basic configuration of the measuring point. FieldCare) vorgenommen. A wizard guides you through the **Setup** menu.

For detailed information on operation, see the Operating Instructions for the device → 9

After the operating language has been selected, the following can be configured:
- Selection and configuration of the medium
- Configure the current output
- 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

For further configuration of the measuring device in special applications a large number of other configuration parameters are available through the **Diagnostics** menu and the **Expert** menu .

For detailed information on the further configuration of the measuring device, refer to the documentation "Description of Device Parameters"

To activate the SIL mode, the device must run through a confirmation sequence. Operation can be via the local display or an operating tool (e.g. FieldCare). While running through this sequence here, critical parameters are either set automatically by the device to standard values or transferred to the 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 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 function is available when the measuring device is delivered to the customer. The function is accessed via the operating interfaces of the measuring device or via the operating tool (e.g. FieldCare).
- 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"*

Additional information on SIL labeling:
- Permitted device types → 🖹 11
- SIL label on the transmitter nameplate → 🖹 12

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.)

Activating SIL mode (= locking)

When SIL mode is activated, 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.

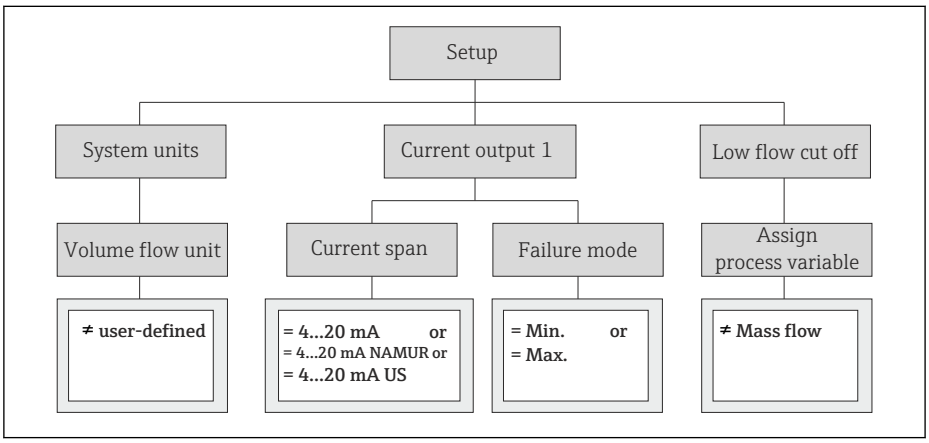
NOTE!

Once the SIL mode has been activated, 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, the HART protocol and the local display.

Locking procedure:

1) www.endress.com/deviceviewer

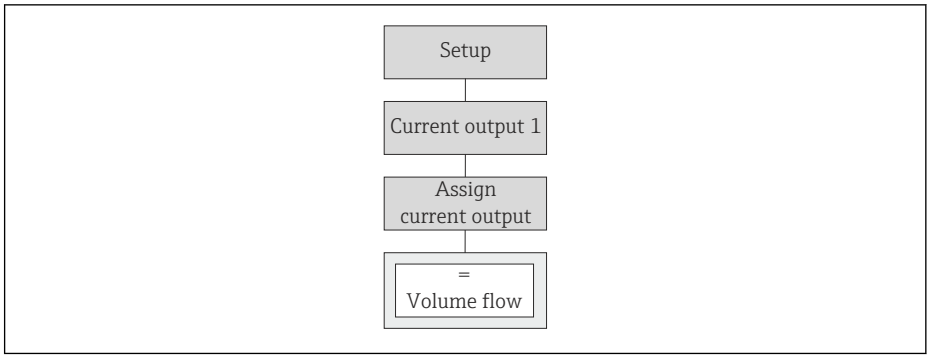
1. Check preconditions.



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

4. Enter the SIL locking code **7452**.

↳ **NOTE!**
The device first checks the preconditions listed under item 1.
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.
If the conditions 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:
NOTE!
If the measuring device has been set to mass flow, the **Assign current output** parameter in the SIL confirmation sequence switches automatically to the **Volume flow** option. Here, the **4 mA value** parameter and the **20 mA value** parameter are reset to default values.
▸ Cancel the SIL confirmation sequence.
▸ Check the settings of the current output and change them if necessary.



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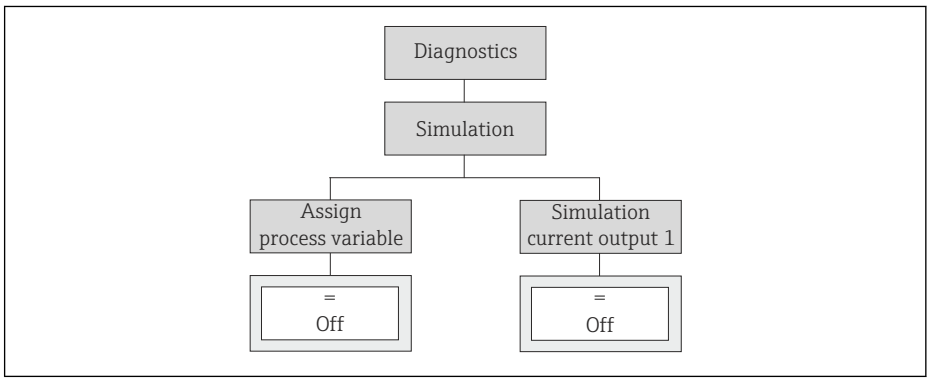

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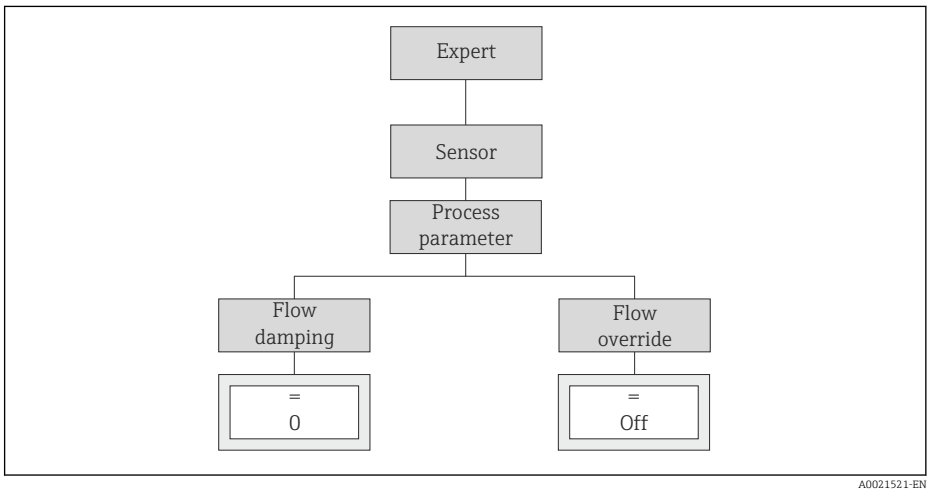
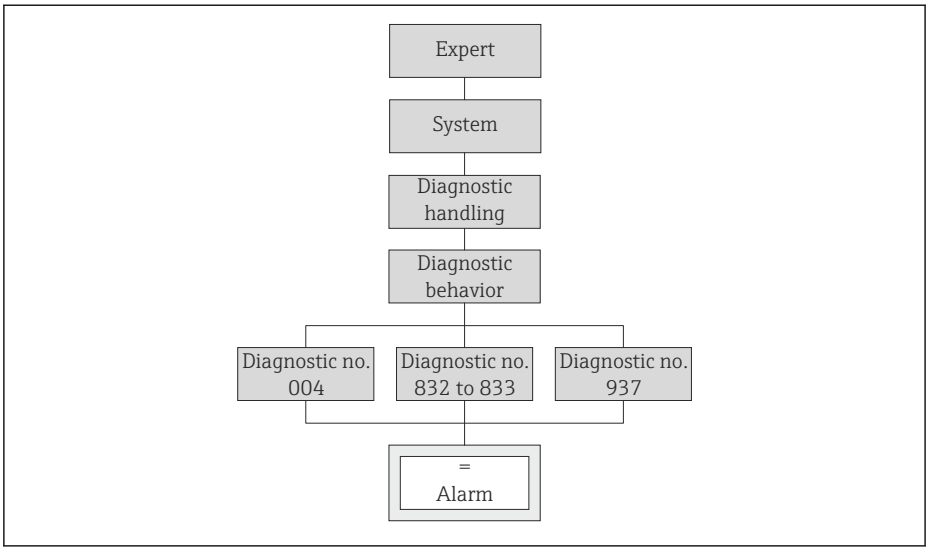


A0021521-EN

NOTE!

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.
004: diagnostic message ⚠**S004 Sensor**
832: diagnostic message ⚠**S832 Electronic temperature too high**
833: diagnostic message ⚠**S833 Electronic temperature too low**
937: diagnostic message ⚠**S937 EMC interference**



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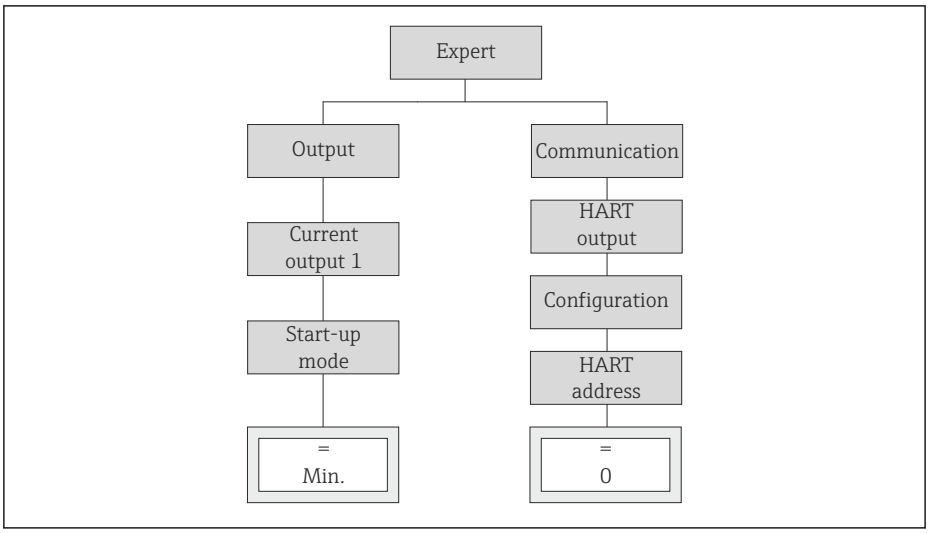

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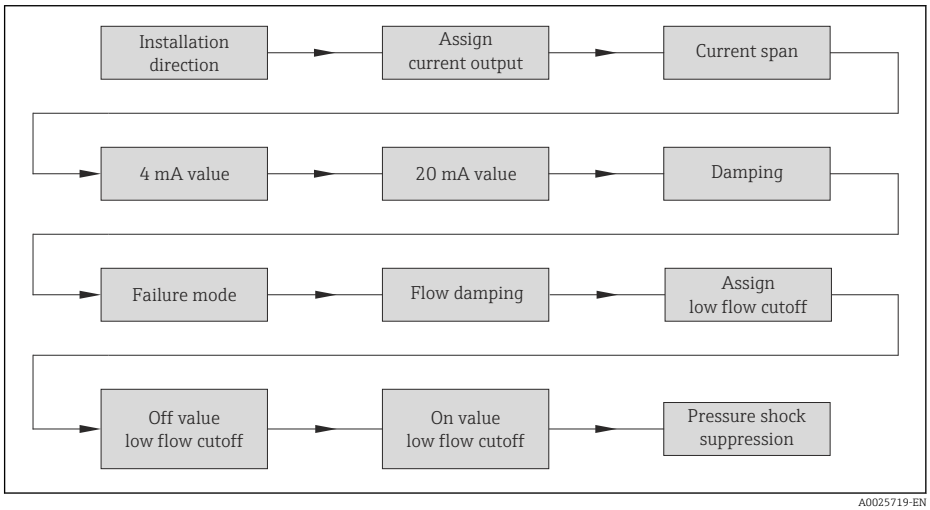
To check that values are displayed correctly, the following string appears on the device display or operating tool: **0123456789+-.**

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:
   NOTE!
   For detailed information on the parameters in the following graphic, see the Operating Instructions for the device → 📖 9



6. At the end of the check, the SIL locking code **7452** must be entered again in the **Set write protection** parameter 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.

Recommendations:
- Check the position of the hardware write protection switch (dip switch marked "WP [2]" on main electronics), and set this switch to **On** if necessary.
- 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 mode is not activated. The safety-oriented parameter settings have been made but SIL locking has not been enabled.

▶ Perform SIL mode activation once more.

Deactivating SIL mode (= unlocking)

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 mode is deactivated.

Unlocking procedure:

1. Check the position of the hardware write protection switch and set this switch to **Off** if necessary.
2. Enter the user-specific release code if necessary.
3. Select the **Deactivate SIL** wizard in the **Setup** menu → **Advanced setup** submenu.

2) Write Protection

4. Select the **Reset write protection** parameter.
5. Enter the SIL locking code **7452**.
   ↳ If the SIL locking code has been entered correctly, the message **"End of sequence"** appears on the display.
6. 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 protection unit.
- ▶ 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:

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

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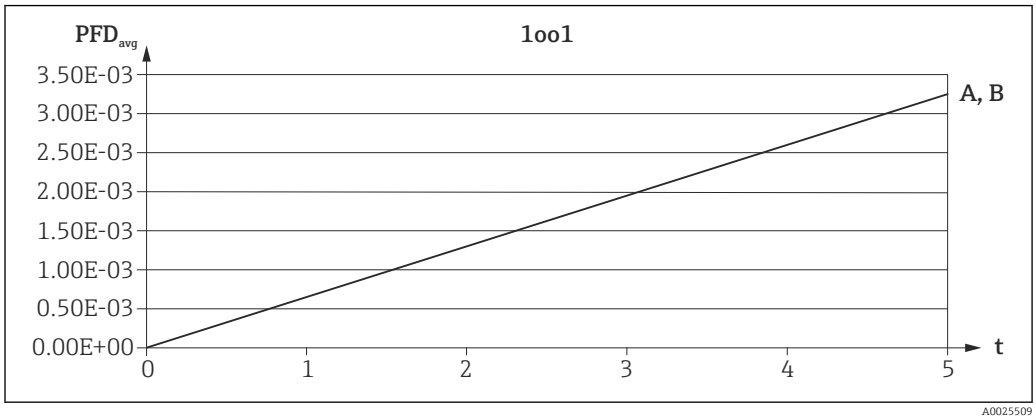
MT Mission time
PTC Proof test coverage
Ti Test interval

3. The operator also specifies the procedure for proof-testing.
   ↳ **NOTE!**
   In accordance with IEC 61511, as an alternative to testing the safety function of the entire system an independent proof test of the subsystems, → 21 e.g. the sensor, is permitted.

Average probability of failure and useful lifetime

PFD_{avg} for a single-channel system:



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t	*Mission time in years*
A, B	*Output versions* → 11
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 alternative is available for testing the sensor subsystem [3] depending on the measured variable "volume flow" used for the safety function.

Check of the measured value for liquid volume flow

I. 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:

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 flow rate and the set point 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" → 12.

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

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.

For detailed information on the orientation, medium properties and operating conditions, refer to the Operating Instructions for the device → 9

Heartbeat Technology

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

Heartbeat 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".

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

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.

For detailed information on the verification of the measuring device with **Heartbeat Verification**,refer to the Special Documentation for the device → 9

Life cycle

Requirements for personnel

The personnel for installation, commissioning, diagnostics, repair and maintenance must meet 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 beginning work, the specialist staff must have read and understood the instructions in the manuals and supplementary documentation as well as in the certificates (depending on the application)
- Follow instructions and comply with basic conditions

The operating personnel must meet 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

For detailed information about the installation and electrical connection, as well as information about the medium properties, the environment and the process, see the Operating Instructions and Technical Information for the device → 9

Orientation

For detailed information on the orientation, see the Operating Instructions for the device → 9

Commissioning

For detailed information on commissioning, see the Operating Instructions for the device → 9

Operation

For detailed information on operation, see the Operating Instructions for the device → 9

Maintenance

For detailed information on maintenance, see the Operating Instructions for the device → 9

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

Repairs

Repair means restoring functional integrity by replacing defective components. Components of the same type must be used for this purpose. We recommend documenting 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 device returns, see the Operating Instructions for the device → 9

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 modules
- 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 capable device in protection system" when returning the defective device. Please also refer to the "Return" section in the Operating Instructions .→ 9.

Modification

Modifications are changes to SIL capable devices already delivered or installed.

Modifications to SIL capable devices are usually performed in the Endress+Hauser manufacturing center.

Modifications to SIL capable devices 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 SIL capable devices by the user are not permitted.

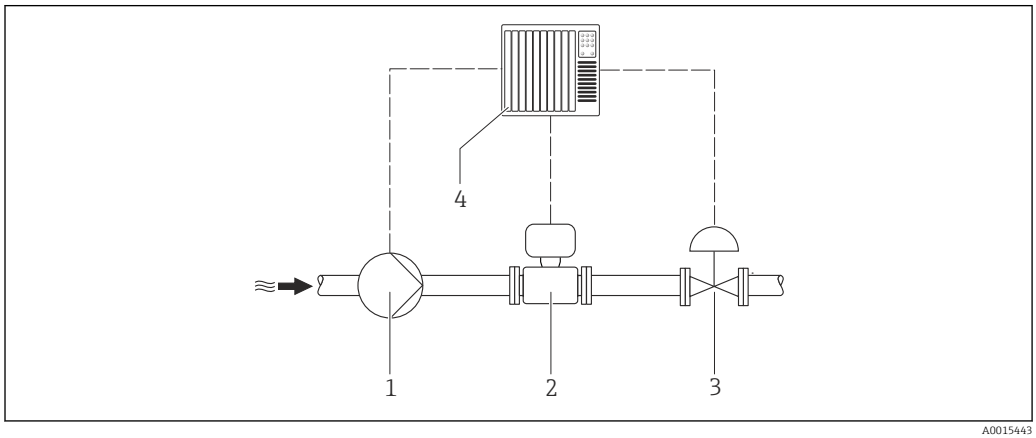
Decommissioning

For detailed information on decommissioning, see the Operating Instructions for the device → 9

Appendix

Structure of the measuring system

System components



1 *System components*

1 *Pump*
2 *Measuring device*
3 *Valve*
4 *Automation system*

An analog signal (4–20 mA) proportional to the volume flow 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 (volume flow monitoring) is implemented in this way.

Description of use of protective system

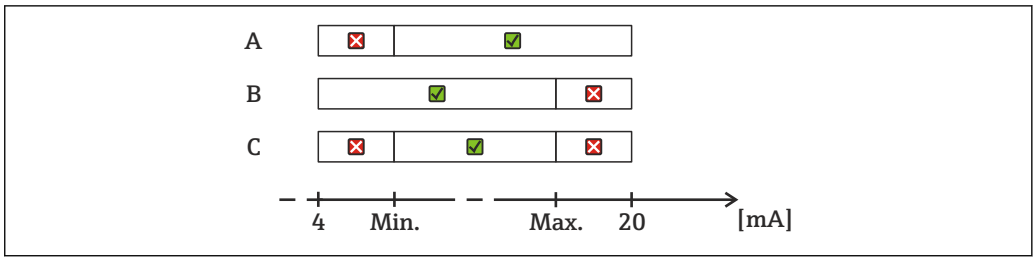
The measuring device can be used in protective systems to monitor the following (Min., Max. and range):
Volume flow

NOTICE

The device must be correctly mounted to guarantee safe operation.

- ▶ Observe the mounting instructions.

For detailed information on mounting, see the Operating Instructions for the device



2 *Monitoring options in protective systems*

A Min. alarm
B Max. alarm
C Range monitoring

= *Safety function is triggered*

= *Permitted operating status*

Verification or calibration

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 .

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. When installing identical sensors, i.e. the same type and nominal diameter, the sensors must not be connected directly flange to flange but at different locations in the pipe. This is to prevent the sensors from affecting each other acoustically.

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
SD01451D/06/xx/01.15	First version	01.01.zz (HART; from delivery date April 1 2015)

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