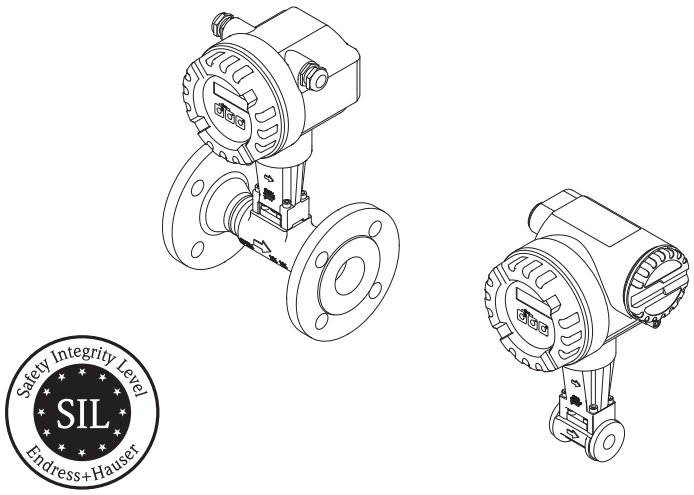
Level | Pressure | Flow | Temperature | Liquid Analysis | Registration | Systems Components | Services | Solutions

Functional Safety Manual

Proline Prowirl 72, 73

Vortex flow measuring system with 4–20 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 in accordance with 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 for Prowirl 72 – independently assessed (Functional Assessment) by exida.com as per IEC/EN 61508 and IEC/EN 61511-1
- For flow monitoring (Min., Max., range) up to SIL 1 for Prowirl 73 – 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

SD00100D/06/EN/13.11
71141458

Valid as of version
V 01.00.zz (device software)

Endress+Hauser
People for Process Automation

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SIL Declaration of Conformity

Prowirl 72

Endress+Hauser
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Ole Koudal
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SIL Declaration of Conformity Prowirl 72
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 device

Prowirl 72 (4...20 mA)

is suitable for the use in a safety instrumented system up to SIL-2 according to IEC 61511-1 if the 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 4 years the following parameters for the worst case of the tested configurations:

SIL (Safety Integrity Level)	:	2
HFT (Hardware Failure Tolerance)	:	0 [1]
Device Type	:	Type B (complex component)
SFF (Safe failure fraction)	:	> 80%
PFD_{avg} (Probability of Failure on Demand)[2]	:	$\leq 3.056 \times 10^{-3}$

Failure rates according to IEC 61508

λ_{du} (failure rate dangerous undetected faults)	:	175×10^{-9} /h (175 FIT)
λ_{dd} (failure rate dangerous detected faults)	:	446×10^{-9} /h (446 FIT)
λ_{su} (failure rate safe undetected faults)	:	402×10^{-9} /h (402 FIT)
λ_{sd} (failure rate safe detected faults)	:	17×10^{-9} /h (17 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 1.00.00, in use since March 2003) including the modification process.

Reinach, 18.01.2005
Endress+Hauser Flowtec AG
Project Manager FEV/OK

SIL Konformitätserklärung 72 e.doc /

Prowirl72-en-konformitaet.pdf

Prowirl 73

Endress+Hauser
People for Process Automation

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SIL Declaration of Conformity Prowirl 73
Functional Safety of a flow measuring device according to IEC 61508

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

Prowirl 73 (4...20 mA)

is suitable for the use in a safety instrumented system up to SIL-1 if the 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 10 years the following parameters for the worst case of the tested configurations:

SIL (Safety Integrity Level)	:	1
HFT (Hardware Failure Tolerance)	:	0
Device Type	:	Type B (complex component)
SFF (Safe failure fraction)	:	> 80%
PFD_{avg} (Probability of Failure on Demand) [1]	:	$\leq 7.90 \times 10^{-3}$

Failure rates according to IEC 61508

λ_{du} (failure rate dangerous undetected faults)	:	181×10^{-9} /h (181 FIT)
λ_{dd} (failure rate dangerous detected faults)	:	462×10^{-9} /h (462 FIT)
λ_{su} (failure rate safe undetected faults)	:	431×10^{-9} /h (431 FIT)
λ_{sd} (failure rate safe detected faults)	:	17×10^{-9} /h (17 FIT)

1) The PFD_{avg} values are also within the range for SIL-2 according to ISA S84.01.

Reinach, 18.01.2005

Endress+Hauser Flowtec AG
Project Manager FEV/OK

SIL Konformitätserklärung 73 e.doc /

Prowirl73-en-konformitaet.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 Prowirl 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		

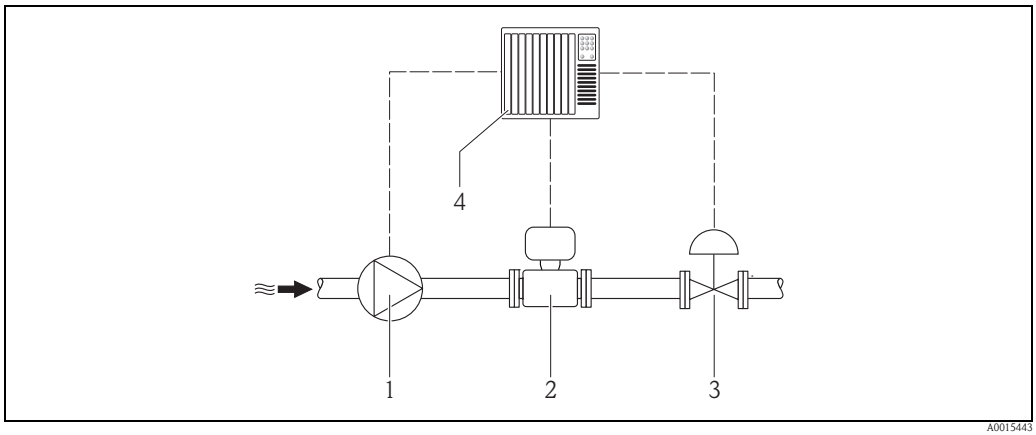
1) In accordance with IEC 61511-1 (section 11.4.4), the HFT can be reduced by one (values in brackets) if the devices used meet the following conditions:
- The device is proven in use
- Only process-relevant parameters can be changed at the device (e.g. measuring range, …)
- Changing the process-relevant parameters is protected (e.g. password, jumper, …)
- The function has a SIL requirement of less than 4

The Prowirl 72 measuring system meets these conditions,
the Prowirl 73 measuring system is not proven in use.

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).

Layout of measuring system with Prowirl 72, 73

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 automation system is also capable of reading in additional process variables, such as pressure or temperature, in order to calculate a mass flow or corrected volume flow using this information and the volume flow measured by Prowirl 72, 73.
- To ensure an intrinsically safe power supply to the Prowirl 72, 73, an active barrier (e.g. RN221N) can also be switched between the automation system and the Prowirl 72, 73:

Sensor	→	Active barrier (e.g. RN 221N)	→	Automation system (e.g. PLC)	→	Actuator (e.g. valve)
PFD…≤ 35 %		PFD…≤ 10 %				

→ Share of active barrier in the “average Probability of Failure on Demand" (PFD_{avg}).

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 Prowirl 72/73 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:
- Prowirl 72/73***-**********A
- Prowirl 72/73***-**********W

Safety function data

The mandatory settings and safety function data emanate from the section "Settings and installation instructions" (→ 🖹 7) and the appendix (→ 🖹 16). 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 incl. Description of Device Functions
Prowirl 72	BA00084D/06
Prowirl 73	BA00094D/06

This document also includes information on application limits and ambient conditions as well as the functional specifications of the current output.
Furthermore, for devices with explosion protection approvals the relevant safety instructions in the accompanying Ex documentation (XA) must be followed.

Configuration and installation instructions

Installation instructions

Instructions for the correct installation of the measuring device can be found in the Operating Instructions (BA) supplied → see "Supplementary device documentation" (→ 7).

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.

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

Configuration instructions

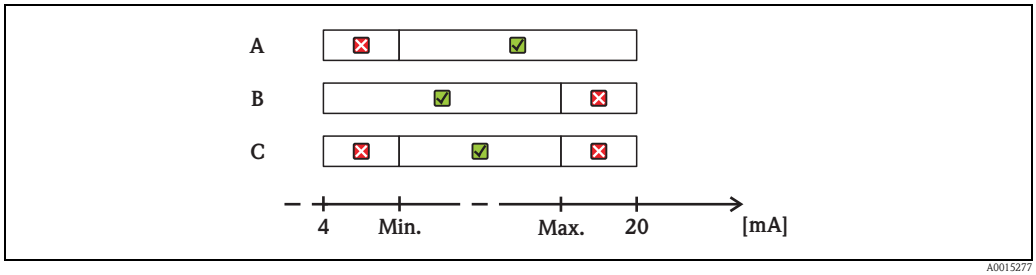
The measuring device can be configured in various ways in process control protection systems:
- Via onsite operation (LCD display)
- Via HART handheld terminal DXR 375
- Via PC (remote operation) using service and configuration software (e.g. "FieldCare")

The tools mentioned can also be used to retrieve information on the software and hardware revision of the device. Further instructions on the settings can be found in the corresponding Operating Instructions → see "Supplementary device documentation" (→ 7).

Monitoring options

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

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 (only Prowirl 73)	Volume flow
CURRENT OUTPUT	CURRENT SPAN	– 4–20 mA HART NAMUR – 0-20 mA HART US 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 value – Max. current value
CURRENT OUTPUT	SIMULATION CURRENT	Off
SYSTEM PARAMETER	POSITIVE ZERO RETURN	Off
SUPERVISION	ASSIGN SYSTEM ERROR	Off (the assignment of notice and error 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 "Supplementary device documentation" (→ 🖹 7).

Security locking

The software must be locked in order to protect the process-related parameters from being changed. This is done using a code which may be selected by the user.

Software locking for local operation	
Function DEFINE PRIVATE CODE	Selectable code number (except 0)

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 "Supplementary device documentation" (→ 🖹 7).

Setting instructions for evaluation unit

The calculated limit value (mA value corresponding to the desired maximum and/or minimum flow rate) must be entered at the following limit contactor (automation system). For all adjustment and setting procedures, please refer to the relevant Operating Instructions → see "Supplementary device documentation" (→ 🖹 7).

Response to errors

The response in operation and failures is described in the Operating Instructions of the device
→ see "Supplementary device documentation" (→ 🖹 7).

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-labeled 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 testing 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:

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

A0015275

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:

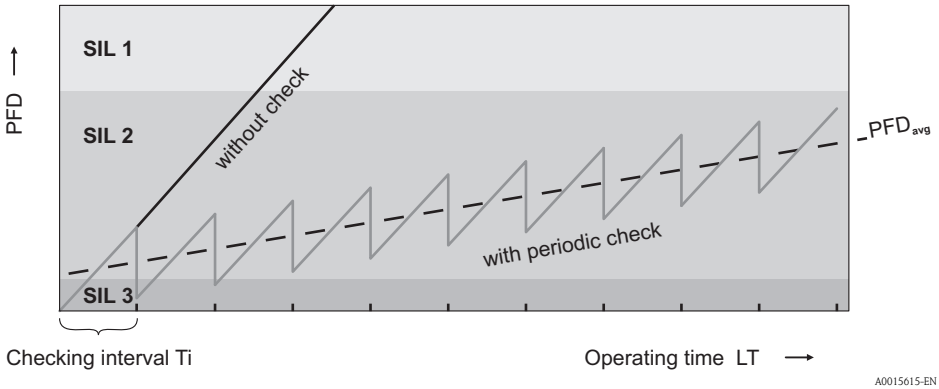
1. **Checking the digital measured value**
   One of the following tests must be carried out depending on the measured variable to be monitored and the available equipment:
   a. Test sequence A – Checking the digital measured value with a calibration rig
      Volume flow
      The measuring device 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 (→ 10) 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 temperature measurement (only Prowirl 73)**
   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. **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.
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 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

Prowirl 72

Assessment Results

Type of Assessment:	FMEDA and Proven-in-use assessment – Option 2
Device Name:	Vortex Flow Measuring System PROWIRL 72
Software Version:	V1.02.01

Table 1: Version overview of the types belonging to the considered devices

V1	PROWIRL 72 Remote Version with COMMODUL HART EEX-D
V2	PROWIRL 72 Remote Version with COMMODUL HART EEX-I
V3	PROWIRL 72 with COMMODUL HART EEX-D
V4	PROWIRL 72 with COMMODUL HART EEX-I

Failure rate Database:	Basic failure rates from the Siemens standard SN 29500
Component Type:	Type B[1]
Hardware Fault Tolerance (HFT):	0
Sensor and mechanical Analysis:	Yes
Useful Lifetime:	10 years
SIL capability:	SIL 2

Version V1: Fail-safe state = "fail high" – IEC 61508 failure rates

Failure Category		λ_{sd}	λ_{su} [2]	λ_{dd}	λ_{du}	SFF	DC_S	DC_D
$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	17 FIT	402 FIT	441 FIT	175 FIT	83,0%	4,0%	71,5%
$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	441 FIT	402 FIT	17 FIT	175 FIT	83,0%	52,3%	8,8%

Version V1: – PFD_{AVG} values

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years
PFD_{AVG} = 7,66E-04	PFD_{AVG} = 3,82E-03	PFD_{AVG} = 7,62E-03

Version V2: Fail-safe state = "fail high" – IEC 61508 failure rates

Failure Category		λ_{sd}	λ_{su} [2]	λ_{dd}	λ_{du}	SFF	DC_S	DC_D
$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	11 FIT	341 FIT	446 FIT	175 FIT	82,0%	3,1%	71,8%
$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	446 FIT	341 FIT	11 FIT	175 FIT	82,0%	56,6%	5,9%

Version V2: – PFD_{AVG} values

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years
PFD_{AVG} = 7,66E-04	PFD_{AVG} = 3,82E-03	PFD_{AVG} = 7,62E-03

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

[2] "no effect" and "annunciation" failures are included in the "λ_{su}" failure category according to IEC 61508. These failures will not affect system reliability and should not be included in spurious trip calculations.

Version V3: Fail-safe state = "fail high" – IEC 61508 failure rates

Failure Category		λ_{sd}	λ_{su} [2]	λ_{dd}	λ_{du}	SFF	DC_S	DC_D
$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	17 FIT	366 FIT	345 FIT	165 FIT	81,5%	4,4%	67,6%
$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	345 FIT	366 FIT	17 FIT	165 FIT	81,5%	48,5%	9,3%

Version V3: – PFD_{AVG} values

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years
PFD_{AVG} = 7,23E-04	PFD_{AVG} = 3,61E-03	PFD_{AVG} = 7,20E-03

Version V4: Fail-safe state = "fail high" – IEC 61508 failure rates

Failure Category		λ_{sd}	λ_{su} [2]	λ_{dd}	λ_{du}	SFF	DC_S	DC_D
$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	11 FIT	306 FIT	350 FIT	165 FIT	80,1%	3,4%	67,9%
$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	350 FIT	306 FIT	11 FIT	165 FIT	80,1%	53,3%	6,2%

Version V4: – PFD_{AVG} values

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years
PFD_{AVG} = 7,23E-04	PFD_{AVG} = 3,61E-03	PFD_{AVG} = 7,20E-03

Prowirl 73

Assessment Results

Type of Assessment:	Hardware assessment (FMEDA) – Option 1
Device Name:	Vortex Flow Measuring System PROWIRL 73
Software Version:	V1.01.00 (PROWIRL 73)

Table 1: Version overview of the types belonging to the considered devices

V1	PROWIRL 73 Remote Version with COMMODUL HART EEX-D
V2	PROWIRL 73 Remote Version with COMMODUL HART EEX-I
V3	PROWIRL 73 with COMMODUL HART EEX-D
V4	PROWIRL 73 with COMMODUL HART EEX-I

Failure rate Database:	Basic failure rates from the Siemens standard SN 29500
Component Type:	Type B[1]
Hardware Fault Tolerance (HFT):	0
Sensor and mechanical Analysis:	Yes
Useful Lifetime:	10 years
SIL capability:	SIL 1

Version V1: Fail-safe state = "fail high" – IEC 61508 failure rates

Failure Category		λ_{sd}	λ_{su} [2]	λ_{dd}	λ_{du}	SFF	DC_S	DC_D
$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	17 FIT	431 FIT	457 FIT	181 FIT	83,3%	3,7%	71,6%
$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	457 FIT	431 FIT	17 FIT	181 FIT	83,3%	51,4%	8,5%

Version V1: – PFD_{AVG} values

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years
PFD_{AVG} = 7,94E-04	PFD_{AVG} = 3,96E-03	PFD_{AVG} = 7,90E-03

Version V2: Fail-safe state = "fail high" – IEC 61508 failure rates

Failure Category		λ_{sd}	λ_{su} [2]	λ_{dd}	λ_{du}	SFF	DC_S	DC_D
$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	11 FIT	370 FIT	462 FIT	181 FIT	82,3%	2,8%	71,8%
$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	462 FIT	370 FIT	11 FIT	181 FIT	82,3%	55,5%	5,7%

Version V2: – PFD_{AVG} values

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years
PFD_{AVG} = 7,93E-04	PFD_{AVG} = 3,96E-03	PFD_{AVG} = 7,89E-03

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

Version V3: Fail-safe state = "fail high" – IEC 61508 failure rates

Failure Category		λ_{sd}	λ_{su} [2]	λ_{dd}	λ_{du}	SFF	DC_S	DC_D
$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	17 FIT	395 FIT	361 FIT	171 FIT	81,8%	4,1%	67,8%
$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	361 FIT	395 FIT	17 FIT	171 FIT	81,8%	47,7%	9,0%

Version V3: – PFD_{AVG} values

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years
PFD_{AVG} = 7,51E-04	PFD_{AVG} = 3,75E-03	PFD_{AVG} = 7,48E-03

Version V4: Fail-safe state = "fail high" – IEC 61508 failure rates

Failure Category		λ_{sd}	λ_{su} [2]	λ_{dd}	λ_{du}	SFF	DC_S	DC_D
$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	11 FIT	335 FIT	366 FIT	171 FIT	80,6%	3,1%	68,1%
$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	366 FIT	335 FIT	11 FIT	171 FIT	80,6%	52,2%	6,0%

Version V4: – PFD_{AVG} values

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years
PFD_{AVG} = 7,51E-04	PFD_{AVG} = 3,75E-03	PFD_{AVG} = 7,47E-03

Appendix (safety-related characteristic values)

Introductory comments

Depending on the order code, Prowirl 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-n". 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).

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 are comparable with the Ground Fixed classification of MIL-HDBK-217F. Alternatively, the assumed environment is similar to IEC 60654-1, Class C (sheltered location) with temperature limits within the manufacturer's rating and an average transmitter temperature of 40°C (104 °F) over a longer time period. The humidity level is assumed to be within the manufacturer's rating.
- 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).

Prowirl 72

Specific values

Prowirl 72	
SIL	SIL 2
HFT	0
SFF	> 76.6 %
PFD_{avg} (based on a service interval of 4 years)	$< 3.06 \cdot 10^{-3}$
Complete functional test e.g. by approaching the flow limit values	every 4 years (for additional values see the following diagram)
Product life span	10 years

Detailed data on error rates:

Sensor Prowirl 72			
λ_{safe}	λ_{dd}	λ_{du}	SFF
0 FIT	138 FIT	4 FIT	97.2 %

Electronics Prowirl 72									
Version	Error category		λ_{sd} [FIT]	λ_{su}[2] [FIT]	λ_{dd} [FIT]	λ_{du} [FIT]	SFF	DC_S	DC_D
Non-Ex + Ex-i/IS; compact	$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	11	168	350	161	76.6 %	6.1 %	68.4 %
	$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	350	168	11	161	76.6 %	67.5 %	6.4 %
Non-Ex + Ex-i/IS; remote	$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	11	203	446	171	79.4 %	5.1 %	72.2 %
	$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	446	203	11	171	79.4 %	68.7 %	6.0 %
Ex-d/XP compact	$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	17	228	345	161	78.5 %	6.9 %	68.1 %
	$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	345	228	17	161	78.5 %	60.2 %	9.5 %
Ex-d/XP remote	$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	17	264	441	171	80.8 %	6.0 %	39.3 %
	$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	441	264	17	171	80.8 %	29.6 %	9.0 %

Prowirl 73

Specific values

Prowirl 73	
SIL	SIL 1
HFT	0
SFF	> 76.8 %
PFD_{avg} (based on a service interval of 4 years)	$< 7.90 \cdot 10^{-3}$
Complete functional test e.g. by approaching the flow limit values	every 10 years (for additional values see the following diagram)
Product life span	10 years

Detailed data on error rates:

Sensor Prowirl 73			
λ_{safe}	λ_{dd}	λ_{du}	SFF
16 FIT	138 FIT	4 FIT	97.5 %

Electronics Prowirl 73									
Version	Error category		λ_{sd} [FIT]	λ_{su}[2] [FIT]	λ_{dd} [FIT]	λ_{du} [FIT]	SFF	DC_S	DC_D
Non-Ex + Ex-i/IS; compact	$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	11	181	366	167	76.8 %	5.7 %	68.6 %
	$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	366	181	11	167	76.8 %	66.9 %	6.1 %
Non-Ex + Ex-i/IS; remote	$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	11	216	462	177	79.5 %	4.8 %	72.3 %
	$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	462	216	11	177	79.5 %	68.1 %	5.8 %
Ex-d/XP compact	$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	17	241	361	167	78.7 %	6.5 %	68.3 %
	$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	361	241	17	167	78.7 %	59.9 %	9.2 %
Ex-d/XP remote	$\lambda_{low} = \lambda_{sd}$	$\lambda_{high} = \lambda_{dd}$	17	277	457	177	80.9 %	5.7 %	72.0 %
	$\lambda_{low} = \lambda_{dd}$	$\lambda_{high} = \lambda_{sd}$	457	277	17	177	80.9 %	62.2 %	8.7 %

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