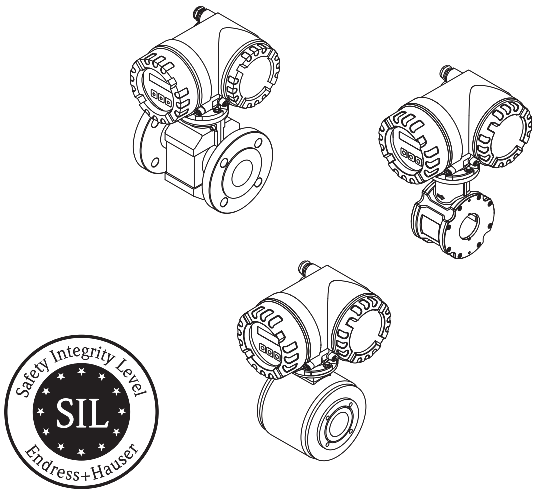
SD00115D/06/EN/15.14
71249502

Valid as of version
V 02.00.zz (device software)

Functional Safety Manual
Proline Promag 50, 53

Electromagnetic flowmeter with 4 to 20 mA output signal



Application

Monitoring of maximum and/or minimum flow in systems which are required to comply with particular safety system requirements as per IEC/EN 61508 and IEC/EN 61511-1.

The measuring device fulfils the requirements concerning:
- Functional safety as per IEC/EN 61508 and IEC/EN 61511-1
- Explosion protection (depending on the version)
- Electromagnetic compatibility as per EN 61326-3-2 and NAMUR recommendation NE 21

Your benefits

- For flow monitoring (Min., Max., range) up to SIL 2 – independently assessed (Functional Assessment) by exida.com as per IEC/EN 61508 and IEC/EN 61511-1
- 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 Declaration of Conformity

Endress+Hauser
People for Process Automation

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SIL Declaration of Conformity Promag 50/Promag 53
Functional Safety of a flow measuring device according to IEC 61508/IEC 61511

Endress+Hauser Flowtec AG, Kägenstrasse 7, 4153 Reinach
declares as manufacturer, that the flow measuring devices

Promag 50 (4…20 mA) and Promag 53 (4…20 mA)

are suitable for the use in a safety instrumented system up to SIL 2 according to IEC 61511-1 und IEC 61508 if the installation is conform to the safety manual and if enclosed safety instructions are observed.

The FMEDA with analysis of the safety critical and dangerous faults provides under the assumption of a functional test cycle of two years the following parameters for the worst case of the tested configurations:

SIL (Safety Integrity Level)	:	2
HFT (Hardware Fault Tolerance)	:	0 [1)]
Device Type	:	Type B (complex component)
SFF (Safe failure fraction)	:	>76%
PFD_{AVG} (Average Probability of Failure on Demand)[2)]	:	$\leq 1.29 \cdot 10^{-3}$ p.a.

Failure rates according to IEC 61508, based on the worst case configuration:

λ_{du} (failure rate dangerous undetected failures)	:	$295 \cdot 10^{-9}$/h (295 FIT)
λ_{dd} (failure rate dangerous detected failures)	:	$756 \cdot 10^{-9}$/h (756 FIT)
λ_{su} (failure rate safe undetected failures)	:	$265 \cdot 10^{-9}$/h (265 FIT)
λ_{sd} (failure rate safe detected failures)	:	$0 \cdot 10^{-9}$/h (0 FIT)

1) According to clause 11.4 of IEC 61511-1
2) The PFD_{AVG} values are also within the range for SIL 2 according to ISA S84.01.

The assessment of the proven-in-use demonstration covers the device and its software (as of software version V2.00.00 (amplifier), and 1.04.00 (communication module)) including the modification process.

Reinach, 05.10.2006

Endress+Hauser Flowtec AG
FEE/SA

SIL2-50-53-Conformity-en.pdf

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 Promag 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	PFD_{AVG}
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

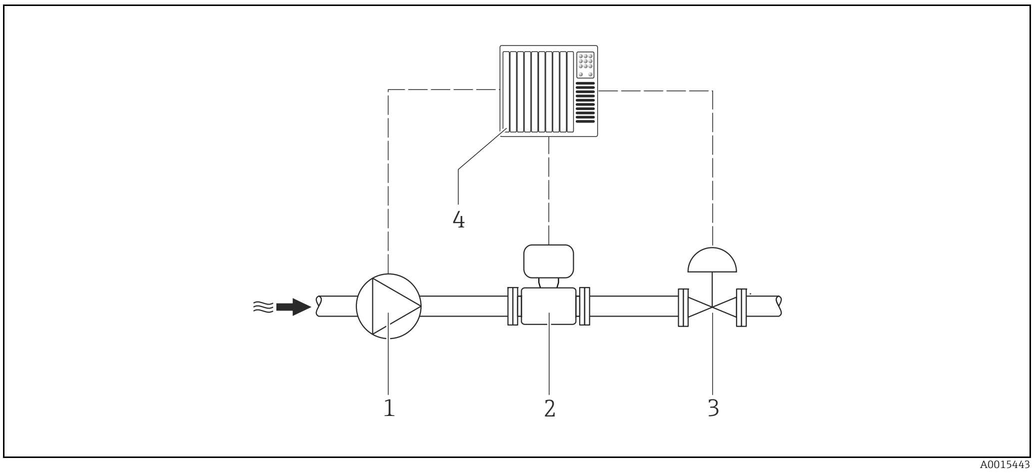
The Promag measuring system meets these conditions.

The measuring device can be used in safety relevant SIL 2 loop. In a safety relevant SIL 3 loop the measuring device must be used in addition to a different measuring principle. Two Promag in homogenous redundancy do not fulfill the SIL 3 requirements.

Note!
General information on functional safety (SIL) is available at:
www.de.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 Promag 50, 53

System components



System components

1 Pump
2 Measuring device
3 Valve
4 Automation system

An analog signal (4–20 mA) proportional to the flow rate 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 (→ 🗎 7).
- 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 Promag 53 measuring device, HART write protection must be activated → see "Locking" section (→ 🗎 7).

The characteristic values determined (see appendix) apply only to the current output (4 to 20 mA) of the following versions:
- Promag 50***–***********(*)
  (*) = Order option for inputs/outputs: A / W / D / S / T
- Promag 53***–***********(*)
  (*) = Order option for inputs/outputs: A / B / C / L / M / S / T / 2 / 4

Safety function data

The mandatory settings and safety function data emanate from the section "Settings and installation instructions" (→ 🗎 6) and the appendix (→ 🗎 15). 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
Promag 50	BA00046D/06	BA00049D/06
Promag 53	BA00047D/06	BA00048D/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.
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

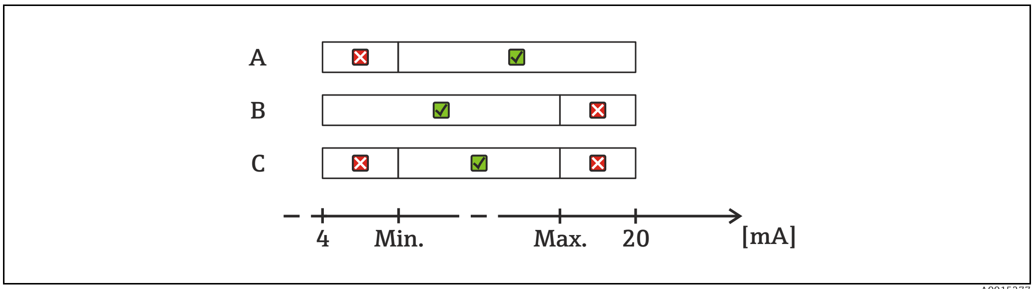
The measuring device can be configured in various ways in process control protection systems:
- Via onsite operation (LCD display)
- Via HART handheld terminal DXR 375
- Via PC (remote operation) using service and configuration software (e.g. "FieldCare")

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" ().

Monitoring options

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

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



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	Volume flow
CURRENT OUTPUT	CURRENT SPAN	– 4–20 mA (.........): All settings with a current output configuration to 4-20 mA. – 0...20 mA: Setting is not allowed. **Promag 50** All configuration options 4 to 20 mA with HART communication are not permitted. **Promag 53** All configuration options 4 to 20 mA with HART communication are only permitted if HART write protection is activated (→ 📄 7, "Locking" section)
CURRENT OUTPUT	FAILSAFE MODE	– Min. current – Max. current
CURRENT OUTPUT	SIMULATION CURRENT	OFF
SYSTEM PARAMETER	POSITIVE ZERO RETURN	OFF
SUPERVISION	ASSIGN SYSTEM ERROR	OFF (the assignment of information messages and fault messages may not be changed)
SUPERVISION	ALARM DELAY	0...20 s
SIMULATION SYSTEM	SIMULATION FAILSAFE MODE	OFF
SIMULATION SYSTEM	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 53:
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. flow) 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.
- If a SIL-type Endress+Hauser device which was used in a protective function fails, the "Declaration of contamination and cleaning" must be enclosed with a note specifying "Use as SIL device in a protective system" when returning the defective device.

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 checking 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 PFD_{avg} value to be used 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:

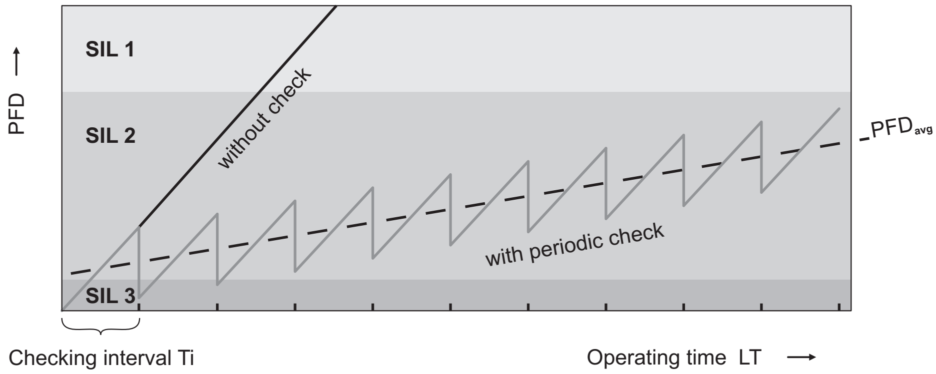
1. **Checking the digital measured value**
   One of the following tests must be carried out depending on the measured variable to be monitored and the available equipment:
   a. Test sequence A – Checking the digital measured value with a calibration rig
      Volume flow
      The measuring device 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 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
      Volume flow
      A calibrated measuring vessel is filled with the medium at a flow rate which approximately 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 separately for the upper and lower limit value.

   c. Test sequence C – Checking the digital measured value using Fieldcheck
      Volume flow
      Verification of the measuring device in an installed state with Fieldcheck as described in Operating Instructions BA00067D/06. Fieldcheck displays the test results (passed/failed) automatically.
      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 average probability of failure PFD_{AVG} is lower than without the check (→ graphic below). The average probability of failure PFD_{AVG} can be estimated using the formula for this (→ 9) and taking into account the intended lifetime t.

      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 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.

3. **Checking 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.

4. 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 4 are accomplished.
98 % of dangerous, undetected failures are detected using test sequences 1a to 1b, whereas 90 % of dangerous, undetected failures are detected using test sequence 1c. 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.

Exida Management Summary

FMEDA and Proven-in-use Assessment

Project:
Electromagnetic Flow Measuring System PROMAG 50/53

Customer:
Endress+Hauser Flowtec AG
Reinach
Switzerland

Contract No.: E+H 06/02-03
Report No.: E+H 06/02-03 R039
Version V1, Revision R1, October 2006
Stephan Aschenbrenner

SIL2-50-53-Manag-Summary-Page1

Management summary

This report summarizes the results of the hardware assessment with proven-in-use consideration according to IEC 61508 / IEC 61511 carried out on the electromagnetic flow measuring system PROMAG 50/53 with 4..20 mA HART® output and software version 02.00.00. The statements made in this report are also valid for further software versions as long as the assessed IEC 61508 modification process is considered. Any changes are under the responsibility of the manufacturer. Table 1 gives an overview of the different types that belong to the considered electromagnetic flow measuring system PROMAG 50/53.

The hardware assessment consists of a Failure Modes, Effects and Diagnostics Analysis (FMEDA). A FMEDA is one of the steps taken to achieve functional safety assessment of a device per IEC 61508. From the FMEDA, failure rates are determined and consequently the Safe Failure Fraction (SFF) is calculated for the device. For full assessment purposes all requirements of IEC 61508 must be considered.

Table 1: Version overview

Version	Type	Commodul	Options
V1	50***-***********W	C03	Current
	50***-***********A	C03	Current + Frequency
	50***-***********D	C03	Current + Frequency + Status output + Status input
V2	53***-***********C	C05	Current + Frequency + 2 * Relays
	53***-***********L	C05	Current + 2 * Relays + Status input
	53***-***********M	C05	Current + 2*Frequency + Status input
	53***-***********2	C05	Current + Current2 + Frequency + Relay
	53***-***********4	C05	Current + Frequency + Current input + Relay
V3	53***-***********A	C06	Current + Frequency
	53***-***********B	C06	Current + Frequency + 2 * Relays
V4	53***-***********S	C07	Current active + Frequency passive
V5	53***-***********T	C07	Current passive + Frequency passive

For safety applications only the 4..20 mA current output was considered. All other possible output variants or electronics are not covered by this report. The different devices can be equipped with or without display.

The failure rates used in this analysis are the basic failure rates from the Siemens standard SN 29500.

According to table 2 of IEC 61508-1 the average PFD for systems operating in low demand mode has to be $\geq 10^{-3}$ to $< 10^{-2}$ for SIL 2 safety functions. A generally accepted distribution of PFD_{AVG} values of a SIF over the sensor part, logic solver part, and final element part assumes that 35% of the total SIF PFD_{AVG} value is caused by the sensor part.

For a SIL 2 application operating in low demand mode the total PFD_{AVG} value of the SIF should be smaller than 1,00E-02, hence the maximum allowable PFD_{AVG} value for the sensor part would then be 3,50E-03.

The electromagnetic flow measuring system PROMAG 50/53 is considered to be a Type B[1] sub-system with a hardware fault tolerance of 0.

Type B sub-systems with a SFF of 60% to < 90% must have a hardware fault tolerance of 1 according to table 3 of IEC 61508-2 for SIL 2 (sub-) systems.

As the electromagnetic flow measuring system PROMAG 50/53 is supposed to be a proven-in-use sub-system, an assessment of the hardware with additional proven-in-use demonstration was carried out. Therefore according to the requirements of IEC 61511-1 First Edition 2003-01 section 11.4.4 and the assessment described in section 6 a hardware fault tolerance of 0 is sufficient for SIL 2 sub- systems being Type B sub-systems and having a SFF of 60% to < 90%.

The proven-in-use investigation was based on field return data collected and analyzed by Endress+Hauser Flowtec AG.

According to the requirements of IEC 61511-1 First Edition 2003-01 section 11.4.4 and the assessment described in section 6 the device is suitable to be used, as a single device, for SIL 2 safety functions. The decision on the usage of proven-in-use devices, however, is always with the end-user.

Endress+Hauser Flowtec AG performed a qualitative analysis of the mechanical parts of the electromagnetic flow measuring system PROMAG 50/53 (see [D7]). This analysis was used by *exida* to calculate the failure rates of the sensor elements using *exida*'s experienced-based data compilation for the different components of the sensor elements (see [R1]). The results of the quantitative analysis were used for the calculations described in sections 5.1 to 5.6.

Assuming that the application program in the safety logic solver is configured to detect under-range and over-range failures and does not automatically trip on these failures, these failures have been classified as dangerous detected failures. The following tables show how the above stated requirements are fulfilled.

Table 2: Summary for the worst case version – Failure rates [2]

Failure category	**Failure rates (in FIT)**
Fail Dangerous Detected	**756**
Fail dangerous detected (internal diagnostics or indirectly [3])	598
Fail high (detected by the logic solver)	7
Fail low (detected by the logic solver)	140
Annunciation detected	11
Fail Dangerous Undetected	**295**
Fail dangerous undetected	285
Annunciation undetected	10
No Effect	**265**
Not part	**194**

[1] Type B sub-system: “Complex” sub-system (using micro controllers or programmable logic); for details see 7.4.3.1.3 of IEC 61508-2.

[2] It is assumed that practical fault insertion tests can demonstrate the correctness of the failure effects assumed during the FMEDAs.

[3] “indirectly” means that these failure are not necessarily detected by diagnostics but lead to either fail low or fail high failures depending on the transmitter setting and are therefore detectable.

Table 3: Summary for the worst case version – IEC 61508 Failure rates

λ_{SD}	λ_{SU} [4]	λ_{DD}	λ_{DU}	SFF	DC_S [5]	DC_D [3]
0 FIT	265 FIT	756 FIT	295 FIT	77%	0%	71%

Table 4: Summary for the worst case version – PFD_{AVG} values

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years
PFD_{AVG} = 1,29E-03	PFD_{AVG} = 6,43E-03	PFD_{AVG} = 1,28E-02

The boxes marked in yellow ( ) mean that the calculated PFD_{AVG} values are within the allowed range for SIL 2 according to table 2 of IEC 61508-1 but do not fulfill the requirement to not claim more than 35% of this range, i.e. to be better than or equal to 3,50E-03. The boxes marked in green ( ) mean that the calculated PFD_{AVG} values are within the allowed range for SIL 2 according to table 2 of IEC 61508-1 and do fulfill the requirement to not claim more than 35% of this range, i.e. to be better than or equal to 3,50E-03. The boxes marked in red ( ) mean that the calculated PFD_{AVG} values do not fulfill the requirements for SIL 2 according to table 2 of IEC 61508-1.

The failure rates listed above do not include failures resulting from incorrect use of the electromagnetic flow measuring system PROMAG 50/53, in particular humidity entering through incompletely closed housings or inadequate cable feeding through the inlets.

The listed failure rates are valid for operating stress conditions typical of an industrial field environment similar to IEC 60654-1 class C (sheltered location) with an average temperature over a long period of time of 40ºC. For a higher average temperature of 60°C, the failure rates should be multiplied with an experience based factor of 2,5. A similar multiplier should be used if frequent temperature fluctuation must be assumed.

A user of the electromagnetic flow measuring system PROMAG 50/53 can utilize these failure rates in a probabilistic model of a safety instrumented function (SIF) to determine suitability in part for safety instrumented system (SIS) usage in a particular safety integrity level (SIL). A full table of failure rates is presented in sections 5.1 to 5.6. along with all assumptions.

It is important to realize that the “no effect” failures are included in the “safe undetected” failure category according to IEC 61508. Note that these failures on its own will not affect system reliability or safety, and should not be included in spurious trip calculations.

The failure rates are valid for the useful life of the electromagnetic flow measuring system PROMAG 50/53 (see Appendix 3).

[4] Note that the SU category includes failures that do not cause a spurious trip

[5] DC means the diagnostic coverage (safe or dangerous).

Appendix (safety-related characteristic values)

Introductory comments

Depending on the order code, Promag 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 1-7". 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 Product structure	Outputs and inputs	Category → 🗎 16
Promag 50		
50 *** – ***********W	Curr. outp.	1
50 *** – ***********A	Curr. outp. / freq. outp.	1
50 *** – ***********D	Curr. outp. / frequency outp. / status outp. / status inp.	1
50 *** – ***********S	Current outp. active (Ex i) / frequency outp. passive (Ex i)	6
50 *** – ***********T	Current outp. passive (Ex i) / frequency outp. passive (Ex i)	7
Promag 53		
53 *** – ***********C	Curr. outp. / frequency outp. / relay / relay 2	2
53 *** – ***********L	Curr. outp. / relay / relay 2 / status inp.	2
53 *** – ***********M	Curr. outp. / frequency outp. / frequency outp. 2 / status inp.	2
53*** – ***********2	Curr. outp. / curr. outp. 2 / frequency outp. / relay	2
53*** – ***********4	Curr. outp. / frequency outp. / relay / curr. inp.	2
53 *** – ***********A	Curr. outp. / freq. outp.	3
53 *** – ***********B	Curr. outp. / frequency outp. / relay / relay 2	3
53 *** – ***********S	Current outp. active (Ex i) / frequency outp. passive (Ex i)	4
53 *** – ***********T	Current outp. passive (Ex i) / frequency outp. passive (Ex i)	5

- ATEX II2G/D, FM/CSA Cl.1 Div.1, TIIS and NEPSI are available options for Promag H/P/W
- ATEX II3G/D is an available option for Promag E/H/P/W
- FM/CSA Cl.1 Div.2 is an available option for Promag D/E/H/L/P/W

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.
- The stress levels are average values for an industrial environment and can be compared to the "Ground Fixed" classification of MIL-HDBK-217F. Alternatively, the presumed environment is similar to IEC 60654-1, Class C (protected mounting location) with temperature limits within the manufacturer's specifications and an average temperature of +40 °C (+104 °F) for the transmitter over an extended period. 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}			λ_{du}	λ_{dd}	λ_{su}	λ_{sd}
		1 year	2 years	5 years				
1	76.68 %	$\leq 1.27 \cdot 10^{-3}$	$\leq 2.54 \cdot 10^{-3}$	$\leq 6.35 \cdot 10^{-3}$	291 FIT	705 FIT	253 FIT	0 FIT
2	77.58 %	$\leq 1.29 \cdot 10^{-3}$	$\leq 2.58 \cdot 10^{-3}$	$\leq 6.45 \cdot 10^{-3}$	295 FIT	756 FIT	265 FIT	0 FIT
3	76.89 %	$\leq 1.28 \cdot 10^{-3}$	$\leq 2.56 \cdot 10^{-3}$	$\leq 6.40 \cdot 10^{-3}$	292 FIT	711 FIT	260 FIT	0 FIT
4	81.06 %	$\leq 1.25 \cdot 10^{-3}$	$\leq 2.50 \cdot 10^{-3}$	$\leq 6.25 \cdot 10^{-3}$	285 FIT	854 FIT	365 FIT	0 FIT
5	80.29 %	$\leq 1.21 \cdot 10^{-3}$	$\leq 2.42 \cdot 10^{-3}$	$\leq 6.05 \cdot 10^{-3}$	277 FIT	847 FIT	283 FIT	0 FIT
6	80.29 %	$\leq 1.24 \cdot 10^{-3}$	$\leq 2.50 \cdot 10^{-3}$	$\leq 6.25 \cdot 10^{-3}$	285 FIT	854 FIT	365 FIT	0 FIT
7	80.29 %	$\leq 1.20 \cdot 10^{-3}$	$\leq 2.42 \cdot 10^{-3}$	$\leq 6.05 \cdot 10^{-3}$	277 FIT	847 FIT	283 FIT	0 FIT

1) Safe Failure Fraction