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

Functional Safety Manual

Proline Prowirl 72, 73 with 4...20 mA output signal

Vortex Flow Measuring System

Application

Monitoring of maximum and / or minimum flow for all types of media using a flowmeter which meets the specific safety requirements of IEC 61508 / IEC 61511-1. The measuring device meets the requirements relating to:

- Functional safety in accordance with IEC 61508 / IEC 61511-1
- Explosion protection (dependant on version)
- Electromagnetic compatibility in accordance with EN 61326 / A1 (IEC 1326) and NAMUR Recommendation NE 21.

Monitoring is done on the current output of the device.

Features and benefits

- For flow monitoring up to SIL 2 for Prowirl 72 - independently assessed (Functional Assessment) by exida.com in accordance with IEC 61508 / IEC 61511-1
- For flow monitoring up to SIL 1 for Prowirl 73 - independently assessed (Hardware Assessment) by exida.com in accordance with IEC 61508
- Permanent automatic monitoring
- Continuous measurement
- Measurement independent of product characteristics
- Easy to commission

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Endress+Hauser

People for Process Automation

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Declaration of conformity

Prowirl 72

Endress+Hauser
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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 /

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 /

General information

General description of a safety system (protection function)

The following tables are used to determine the attainable SIL (Safety Integrity Level) or the requirements regarding the "average Probability of Failure on Demand" (PFD_{avg}), the "Hardware Fault Tolerance" (HFT) and the "Safe Failure Fraction" (SFF) for the safety system.
The specific values for the Prowirl measuring system can be found in the tables in the Appendix. Permitted probability of failure for the entire safety function depending on the SIL for systems which must react to demands (e.g. if a defined max. flow rate is exceeded) (source: IEC 61508, Part 1):

SIL	PFD_{avg}
4	$\geq 10^{-5} ... < 10^{-4}$
3	$\geq 10^{-4} ... < 10^{-3}$
2	$\geq 10^{-3} ... < 10^{-2}$
1	$\geq 10^{-2} ... < 10^{-1}$

The following table shows the attainable SIL depending on the Safe Failure Fraction and the Hardware Fault Tolerance of the entire safety system for systems of type B (complex components, for definition see IEC 61508, Part 2):

SFF		HFT		
		0	1 (0)[1)]	2 (1)[1)]
none:	< 60%	not allowed	SIL 1	SIL 2
low:	60%...< 90%	SIL 1	SIL 2	SIL 3
medium:	90%...< 99%	SIL 2	SIL 3	
high:	≥ 90%	SIL 3		

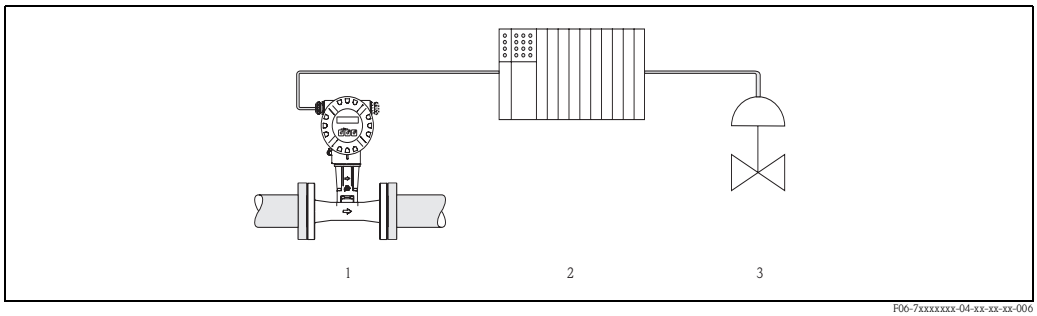
[1)] According to IEC 61511-1 (Chapter 11.4.4), the HFT can be reduced by one (value in brackets) if the deployed devices meet the following requirements:

1. The device is proven in use
2. The device allows only process-related parameters to be adjusted (e.g. measuring range, ...)
3. The adjustment of the process-related parameters is protected (e.g. password, jumper, ...)
4. The function has a SIL requirement of less than 4

The conditions:

- 1 to 4 apply to Prowirl 72
- 2 to 4 apply to Prowirl 73

Layout of measuring system with Prowirl 72, 73



Layout of a Prowirl 72, 73 in a system environment

1. Prowirl 72, 73
2. Logic solver (e.g. PLC)
3. Actuator (e.g. valve)

A flow-proportional analog signal (4...20 mA) is generated in the transmitter (Prowirl 72, 73). This signal is sent to a downstream logic solver (e.g. PLC, ...). The logic monitors whether a particular flow rate is overshot or undershot. For fault monitoring, the logic solver must also be able to recognise both HI alarms (> 22.0 mA) and LO alarms (< 3.8 mA).

Note!

1. The logic solver 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.
2. To ensure an intrinsically safe power supply to the Prowirl 72, 73, an active barrier (e.g. RN221N) can also be switched between the logic solver and the Prowirl 72, 73:

Sensor	→	Active barrier (e.g. RN 221N)	→	Logic solver (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})

The characteristic values calculated (see appendix → Page 10) apply exclusively to the 4...20 mA current output of the following versions:

- Prowirl 72***-**********A
- Prowirl 72***-**********W
- Prowirl 73***-**********A
- Prowirl 73***-**********W

Data for safety function

The **mandatory configuration** and data for the safety function can be found in the chapter **"Configuration and installation instructions"** and in the **"Appendix"**.

Note!
The "Mean Time To Repair (MTTR)" is set at 8 hours.

Additional relevant device documentation

The following documentation must be available for the measuring system:

Device type	Operating Instructions
Prowirl 72	BA084D/06/en
Prowirl 73	BA094D/06/en

This documentation also contains information on the application limits and the environmental conditions in addition to 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 Prowirl 72, 73 can be found in the accompanying Operating Instructions (BA) (see table → Page 7).

Configuration instructions

The Prowirl 72, 73 can be configured in different ways:
- Local operation using LCD display
- Operation using DXR 375 handheld terminal
- Remote operation using PC: FieldTool (service and configuration software)

The specified tools can also be used to obtain information on the software and hardware revision of the device.

Additional configuration instructions can be found in the relevant Operating Instructions (BA) (see table → Page 7).

Configuration of Prowirl 72, 73 for monitoring maximum and / or minimum flow rate

The table below shows the configuration necessary if the Prowirl 72, 73 is to be used in a safety application.

The fields of application are:
- Monitoring of a maximum flow rate
- Monitoring of a minimum flow rate
- Monitoring of a flow range (max. and min. flow rate simultaneously)

The configuration always refers to the 4...20 mA output value of the current output corresponding to the flow value.

Group	Function name	Configuration possibilities when using the Prowirl for a safety function
CURRENT OUTPUT	ASSIGN CURRENT (Prowirl 73 only)	VOLUME FLOW
CURRENT OUTPUT	CURRENT RANGE	– 4...20 mA HART NAMUR – 4...20 mA HART US The HART write protection must be activated (for HART write protection see security locking on the next page)
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 measuring device can be found in the accompanying Operating Instructions (see table → Page 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	
Private code function	Selectable code number (except 0)

If using a HART interface, the HART write protection must be activated. This is done using a switch on the main board. The correct procedure for activating the HART write protection can be found in the relevant Operating Instructions (see table → Page 7).

Configuration 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 (logic solver). All calibrations and configurations must be done in accordance with the relevant Operating Instructions.

Response to errors

Note!
The behaviour during operation and in case of error is described in the documentation pertaining to the device. (see table → Page 7).

- Any repairs to the device must be carried out exclusively by the manufacturer.
- Instrument errors must be reported to the manufacturer. The user describes the error and the possible consequences to the manufacturer in the form of a detailed notification. In addition, information is exchanged to establish if the fault is dangerous or cannot be directly ascertained.

Recurrent testing of measuring system

The operativeness of the safety device must be tested at appropriate intervals (see Appendix → Page 10). We recommend testing at least every 4 years in the case of the Prowirl 72 and every 10 years in the case of the Prowirl 73. It is the responsibility of the operator to choose the type of inspection and the time intervals within the specified timeframe. The test should be performed in such a way that the safety device is proven to function perfectly in combination with all components. This is achieved by approaching the flow limit values or comparing the totalizer value with a balancing option (e.g. filling of a tank) once per maintenance period. This results in both cases in Diagnostic Coverage of 100%. If the operativeness of the flow sensor / transmitter can be ascertained by other means (elimination of faults which inhibit functions), the test may also be performed by simulating the relevant output signal.

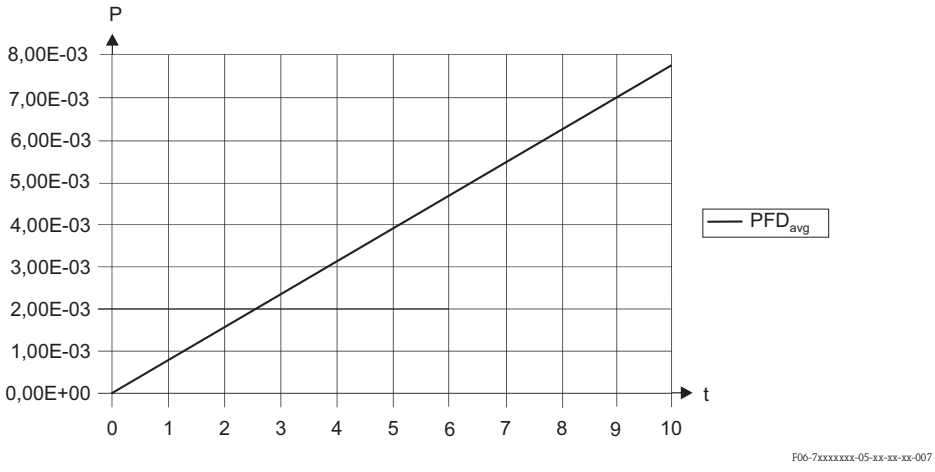
Appendix

Specific values for Prowirl 72 measuring system

The following table shows the specific safety-related characteristic values for the Prowirl 72 measuring system when using the current output. The values apply to all fields of application: monitoring of the maximum flow, monitoring of the minimum flow or monitoring of a flow range (maximum and minimum flow). The error rates given refer to the failure rates of the Siemens Norm SN29500 at an ambient temperature of 40 °C. The values were based on devices with software version 1.01.00.

Specific values

Prowirl 72	
SIL	SIL 2
HFT	0
SFF	> 76.6%
PFD_{avg} (based on a service interval of 4 years)	< 3.06E–03
Complete functional test e.g. by approaching the flow limit values	every 4 years (for additional values see the diagram below)
Product life span	10 years



PFD_{avg}(t) for Prowirl 72

1001D Structure:
t = years
P = probability

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%

A failure is regarded as a “dangerous failure” if no response is given to a request from the process (i.e. the Prowirl 72 device does not respond to the failure in the predefined way).

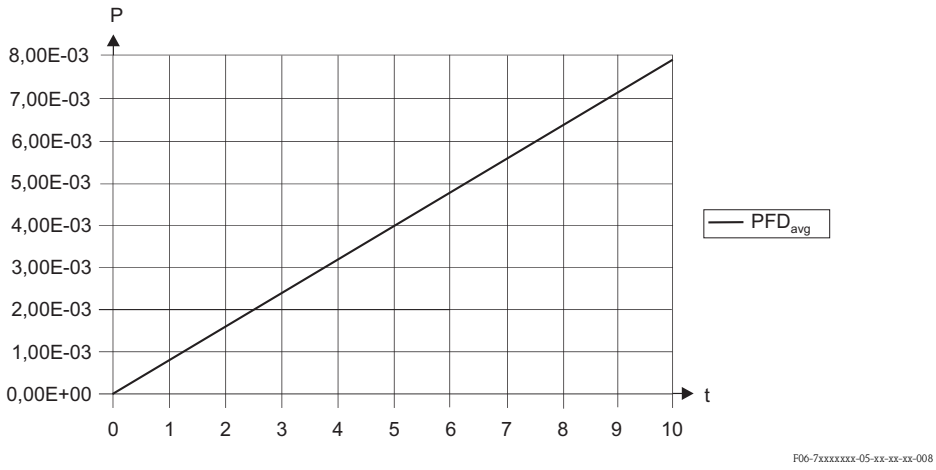
The following assumptions were made:
- Error rates are constant. Wear mechanisms are not taken into account.
- Error propagation is not relevant.
- The HART protocol is used only for programming, calibration and diagnostic purposes and not during normal operation.
- The recovery period following a safe failure is 8 hours.
- The test time for the logic solver to respond to a detected error is 1 hour.
- All modules are operated in Low Demand mode.
- Only the current output is used for safety-relevant applications.
- Error rates of the external power supply are not taken into account.
- 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 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 is not part of the safety function, the error rate of the display is not taken into account in the calculations.
- The application program in the safety logic solver is designed in such a way that Fail High and Fail Low failures are detected regardless of the effect, safe or dangerous, on the safety function.

Specific values for Prowirl 73 measuring system

The following table shows the specific safety-related characteristic values for the Prowirl 73 measuring system when using the current output. The values apply to all fields of application: monitoring of the maximum flow, monitoring of the minimum flow or monitoring of a flow range (maximum and minimum flow). The error rates given refer to the failure rates of the Siemens Norm SN29500 at an ambient temperature of 40 °C. The values were based on devices with software version 1.01.00.

Specific values

Prowirl 73	
SIL	SIL 1
HFT	0
SFF	> 76.8%
PFD_{avg} (based on a service interval of 4 years)	< 7.90E–03
Complete functional test e.g. by approaching the flow limit values	every 10 years (for additional values see the diagram below)
Product life span	10 years



PFD_{avg}(t) for Prowirl 73

1001D Structure:
t = years
P = probability

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%

A failure is regarded as a “dangerous failure” (λ_{dd} and λ_{du}) if no response is given to a request from the process (i.e. Prowirl does not respond to the failure in the predefined way).

The following assumptions were made:
- The error rates are constant. Wear mechanisms are not taken into account.
- Error propagation is not relevant.
- The HART protocol is used only for programming, calibration and diagnostic purposes and not during normal operation.
- The recovery period following a safe failure is 8 hours.
- The test time for the logic solver to respond to a detected error is 1 hour.
- All modules are operated in Low Demand mode.
- Only the current output is used for safety-relevant applications.
- Error rates of the external power supply are not taken into account.
- 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 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 is not part of the safety function, the error rate of the display is not taken into account in the calculations.
- The application program in the safety logic solver is designed in such a way that Fail High and Fail Low failures are detected regardless of the effect, safe or dangerous, on the safety function.

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.

Prowirl 72

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.

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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

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