Coriolis flowmeter

Application
Monitoring of the maximum and/or minimum flow or density in systems which are required to comply with the particular functional safety 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 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
- Alternatively also suitable for density monitoring
- 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
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Manufacturer's Declaration

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

Endress+Hauser Flowtec AG, Rügenstrasse 7, 4153 Reinsch

erklärt als Hersteller, dass die Durchflussmessgeräte aus der Serie Proline Promass 300 (8a3B )
Proline Promass 500 (8a5B )
Proline Cubemass 300 (8C3B )
Proline Cubemass 500 (8C5B )
a = A, B, F, H, I, O, P, Q, S, X
in sicherheitsrelevanten Anwendungen SIL 2 (HFT=0) bzw. SIL 3 (HFT=1) nach IEC 61508:2010
eingesetzt werden können.
are suitable for use in safety relevant applications up to SIL 2 (HFT=0) resp. SIL 3 (HFT=1) acc. IEC
61508:2010.

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

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

Endress+Hauser Flowtec AG

[Signatures]

Dr. B.-J. Schäfer
Managing Director

M. Karolczak
Project Manager Functional Safety

Endress+Hauser
People for Process Automation
# Safety-related characteristic values

## General

<table>
<thead>
<tr>
<th>Device designation and permitted versions</th>
<th>8A3B (Promass A 300)</th>
<th>8E3B (Promass E 300)</th>
<th>8F3B (Promass F 300)</th>
<th>8H3B (Promass H 300)</th>
<th>8I3B (Promass I 300)</th>
<th>8O3B (Promass O 300)</th>
<th>8P3B (Promass P 300)</th>
<th>8Q3B (Promass Q 300)</th>
<th>8S3B (Promass S 300)</th>
<th>8X3B (Promass X 300)</th>
</tr>
</thead>
</table>

Order code for "Output; input 1":
- Option BA "4-20mA HART"
- Option BB "4-20mA + Wireless HART"
- Option CA "4-20mA HART Ex-i"
- Option CB "4-20mA Ex-i + Wireless HART"

Order code for "Output; input 2": All options
Order code for "Output; input 3": All options
Order code for "Additional approval": Option LA "SIL"

### Safety-related output signal
- 4 to 20 mA (output; input 1)

### Error current
- $\leq 3.6$ mA or $\geq 21$ 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
- $\square$ Type A
- $\otimes$ Type B

### Operating mode
- $\checkmark$ Low Demand Mode
- $\otimes$ High Demand Mode
- $\square$ Continuous Mode

### Valid hardware version (main electronics)
- From delivery date August 2, 2016

### Valid firmware version
- 01.00.zz and higher (HART; from delivery date August 2, 2016)

### Safety manual
- SD01727D

### Type of assessment (only 1 version can be selected)
- $\checkmark$ Complete HW/SW assessment in the context of development including FMEDA and change process according to 61508-2, 3
- $\square$ Assessment of evidence for proven-in-use HW/SW including FMEDA and change process according to 61508-2, 3
- $\square$ Analysis of HW/SW field data for evidence of "prior use" according to IEC 61511
- $\square$ 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 1306.00/16

### Test documents
- Development documents, test reports, data sheets

### SIL integrity

<table>
<thead>
<tr>
<th>Systematic safety integrity</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\square$ SIL 2 capable</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Hardware safety integrity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single-channel service (HFT = 0)</td>
</tr>
<tr>
<td>Multi-channel service (HFT $\geq$ 1)</td>
</tr>
</tbody>
</table>

### FMEDA

<table>
<thead>
<tr>
<th>Safety function(s)</th>
<th>Min., Max., Range</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Option BA, BB</td>
</tr>
<tr>
<td>$\lambda_{DU}$ $^{2)}$</td>
<td>121 FIT</td>
</tr>
<tr>
<td>$\lambda_{DD}$ $^{2)}$</td>
<td>1366 FIT</td>
</tr>
<tr>
<td>Parameter</td>
<td>Value</td>
</tr>
<tr>
<td>-----------------------------------------------</td>
<td>---------------</td>
</tr>
<tr>
<td>( \lambda_{SU} ) 2)</td>
<td>871 FIT</td>
</tr>
<tr>
<td>( \lambda_{SD} ) 2)</td>
<td>1067 FIT</td>
</tr>
<tr>
<td>SFF - Safe Failure Fraction</td>
<td>97 %</td>
</tr>
<tr>
<td>FIT = Failure In Time, number of failures per 10^9 h</td>
<td></td>
</tr>
<tr>
<td>( PFD_{avg} ) for ( T_1 = 1 ) year 3) (single-channel architecture)</td>
<td>5.3 \cdot 10^{-4}</td>
</tr>
<tr>
<td>( PFD_{avg} ) for ( T_1 = 4 ) years 3) (single-channel architecture)</td>
<td>2.1 \cdot 10^{-3}</td>
</tr>
<tr>
<td>PFH</td>
<td>6.1 \cdot 10^{-8}</td>
</tr>
<tr>
<td>FIT = Failure In Time, number of failures per 10^9 h</td>
<td></td>
</tr>
<tr>
<td>PTC 4)</td>
<td>Up to 98 %</td>
</tr>
<tr>
<td>MTBF(_{tot}) 5)</td>
<td>66 years</td>
</tr>
<tr>
<td>Diagnostic test interval 6)</td>
<td>30 min</td>
</tr>
<tr>
<td>Fault response time 7)</td>
<td>30 s</td>
</tr>
<tr>
<td>Process safety time 8)</td>
<td>50 h</td>
</tr>
<tr>
<td>Recommended test interval ( T_1 )</td>
<td>4 years</td>
</tr>
<tr>
<td>MTTF(_{D}) 9)</td>
<td>77 years</td>
</tr>
<tr>
<td>MTTF(_{D}) as per ISO 13849/IEC 62061 also includes soft errors (sporadic bit errors in data memories)</td>
<td>78 years</td>
</tr>
</tbody>
</table>

**Note**

The measuring device has been developed for use in 'Low Demand' and 'High Demand' mode.

**Explanation**

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 capability.
4) PTC = Proof Test Coverage (diagnostic coverage achieved by device failure detection during manual proof testing)
5) This value takes into account all failure types of the electronic components as per Siemens SN29500
6) All diagnostic functions are carried out at least once during this time.
7) Maximum time between fault detection and fault response.
8) The process safety time amounts to the diagnostic test interval * 100 (calculation as per IEC 61508).
9) MTTF\(_{D}\) as per ISO 13849/IEC 62061 also includes soft errors (sporadic bit errors in data memories).
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 L5ABBF02000 → year of manufacture 2016

<table>
<thead>
<tr>
<th>ASCII character</th>
<th>Meaning</th>
<th>ASCII character</th>
<th>Meaning</th>
<th>ASCII character</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td>2010</td>
<td>K</td>
<td>2015</td>
<td>R</td>
<td>2020</td>
</tr>
<tr>
<td>E</td>
<td>2011</td>
<td>L</td>
<td>2016</td>
<td>S</td>
<td>2021</td>
</tr>
<tr>
<td>F</td>
<td>2012</td>
<td>M</td>
<td>2017</td>
<td>T</td>
<td>2022</td>
</tr>
<tr>
<td>H</td>
<td>2013</td>
<td>N</td>
<td>2018</td>
<td>V</td>
<td>2023</td>
</tr>
<tr>
<td>J</td>
<td>2014</td>
<td>P</td>
<td>2019</td>
<td>W</td>
<td>2024</td>
</tr>
</tbody>
</table>

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 the arrangement of the parameters as per the 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

<table>
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<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>![DANGER]</td>
<td>DANGER! This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.</td>
</tr>
<tr>
<td>![WARNING]</td>
<td>WARNING! This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.</td>
</tr>
<tr>
<td>![CAUTION]</td>
<td>CAUTION! This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.</td>
</tr>
<tr>
<td>![NOTICE]</td>
<td>NOTE! This symbol contains information on procedures and other facts which do not result in personal injury.</td>
</tr>
</tbody>
</table>

Symbols for certain types of information

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>![Tip]</td>
<td>Indicates additional information.</td>
</tr>
<tr>
<td>![Reference]</td>
<td>Reference to documentation</td>
</tr>
<tr>
<td>![Reference]</td>
<td>Reference to page</td>
</tr>
</tbody>
</table>
Symbols in graphics

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>1, 2, 3 ...</td>
<td>Item numbers</td>
</tr>
<tr>
<td>A, B, C, ...</td>
<td>Views</td>
</tr>
<tr>
<td>A-A, B-B, C-C, ...</td>
<td>Sections</td>
</tr>
</tbody>
</table>

Supplementary device documentation

For an overview of the scope of the associated Technical Documentation, refer to the following:
- 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

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<th>Documentation code</th>
</tr>
</thead>
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<td>Promass A 300</td>
<td>BA01482D</td>
</tr>
<tr>
<td>Promass E 300</td>
<td>BA01484D</td>
</tr>
<tr>
<td>Promass F 300</td>
<td>BA01485D</td>
</tr>
<tr>
<td>Promass H 300</td>
<td>BA01486D</td>
</tr>
<tr>
<td>Promass I 300</td>
<td>BA01487D</td>
</tr>
<tr>
<td>Promass O 300</td>
<td>BA01488D</td>
</tr>
<tr>
<td>Promass P 300</td>
<td>BA01489D</td>
</tr>
<tr>
<td>Promass Q 300</td>
<td>BA01490D</td>
</tr>
<tr>
<td>Promass S 300</td>
<td>BA01491D</td>
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<tr>
<td>Promass X 300</td>
<td>BA01492D</td>
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</table>

Description of Device Parameters

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<th>Documentation code</th>
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<tr>
<td>Promass 300</td>
<td>GP01057D</td>
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Technical Information

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<tr>
<th>Measuring device</th>
<th>Documentation code</th>
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</thead>
<tbody>
<tr>
<td>Promass A 300</td>
<td>TI01270D</td>
</tr>
<tr>
<td>Promass E 300</td>
<td>TI01272D</td>
</tr>
<tr>
<td>Promass F 300</td>
<td>TI01221D</td>
</tr>
<tr>
<td>Promass H 300</td>
<td>TI01273D</td>
</tr>
<tr>
<td>Promass I 300</td>
<td>TI01274D</td>
</tr>
<tr>
<td>Promass O 300</td>
<td>TI01275D</td>
</tr>
<tr>
<td>Promass P 300</td>
<td>TI01276D</td>
</tr>
<tr>
<td>Promass Q 300</td>
<td>TI01277D</td>
</tr>
<tr>
<td>Promass S 300</td>
<td>TI01278D</td>
</tr>
<tr>
<td>Promass X 300</td>
<td>TI01279D</td>
</tr>
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</table>

Supplementary device-dependent documentation

Safety Instructions

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<tr>
<th>Contents</th>
<th>Documentation code</th>
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</thead>
<tbody>
<tr>
<td>ATEX/IECEx Ex d/Ex de</td>
<td>XA01414D</td>
</tr>
<tr>
<td>ATEX/IECEx Ex ec</td>
<td>XA01514D</td>
</tr>
<tr>
<td>cCSAus XP</td>
<td>XA01515D</td>
</tr>
<tr>
<td>cCSAus Ex d/ Ex de</td>
<td>XA01516D</td>
</tr>
<tr>
<td>cCSAus Ex nA</td>
<td>XA01517D</td>
</tr>
<tr>
<td>INMETRO Ex d/Ex de</td>
<td>XA01518D</td>
</tr>
<tr>
<td>INMETRO Ex ec</td>
<td>XA01519D</td>
</tr>
<tr>
<td>NEPSI Ex d/Ex de</td>
<td>XA01520D</td>
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<tr>
<td>NEPSI Ex nA</td>
<td>XA01521D</td>
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</tbody>
</table>

Remote display and operating module DKX001

<table>
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<th>Documentation code</th>
</tr>
</thead>
<tbody>
<tr>
<td>ATEX/IECEx Ex i</td>
<td>XA01494D</td>
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<tr>
<td>ATEX/IECEx Ex ec</td>
<td>XA01498D</td>
</tr>
<tr>
<td>cCSAus IS</td>
<td>XA01499D</td>
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<td>cCSAus Ex nA</td>
<td>XA01513D</td>
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<td>INMETRO Ex i</td>
<td>XA01500D</td>
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<td>INMETRO Ex ec</td>
<td>XA01501D</td>
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<td>NEPSI Ex i</td>
<td>XA01502D</td>
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<tr>
<td>NEPSI Ex nA</td>
<td>XA01503D</td>
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</table>

Special Documentation

<table>
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<tr>
<th>Contents</th>
<th>Documentation code</th>
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</thead>
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<td>Information on the Pressure Equipment Directive</td>
<td>SD01614D</td>
</tr>
<tr>
<td>Remote display and operating module DKX001</td>
<td>SD01763D</td>
</tr>
</tbody>
</table>
Installation Instructions

<table>
<thead>
<tr>
<th>Contents</th>
<th>Documentation code</th>
</tr>
</thead>
<tbody>
<tr>
<td>Installation Instructions for spare part sets</td>
<td>For an overview of the accessories available for order, see the Operating Instructions for the device</td>
</tr>
</tbody>
</table>

Permitted device types

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

<table>
<thead>
<tr>
<th>Feature</th>
<th>Designation</th>
<th>Option selected</th>
</tr>
</thead>
<tbody>
<tr>
<td>-</td>
<td>Order code</td>
<td>8A3B (Promass A 300)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8E3B (Promass E 300)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8F3B (Promass F 300)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8H3B (Promass H 300)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8I3B (Promass I 300)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8O3B (Promass O 300)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8P3B (Promass P 300)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8Q3B (Promass Q 300)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8S3B (Promass S 300)</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8X3B (Promass X 300)</td>
</tr>
<tr>
<td>000</td>
<td>Nominal diameter</td>
<td>All</td>
</tr>
<tr>
<td>010</td>
<td>Approval; transmitter + sensor</td>
<td>All</td>
</tr>
<tr>
<td>015</td>
<td>Power supply</td>
<td>All</td>
</tr>
<tr>
<td>020</td>
<td>Output; input 1 1)</td>
<td>• Option BA ‘4-20mA HART’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Option BB ‘4-20mA + Wireless HART’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Option CA ‘4-20mA HART Ex-i’</td>
</tr>
<tr>
<td></td>
<td></td>
<td>• Option CB ‘4-20mA Ex-i + Wireless HART’</td>
</tr>
<tr>
<td>021</td>
<td>Output; input 2</td>
<td>All</td>
</tr>
<tr>
<td>022</td>
<td>Output; input 3</td>
<td>All</td>
</tr>
<tr>
<td>030</td>
<td>Display; Operation</td>
<td>All</td>
</tr>
<tr>
<td>040</td>
<td>Housing</td>
<td>All</td>
</tr>
<tr>
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<td>Measuring tube mat., wetted surface</td>
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<td>Process connection</td>
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<td>Calibration flow</td>
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<td>Display operating language</td>
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### Feature Designation Option selected

<p>| | | |</p>
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<tr>
<td>850</td>
<td>Firmware version</td>
<td>Firmware with SIL capability, e.g. 01.00.zz (HART)</td>
</tr>
<tr>
<td>895</td>
<td>Marking</td>
<td>All</td>
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</table>

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

2) Only for devices with approval for custody transfer

3) Additional selection of further approvals is possible.

### SIL label on the 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 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 (output; input 1). All safety measures refer to this signal exclusively.

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

The safety-related output signal is fed to a downstream automation system where it is monitored for the following:

- Overshooting and/or undershooting of a specified limit value for the flow or the density of the medium
- The occurrence of a fault: e.g. error current (≤ 3.6 mA, ≥ 21 mA), interruption or short-circuit of the signal line

#### Restrictions for use in safety-related applications

Do not exceed the specifications indicated in 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.
Detailed information concerning measured errors:

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

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 detailed information, see the Technical Information for the device → 8

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 for the device → 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.

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 → 8

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 fluids)

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 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 to the 4–20 mA current output
Overvoltages at the 4–20 mA current output (passive, output; input 1) - caused by a fault in the
supply unit for example - can result in a leak current in the device's input protection 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.
   ▶ 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’ documentation → 8

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

NOTICE
The measuring device's safety-related signal is the 4–20 mA analog output signal (output;
input 1).
All safety measures refer to this signal exclusively.
   ▶ Please note the following: → 10.

NOTICE
When the SIL locking code is entered, the device parameters that affect the safety-related
output signal are locked and write-protected. It is still possible to read the parameters.
When SIL locking is enabled, restrictions apply on all communication options, such as the service
interface (CDI-RJ45), HART protocol and WirelessHART protocol, local display and WLAN.
   ▶ Deactivation of the SIL mode → 19.

Use in protective systems

<table>
<thead>
<tr>
<th>Device behavior during operation</th>
<th>Device behavior during power-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>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 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).</td>
</tr>
<tr>
<td></td>
<td>Behavior of device during operation</td>
</tr>
<tr>
<td></td>
<td>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.</td>
</tr>
</tbody>
</table>
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 error current ≥ 21 mA) output currents of ≤ 3.6 mA occur irrespective of the configured error current.

In some other cases (e.g. short circuit of cabling), 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 detailed information on diagnostic events, see the Operating Instructions for the device →  7

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.
- 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

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 operation options, see the Operating Instructions for the device →  7

For detailed information on the configuration of the measuring device, see the Operating Instructions for the device and the 'Description of Device Parameters' documentation →  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 function 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 → Order code for "Additional approval", option LA "SIL"

1) www.endress.com/deviceviewer
Detailed information concerning the SIL label:
- Permitted device types → 9
- SIL label on the transmitter nameplate → 10

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

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

Follow the specified locking sequence.

1. Check preconditions.

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 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:
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 → 12.

- Diagnostic message 046 Sensor limit exceeded
- Diagnostic message 140 Sensor signal
- Diagnostic message 274 Main electronic failure
- Diagnostic message 374 Sensor electronic (ISEM) faulty
- Diagnostic message 830 Sensor temperature too high
- Diagnostic message 831 Sensor temperature too low
- Diagnostic message 834 Process temperature too high
- Diagnostic message 835 Process temperature too low
- Diagnostic message 913 Medium unsuitable
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 for the device → 👇 7
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.

Press the Œ 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 Œ 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 (output; input 1) 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 $\lambda_{du}$, the proof test coverage $PTC$ and the assumed mission time by close approximation as follows:

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

   - $MT$ - Mission time
   - $PTC$ - Proof test coverage
   - $T_i$ - Test interval

3. The operator also specifies the procedure for proof-testing.

   In accordance with IEC 61511, as an alternative to testing the safety function of the entire system an independent proof test of the subsystems, e.g. the sensor, is permitted.
Average probability of failure and useful lifetime

$PFD_{av}$ for a single-channel system:

SIL2 - 1oo1

![Graph showing PFD vs. Time]

Option BA “4-20mA HART”, option BB “4-20mA + Wireless HART”

Option CA “4-20mA HART Ex-i”, option CB “4-20mA Ex-i + Wireless HART”

Mission time in years

1. $PFD_{av}$: Average probability of dangerous failure on demand

Limit value for average probability of failure

1001: 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 (depending on the measured variable used for the safety function (A = mass flow/volume flow; B = density).

A. Check of the measured value for liquid and gaseous mass flow or 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:

2) Under IEC 61508 the sensor is synonymous with the entire flowmeter.
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" → ☞ 10.

B. Check of the measured value for density

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.

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.

Detailed information on:
- Orientation
- Medium properties
- Operating conditions

Operating Instructions for the device → 7

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.

For detailed information on the verification of the measuring device with Heartbeat Verification, application package, refer to the Special Documentation for the device → 8

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 for the device → 7
Orientation

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

Commissioning

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

Operation

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

Maintenance

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

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. 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 device returns, see the Operating Instructions for the device →  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:

- Sensor
- Transmitter without a sensor
- Display module
- Power unit
- Main electronics module
- I/O-Module
- Terminals
- Connection compartment cover
- Electronics compartment cover
- Seal sets for electronics compartment cover
- Securing clamps for electronics compartment cover
- Cable glands

Installation Instructions: see the Download Area 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...

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

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.

3  System components
1  Pump
2  Measuring device
3  Valve
4  Automation system
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 for the device → 7

| 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 → 14.

**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 $\beta$ and $\beta_0$ indicated below are minimum values for the device. These must be used when designing the sensor subsystem:

- Minimum value $\beta$ for homogeneously redundant use: 2 \%
- Minimum value $\beta_0$ 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**

<table>
<thead>
<tr>
<th>Version</th>
<th>changes</th>
<th>Valid as of firmware version</th>
</tr>
</thead>
<tbody>
<tr>
<td>SD01727D/06/xx/01.16</td>
<td>First version</td>
<td>01.00.zz (HART; from delivery date August 2, 2016)</td>
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