SD00077D/06/EN/15.18
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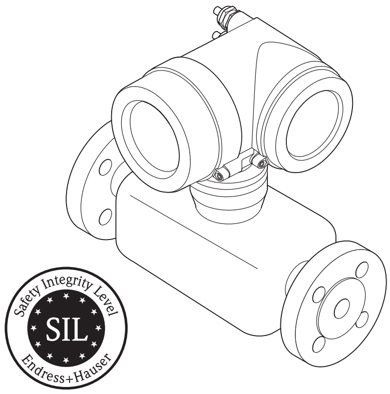
# Special Documentation
# **Proline Promass 80, 83**
Functional safety manual




## Coriolis mass flow measuring system with 4–20 mA output signal

**Application**
Monitoring of maximum and/or minimum flow or density in systems which are required to comply with particular safety system requirements as per IEC/EN 61508.

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

**Your benefits**
- For flow monitoring (Min., Max., range) up to SIL 2 (single-channel architecture) or SIL 3 (multichannel architecture with homogeneous redundancy).
  Independently assessed and certified by TÜV as per IEC/EN 61508
- Alternatively, suitable for density monitoring also (Min., Max., range)
- Continuous measurement
- Measurement is virtually independent of product properties
- Permanent self-monitoring
- Easy installation and commissioning
- Proof test possible without removal of the measuring device

Endress+Hauser
People for Process Automation

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# SIL Certificate

## Certificate

Product Safety
Functional
Safety

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CERTIFIED

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ID 0600000000

**Nr./No.: 968/EZ 295.03/17**

| | | | |
|---|---|---|---|
| **Prüfgegenstand**<br>**Product tested** | Durchflussmessgerät für die sichere Messung von Massedurchfluss, Dichte und Volumendurchfluss<br>Flow rate meter for the safe measurement of massflow rate, density and volumeflow rate | **Zertifikats-inhaber**<br>**Certificate holder** | Endress + Hauser<br>Flowtec AG<br>Kägenstr. 7<br>4153 Reinach BL 1<br>Switzerland |

**Typbezeichnung**
**Type designation**

PROMASS 80,
PROMASS 83

**Prüfgrundlagen**
**Codes and standards**

IEC 61508 Parts 1-7:2010 IEC 61010-1:2017

**Bestimmungsgemäße Verwendung**
**Intended application**

Die Messgeräte sind in Anwendungen bis SIL 2 gemäß IEC 61508 (einkanalig) sowie bis SIL 3 (redundante Verwendung) einsetzbar.
The meters can be used in applications up to SIL 2 acc. to IEC 61508 (single channel) and up to SIL 3 (redundant use).

**Besondere Bedingungen**
**Specific requirements**

Bei der Verwendung des Gerätes müssen das Anwenderhandbuch und das Sicherheitshandbuch berücksichtigt werden.
For the use of the product the Safety Manual and the User Manual have to be considered.

Gültig bis / Valid until 2022-12-14

Der Ausstellung dieses Zertifikates liegt eine Prüfung zugrunde, deren Ergebnisse im Bericht Nr. 968/EZ 295.03/17 vom 14.12.2017 dokumentiert sind.
Dieses Zertifikat ist nur gültig für Erzeugnisse, die mit dem Prüfgegenstand übereinstimmen.
The issue of this certificate is based upon an examination, whose results are documented in Report No. 968/EZ 295.03/17 dated 2017-12-14.
This certificate is valid only for products which are identical with the product tested.

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

Köln, 2017-12-14

Certification Body Safety & Security for Automation & Grid

Dr.-Ing. Thorsten Gantevoort

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www.tuvasi.com

TÜVRheinland®
Precisely Right.



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# Introduction

**Depiction of a safety system (protection function)**

The following tables define the achievable Safety Integrity Level (SIL) or the requirements regarding the "Average Probability of Failure on Demand" ($PFD_{AVG}$), the "Hardware Fault Tolerance" (HFT) and the "Safe Failure Fraction" (SFF) of the safety system. The specific values for the Promass measuring system can be found in the tables in the appendix.

In general, the following permitted failure probability of the complete safety function applies, depending on the SIL for systems which must react on demand - e.g. a defined max. flow exceeded - (Source: IEC 61508, Part 1):

| SIL | PFDAVG |
|---|---|
| 4 | $\geq 10^{-5}$ to $< 10^{-4}$ |
| 3 | $\geq 10^{-4}$ to $< 10^{-3}$ |
| 2 | $\geq 10^{-3}$ to $< 10^{-2}$ |
| 1 | $\geq 10^{-2}$ to $< 10^{-1}$ |

The following table shows the achievable SIL as a function of the safe failure fraction and the hardware fault tolerance of the complete safety system for type B systems (complex components, for definition see IEC 61508, Part 2):

| SFF | HFT | | |
|---|---|---|---|
| | 0 | 1 (0)[1)] | 2 (1)[1)] |
| < 60% | Not permitted | SIL 1 | SIL 2 |
| 60 % to < 90 % | SIL 1 | **SIL 2** | SIL 3 |
| 90 % to < 99 % | SIL 2 | SIL 3 | |
| ≥ 99 % | SIL 3 | | |

1) In accordance with IEC 61511-1 (section 11.4.41 ), the HFT can be reduced by one (values in brackets) if the devices used meet the following conditions:
- The device is proven in use
- Only process-relevant parameters can be changed at the device (e.g. measuring range, … )
- Changing the process-relevant parameters is protected (e.g. password, jumper, … )
- The function requires less than SIL 4

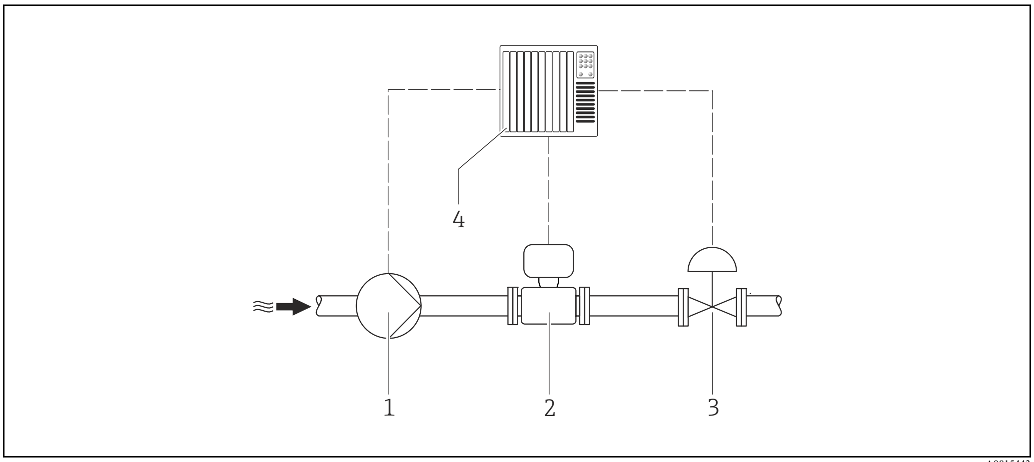
The Promass measuring system meets these conditions.

The measuring device can be used in safety relevant SIL 2 loop.
Additionally the measuring device can be used up to SIL 3 loop in a redundant structure (e.g. 1002 or 2003)

✎ Note!
General information on functional safety (SIL) is available at:
www.endress.com/SIL and in Competence Brochure CP002Z "Functional Safety in the Process Industry - Risk Reduction with Safety Instrumented Systems" (available in the download section of the Endress+Hauser website: www.endress.com → Download → Document code: CP002Z).

# Measuring system layout with Promass 80/83

**System components**

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System components

1 Pump
2 Measuring device
3 Valve
4 Automation system

An analog signal (4–20 mA) proportional to the flow rate or the 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.

Note!
- The safety-related signal is the 4 to 20 mA analog output signal of the measuring device. All safety functions refer exclusively to current output 1.
- The measuring device must be protected against unauthorized access → see "Locking" section (→ 8).
- The application program in the safety automation system is designed in such a way that "fail high" and "fail low" failures are detected by the safety function regardless of the effect (safe or dangerous).
- If communication also takes place via the HART protocol in the Promass 83 measuring device, HART write protection must be activated → see the "Locking" section (→ 8).

The characteristic values determined (see appendix) apply only to the current output (4 to 20 mA) of the following versions:
- Promass 80***–***********(*)
  (*) = Order option for inputs/outputs: A / D / S / T / 8
- Promass 83***–***********(*)
  (*) = Order option for inputs/outputs: A / B / C / D / E / L / M / R / S / T / U / W / 0 / 2 / 3 / 4 / 5 / 6

**Safety function data**

The mandatory settings and safety function data emanate from the section "Settings and installation instructions" (→ 6) and the appendix (→ 11). The measuring system's response time is ≤ 2 s. The monitoring function's alarm delay does not start until after this.

Note!
8 hours is set for the time between when the failure occurs and the failure is eliminated (MTTR).

**Supplementary device documentation**

The following documentation must be available for the measuring system:

| Device type | Operating Instructions | Description of the device functions |
|---|---|---|
| Promass 80 | BA00057D/06 | BA00058D/06 |
| Promass 83 | BA00059D/06 | BA00060D/06 |

This document also includes information on application limits and ambient conditions as well as the functional specifications of the current output.
For devices with an explosion protection approval, the corresponding Safety Instructions (XA) or Control Drawings (ZD) must also be observed.

# Settings and installation instructions

**Installation instructions**

Instructions for the correct installation of the measuring device can be found in the Operating Instructions (BA) supplied → see "Further applicable device documentation" (→ 🗎 5).

**Suitability of the measuring device**

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. In safety-related applications, it is also recommended to select a limit value for monitoring the minimum flow rate that is not smaller than 5 % of the specified maximum value of the sensor.

The measuring device must be used correctly for the specific application, taking into account the medium properties and ambient conditions. Carefully follow instructions pertaining to critical process situations and installation conditions from the device documentation.

Please pay particular attention to the following:
- It is very important to avoid the occurrence of air, gas bubble formation or two-phase mixtures in the measuring pipe as they can lead to increased measurement errors.
- For liquids that readily boil and in the case of suction conveying: 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. Such effects can be prevented when system pressure is sufficiently high.
- Ensure that no cavitation occurs as it can affect the vibration and operating life of the measuring pipes.
- In principle, the device supports the mass flow of gaseous media under pressure. This application is not recommended for safety-related flow monitoring.
- Avoid applications that cause buildup or corrosion in the measuring pipe.

In general, there are no specific requirements for single-phase, liquid media with properties similar to those of water.

✎ Note!
Please contact your Endress+Hauser sales office for further information.

**Setting instructions**

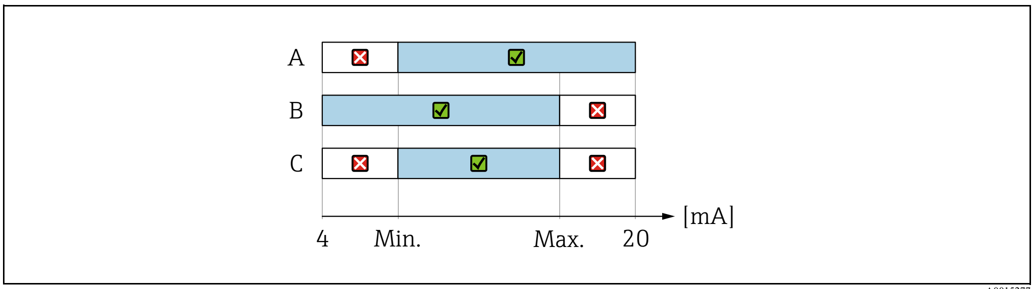
The measuring device can be configured in various ways in process control protection systems:
- Via onsite operation (LCD display)
- Via HART handheld terminal DXR 375
- Via PC (remote operation) using service and configuration software (e.g. "FieldCare")

The tools mentioned can also be used to retrieve information on the software and hardware revision of the device. → 🗎 5Further instructions on the settings can be found in the corresponding Operating Instructions → see "Supplementary device documentation" (→ 🗎 5).

**Monitoring options**

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

Note!
The device must be correctly installed to guarantee safe operation.

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Monitoring options in protective systems

A Min. alarm
B Max. alarm
C Range monitoring

= Safety function activated
= Permitted operating status

The following table shows the settings which are necessary to use the measuring device in a safety-related application. The settings refer to the 4 to 20 mA output value of the current output which corresponds to the flow value.

| Group | Name of function in the group | Allowed setting when Promass is used for a safety function |
|---|---|---|
| CURRENT OUTPUT | ASSIGN CURRENT OUTPUT | – Mass flow<br>– Volume flow<br>– Density |
| CURRENT OUTPUT | CURRENT SPAN | – 4–20 mA (………): All settings with a current output configuration to 4-20 mA.<br>– 0…20 mA: Setting is not allowed.<br>**Promass 80**<br>All configuration options 4 to 20 mA with HART communication are not permitted.<br>**Promass 83**<br>All configuration options 4 to 20 mA with HART communication are only permitted if HART write protection is activated (→ 8, "Locking" section) |
| CURRENT OUTPUT | FAILSAFE MODE | – Min. current<br>– Max. current |
| CURRENT OUTPUT | SIMULATION CURRENT | OFF |
| SYSTEM PARAMETER | POSITIVE ZERO RETURN | OFF |
| SUPERVISION | ASSIGN SYSTEM ERROR | OFF<br>(the assignment of information messages and fault messages may not be changed) |
| SUPERVISION | ALARM DELAY | 0…20 s |
| SIMULATION SYS-TEM | SIMULATION FAILSAFE MODE | OFF |
| SIMULATION SYS-TEM | SIMULATION MEASURAND | OFF |

A detailed description of the functions of the device can be found in the appropriate "Description of Device Functions" → see "Further applicable device documentation" (→ 5).

**Locking**

In order to protect the process relevant parameters against change, the software has to be locked.
This is done via a code set by the customer.

| Software lock for local programming | |
|---|---|
| Function DEFINE PRIVATE CODE | Freely choosable code number (except for 0) |

**Promass 83:**
When using HART communication, the HART write protection must be activated. This can be done with the aid of a jumper on the I/O board. Please refer to the appropriate Operating Instructions for the correct procedure to activate the HART write protection → see "Further applicable device documentation" (→ 🗎 5).

**Setting instructions for evaluation unit**

The determined limit value (mA value corresponding to chosen max. and/or min.) must be entered at the subsequent limit contactor (automation system). For all adjustment and setting procedures, please refer to the relevant Operating Instructions → see "Further applicable device documentation" (→ 🗎 5).

**Response in operation and failure**

The response in operation and failures is described in the Operating Instructions of the device
→ see "Further applicable device documentation" (→ 🗎 5).

Note!
- **Repair:** The repair of the devices must principally be performed by Endress+Hauser.
  Is the repair carried out by other people, the safety related functions can no longer be assured.
  **Exception:** The replacement of modular components by original spare parts is permitted by qualified personnel of the customer, if trained by Endress+Hauser for this purpose.
- A failure of a SIL marked Endress+Hauser product, which was operated in a safety instrumented system, shall be reported to sil@endress.com including product type, serial number and description of the failure. Device failures must be reported to the manufacturer. The user provides a detailed statement to the manufacturer describing the failure and any possible effects. There is also information flow as to whether this is a dangerous failure or a failure which cannot be detected directly.
- In the event of failure of a SIL marked Endress+Hauser device, which has been operated in a safety function, the "Declaration of Contamination and Cleaning" with the corresponding note "Used as SIL device in protection system" must be enclosed when the defective device is returned.

**Information on the useful lifetime of electric components**

The established failure rates of electrical components apply within the useful lifetime as per
IEC/EN 61508-2, section 7.4.7.4, note 3.

Note!
The manufacturer and plant owner/operator must take appropriate measures to achieve a longer service life as per DIN EN 61508-2, note NA4.

# Proof test

**Proof test of the measuring system**

Check the operativeness of safety functions at appropriate intervals. The operator must determine the time interval and take this into account when determining the probability of failure $PFD_{avg}$ of the sensor system.

Note!
In a single-channel architecture, the maximum value of $PFD_{avg}$ depends on the diagnostic coverage of the proof test (PTC = Proof Test Coverage) and the intended lifetime (LT = Lifetime) in accordance with the following formula:

$$PFD_{avg} \approx \lambda_{du} \cdot [PTC/2 \cdot T_i + (1 - PTC)/2 \cdot LT]$$

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The functional test must be carried out in such a way that it verifies correct operation of the safety device in conjunction with all of the other components. Each test must be fully documented.

The accuracy of the measured value must first be checked in order to test the safety function (Min., Max., range). This involves approaching the configured limit values upon which the safety function (including actuator) should be activated. Checking the accuracy of the measured values is sufficient in order to test the "Range" safety function.

During the proof test, alternative monitoring measures must be taken to ensure process safety.

A proof test of the device can be performed in the following steps:

1. **Checking the digital measured value**
   One of the following tests must be carried out depending on the measured variable to be monitored and the available equipment:
   a. Test sequence A – Checking the digital measured value with a calibration rig
      Mass flow, volume flow or density
      The measuring device is recalibrated using a calibration rig that is certified in accordance with ISO 17025. This can be done on an installed device using a mobile calibration rig or using factory calibration if the device has been disassembled. The amount of deviation between the measured flow rate or density and the set point must not exceed the maximum measured error specified in the Operating Instructions.

      Note!
      Please contact your Endress+Hauser sales office for further information on standard methods for on-site calibration of flowmeters.

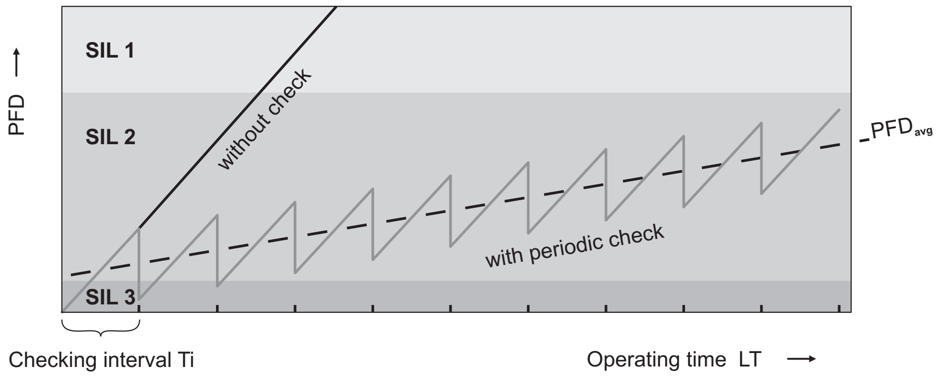
   b. Test sequence B – Checking the digital measured value using the installed totalizer
      Mass flow
      A measuring vessel is filled with the medium at a flow rate which corresponds to the limit value to be monitored. A calibrated scales is used to determine the change in the overall mass in the measuring vessel before and after filling which is then compared with the totalizer installed in the device. The amount of deviation must not exceed the maximum measured error specified in the Operating Instructions. For range monitoring, this test must be carried out separately for the upper and lower limit value.

      Volume flow
      A calibrated measuring vessel is filled with the medium at a flow rate which corresponds to the limit value to be monitored. The change in the volume in the measuring vessel is read off before and after filling and compared with the totalizer installed in the measuring device. The amount of deviation must not exceed the maximum measured error specified in the Operating Instructions. For range monitoring, this test must be carried out in 5 stages between the upper and lower limit value.

   c. Test sequence C – Checking the digital measured value using liquids of known density
      Density
      The device's measuring pipes are filled with at least two different liquids of known density one after the other. The digital density measured value determined in each case is compared with the actual density of the measurement liquid. The amount of deviation must not exceed the maximum measured error specified in the Operating Instructions.

d. Test sequence D – Checking the digital measured value using Fieldcheck
Mass flow, volume flow or density
Fieldcheck is used to verify the measuring device when installed in accordance with Operating Instructions BA00067D/06. Fieldcheck automatically displays the test result (passed/failed). This test can be carried out without removal of the flowmeter and makes periodic inspection easier. The high diagnostic coverage means that > 90 % of undetected failures are detected whereby the level of increase in the probability of failure is lower than without the check (→ graphic below). The average probability of failure $PFD_{AVG}$ can be estimated using the formula for this (→ 9), taking into account the intended lifetime LT.

When used in conjunction with the "FieldCare" software package, test results can be imported into a database, printed and used as verification for the relevant certification body.




Single-channel system architecture 1oo1

2. **Checking the temperature measurement**
The medium temperature is required by the device for compensation of measured values and for diagnostic purposes. The medium temperature determined digitally by the device is compared with the measured value of a calibrated thermometer. The amount of deviation must not exceed 2 °C (4 °F).

3. **Checking the 4–20 mA current output**
Using the current simulation (fixed current value) option available in the operating menu, set the current output of the device to the values 3.6 mA, 4.0 mA, 20.0 mA and 22.0 mA one after another and compare with the measured values of a calibrated, external current measuring device.

4. **Activation of the safety function**
Correct activation of the safety function - including actuator - must be checked by outputting suitable current values on the 4–20 mA interface per current simulation (just below and above the switch point). For range monitoring, this test must be carried out separately for the upper and lower limit value.

5. **Completing the proof test**
Switch the 4–20 mA current output to measured value output (if necessary).

Note!
The proof test is only completed when steps 1 to 5 are accomplished.

98 % of dangerous, undetected failures are detected using test sequences 1a to 1c, whereas 90 % of dangerous, undetected failures are detected using test sequence 1d. 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.

The influence of systematic faults on the safety function are not covered by the test and must be examined separately. Systematic faults can be caused, for example, by medium properties, operating conditions, build-up or corrosion.

# Appendix (safety-related characteristic values)

**Introductory comments**

Depending on the order code, Promass flow measuring systems are supplied with different signal inputs and outputs. For the purposes of clarity, similar types of electronics modules are grouped into categories.

Note!
- The safety-related characteristic values are described separately for each of these categories → see sections "Category 1-10". The tables provided in these category sections contain all the important characteristic values. The values apply to all possible applications:
- The failure rates indicated refer to the failure rates of Siemens Standard SN29500 at an ambient temperature of +40 °C (+104 °F).

| Measuring system / electronics<br>Product structure | Ex | Outputs and inputs | Category<br>→ 13 |
|---|---|---|---|
| **Promass 80** | | | |
| 80 *** – ***********A | – | Curr. outp. / freq. outp. | 1 |
| 80 *** – ***********D | – | Curr. outp. / freq. outp. / status outp. / status inp. | 1 |
| 80 *** – ***********8 | – | Curr. outp. / curr. outp. 2 / freq. outp. / status inp. | 5 |
| 80 *** – ***********A | Ex | Curr. outp. / freq. outp. | 2 |
| 80 *** – ***********D | Ex | Curr. outp. / freq. outp. / status outp. / status inp. | 2 |
| 80 *** – ***********S | Ex | Curr. outp. (Ex i) / freq. outp. (Ex i) | 7 |
| 80 *** – ***********T | Ex | Curr. outp. (Ex i) / freq. outp. (Ex i) | 8 |
| 80 *** – ***********8 | Ex | Curr. outp. / curr. outp. 2 / freq. outp. / status inp. | 6 |
| **Promass 83** | | | |
| 83 *** – ***********A | – | Curr. outp. / freq. outp. | 3 |
| 83 *** – ***********B | – | Curr. outp. / freq. outp. / relay / relay 2 | 3 |
| 83 *** – ***********C | – | Curr. outp. / freq. outp. / relay / relay 2 | 5 |
| 83 *** – ***********D | – | Curr. outp. / freq. outp. / relay / status inp. | 5 |
| 83 *** – ***********E | – | Curr. outp. / curr. outp. 2 / relay / status inp. | 5 |
| 83 *** – ***********L | – | Curr. outp. / relay / relay 2 / status inp. | 5 |
| 83 *** – ***********M | – | Curr. outp. / freq. outp. / freq. outp. 2 / status inp. | 5 |
| 83 *** – ***********W | – | Curr. outp. / curr. outp. 2 / curr. outp. 3 / relay | 5 |
| 83 *** – ***********0 | – | Curr. outp. / curr. outp. 2 / curr. outp. 3 / status inp. | 5 |
| 83 *** – ***********2 | – | Curr. outp. / curr. outp. 2 / freq. outp. / relay | 5 |
| 83 *** – ***********3 | – | Curr. outp. / curr. outp. 2 / relay / curr. inp. | 5 |
| 83 *** – ***********4 | – | Curr. outp. / freq. outp. / relay / curr. inp. | 5 |
| 83 *** – ***********5 | – | Curr. outp. / freq. outp. / curr. inp. / status inp. | 5 |
| 83 *** – ***********6 | – | Curr. outp. / curr. outp. 2 / curr. inp. / status inp. | 5 |
| 83 *** – ***********A | Ex | Curr. outp. / freq. outp. | 4 |
| 83 *** – ***********B | Ex | Curr. outp. / freq. outp. / relay / relay 2 | 4 |
| 83 *** – ***********C | Ex | Curr. outp. / freq. outp. / relay / relay 2 | 6 |
| 83 *** – ***********D | Ex | Curr. outp. / freq. outp. / relay / status inp. | 6 |
| 83 *** – ***********E | Ex | Curr. outp. / curr. outp. 2 / relay / status inp. | 6 |
| 83 *** – ***********L | Ex | Curr. outp. / relay / relay 2 / status inp. | 6 |

| Measuring system / electronics<br>Product structure | Ex | Outputs and inputs | Category<br>→ 🗎 13 |
|---|---|---|---|
| 83 *** – ***********M | Ex | Curr. outp. / freq. outp. / freq. outp. 2 / status inp. | 6 |
| 83 *** – ***********R | Ex | Curr. outp. (Ex i) / curr. outp. 2 (Ex i) | 9 |
| 83 *** – ***********S | Ex | Curr. outp. (Ex i) / freq. outp. (Ex i) | 7 |
| 83 *** – ***********T | Ex | Curr. outp. (Ex i) / freq. outp. (Ex i) | 8 |
| 83 *** – ***********U | Ex | Curr. outp. (Ex i) / curr. outp. 2 (Ex i) | 10 |
| 83 *** – ***********W | Ex | Curr. outp. / curr. outp. 2 / curr. outp. 3 / relay | 6 |
| 83 *** – ***********0 | Ex | Curr. outp. / curr. outp. 2 / curr. outp. 3 / status inp. | 6 |
| 83 *** – ***********2 | Ex | Curr. outp. / curr. outp. 2 / freq. outp. / relay | 6 |
| 83 *** – ***********3 | Ex | Curr. outp. / curr. outp. 2 / relay / curr. inp. | 6 |
| 83 *** – ***********4 | Ex | Curr. outp. / freq. outp. / relay / curr. inp. | 6 |
| 83 *** – ***********5 | Ex | Curr. outp. / freq. outp. / curr. inp. / status inp. | 6 |
| 83 *** – ***********6 | Ex | Curr. outp. / curr. outp. 2 / curr. inp. / status inp. | 6 |

**Comments on the term "dangerous undetected failures"**

Situations in which the process does not respond to a demand (i.e. the measuring device does not demonstrate the predefined failsafe mode) or in which the output signal deviates more than the total measured error as specified. Please refer to the "Performance characteristics" section of the Operating Instructions for more detailed information on the total measured error.

The following presumptions are made:
- The failure rates are constant, wear out mechanisms are not included.
- Failure propagation is not relevant.
- The HART protocol is only used to read out data during normal operation.
- The recovery time after a safe failure is 8 hours.
- The test time of the automation system to react to a detected failure is one hour.
- All modules are operated in the "low demand mode".
- Only current output 1 is used for safety-related applications.
- Failure rates of the external power supply are not included.
- "Stress levels" are average values for an industrial environment and are comparable to the "Ground, Fixed" classification as per MIL-HDBK-217F. Alternatively, the assumed environment is similar to IEC 60654-1, class C (sheltered location) with temperature limits within manufacturer's specifications and an average temperature of 40 °C (104 °F) over a longer period for the transducer (transmitter). Humidity is assumed within the manufacturer's specification.
- Only the versions described are used for safety applications.
- As the optional display does not constitute a part of the safety function, the failure rate of the display is not taken into account in the calculations.
- The application program in the safety automation system is designed in such a way that "fail high" and "fail low" failures are detected by the safety function regardless of the effect (safe or dangerous).

**Categories**

- SIL (Safety Integrity Level) = 2
- HFT (Hardware Fault Tolerance In accordance with IEC 61511-1, section 11.4) = 0
- Device type = Type B (complex components)

| Category | SFF[1)] | $PFD_{AVG}$ | | | $\lambda_{du}$ | $\lambda_{dd}$ | $\lambda_{su}$ | $\lambda_{sd}$ | MTBF |
|---|---|---|---|---|---|---|---|---|---|
| | | 1 year | 2 years | 5 years | | | | | |
| 1 | 89.5 % | $7.83 \cdot 10^{-4}$ | $1.56 \cdot 10^{-3}$ | $3.90 \cdot 10^{-3}$ | 178 FIT | 1214 FIT | 316 FIT | 0 FIT | 65 years |
| 2 | 91.1 % | $6.92 \cdot 10^{-4}$ | $1.38 \cdot 10^{-3}$ | $3.45 \cdot 10^{-3}$ | 158 FIT | 1292 FIT | 329 FIT | 0 FIT | 62 years |
| 3 | 89.6 % | $7.83 \cdot 10^{-4}$ | $1.56 \cdot 10^{-3}$ | $3.90 \cdot 10^{-3}$ | 178 FIT | 1221 FIT | 323 FIT | 0 FIT | 63 years |
| 4 | 91.2 % | $6.92 \cdot 10^{-4}$ | $1.38 \cdot 10^{-3}$ | $3.45 \cdot 10^{-3}$ | 158 FIT | 1300 FIT | 336 FIT | 0 FIT | 60 years |
| 5 | 90.0 % | $7.87 \cdot 10^{-4}$ | $1.57 \cdot 10^{-3}$ | $3.93 \cdot 10^{-3}$ | 179 FIT | 1278 FIT | 333 FIT | 0 FIT | 59 years |
| 6 | 91.5 % | $6.96 \cdot 10^{-4}$ | $1.39 \cdot 10^{-3}$ | $3.47 \cdot 10^{-3}$ | 159 FIT | 1356 FIT | 346 FIT | 0 FIT | 57 years |
| 7 | 91.6 % | $7.31 \cdot 10^{-4}$ | $1.46 \cdot 10^{-3}$ | $3.65 \cdot 10^{-3}$ | 167 FIT | 1382 FIT | 435 FIT | 0 FIT | 53 years |
| 8 | 91.6 % | $6.99 \cdot 10^{-4}$ | $1.40 \cdot 10^{-3}$ | $3.49 \cdot 10^{-3}$ | 160 FIT | 1376 FIT | 351 FIT | 0 FIT | 56 years |
| 9 | 91.9 % | $6.94 \cdot 10^{-4}$ | $1.39 \cdot 10^{-3}$ | $3.46 \cdot 10^{-3}$ | 159 FIT | 1384 FIT | 412 FIT | 0 FIT | 48 years |
| 10 | 91.6 % | $6.94 \cdot 10^{-4}$ | $1.39 \cdot 10^{-3}$ | $3.46 \cdot 10^{-3}$ | 159 FIT | 1374 FIT | 350 FIT | 0 FIT | 51 years |

1) Safe Failure Fraction

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