



Level



Pressure



Flow



Temperature



Liquid  
Analysis



Registration



Systems  
Components



Services



Solutions

## Functional safety manual

# RN221N

## Active barrier



### Application

Galvanic isolation of 4 to 20 mA current circuits and powering 2 wire transmitters, when used in safety relevant applications to satisfy particular safety systems requirements as per IEC 61508/ IEC 61511-1.

The active barrier fulfils the requirements concerning

- Functional safety as per IEC 61508/IEC 61511-1
- Explosion protection (depending on the version)
- Electromagnetic compatibility as per IEC 61326.

### Your benefits

- Used in safety relevant applications to satisfy particular safety systems requirements up to SIL 2, independently evaluated (Functional Assessment) by [exida.com](http://exida.com) as per IEC 61508/IEC 61511-1

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## SIL Declaration of Conformity

**Functional safety of an active barrier  
according to IEC 61508/IEC 61511**

**Endress+Hauser Wetzler GmbH+Co. KG, Obere Wank 1, 87484 Nesselwang**

declares as manufacturer, that the active barrier

### RN 221N

is suitable for the use in a safety-instrumented system according to standard IEC 61511-1, provided the relevant safety instructions are observed.

The FMEDA provides the following parameters:

SIL	2		
Proof test interval	1 year		
Device type	A		
HFT <sup>1)</sup>	0 (single channel use)		
SFF	> 83 %		
PFD <sub>AVG</sub> <sup>2)</sup>	2.76x10 <sup>-4</sup>		
MTBF <sup>3)</sup>	305 years		
Safety function <sup>4)</sup> monitoring	low level	high level	range
$\lambda_{sd}$	122 FIT	72 FIT	194 FIT
$\lambda_{su}$	122 FIT	122 FIT	122 FIT
$\lambda_{dd}$	72 FIT	122 FIT	0 FIT
$\lambda_{du}$	63 FIT	63 FIT	63 FIT

<sup>1)</sup> according to clause 11.4.4 of IEC 61511-1

<sup>2)</sup> the value complies with SIL2 according to ISA S84.01 and IEC 61511-1

<sup>3)</sup> according to Siemens SN29500

<sup>4)</sup> assuming transmitter setting of 4 to 20 mA

The device including the modification process was assessed on the basis of prior use.

Nesselwang, 30 July 2003

Endress+Hauser Wetzler GmbH+Co. KG



General manager

**Endress + Hauser**

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## Introduction

### Abbreviations, standards and terms

#### Abbreviations

Explanation to the abbreviations used can be found in the SIL-Brochure (SI002Z/11).

#### Relevant standards

Standard	Explanation
IEC 61508, Part 1 – 7	Functional safety of electrical/electronic/programmable electronic safety-related systems (Target group: Manufacturers and Suppliers of Devices)
IEC 61511 Part 1 – 3 (FDIS)	Functional safety – Safety Instrumented Systems for the process industry sector (Target group: Safety Instrumented Systems Designers, Integrators and Users)

#### Terms

Term	Explanation
Dangerous failure	Failure with the potential to put the safety-related system in a dangerous or non-functional condition.
Safety-related system	A safety-related system performs the safety functions that are required to achieve or maintain a safe condition e.g. in a plant. Example: temperature measuring device – logic unit (e.g. limit signal generator) – valve form a safety-related system.
Safety function	Defined function, which is performed by a safety-related system with the aim of achieving or maintaining a safe condition for the plant, considering a specified dangerous incident. Example: limit temperature monitoring

### Determining the Safety Integrity Level (SIL)

The achievable Safety Integrity Level is determined by the following safety-related parameters:

- Average Probability of Failure on Demand ( $PFD_{AVG}$ )
- Hardware Fault Tolerance (HFT) and
- Safe Failure Fraction (SFF).

The specific safety-related parameters for the RN221N, as a part of a safety function, are listed in the "Safety-related parameters" chapter.

The following table displays the dependence of the "Safety Integrity Level" (SIL) on the "Average Probability of Failure on Demand" ( $PFD_{AVG}$ ). Here, the "Low demand mode" has been observed, i.e. the requirement rate for the safety-related system is maximum once a year.

Safety Integrity Level (SIL)	$PFD_{AVG}$ (Low demand mode)
4	$\geq 10^{-5} \dots < 10^{-4}$
3	$\geq 10^{-4} \dots < 10^{-3}$
2	$\geq 10^{-3} \dots < 10^{-2}$
1	$\geq 10^{-2} \dots < 10^{-1}$

Sensor, active barrier, logic unit and actuator together form a safety-related system, which performs a safety function. The "Average Probability of Failure on Demand" ( $PFD_{AVG}$ ) is usually divided up into the sensor, active barrier, logic unit and actuator sub-systems as per Figure 1.

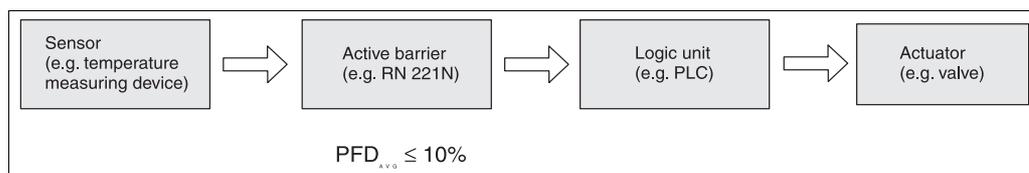


Fig. 1: Active barrier part of the "Average Probability of Failure on Demand" ( $PFD_{AVG}$ )



#### Note!

This documentation considers the RN221N as a component of a safety function.

### Safety Integrity Level RN221N (Type A)

The following table displays the achievable "Safety Integrity Level" (SIL) of the entire safety-related system for type A systems depending on the "Safe Failure Fraction" (SFF) and the "Hardware Fault Tolerance" (HFT). Type A systems are, for example, units with simple components (→ see also IEC 61508, Part 2).

Safe Failure Fraction (SFF)	Hardware Fault Tolerance (HFT)		
	0	1	2
< 60%	SIL 1	SIL 2	SIL 3
60 ... < 90 %	<b>SIL 2</b>	SIL 3	SIL 4
90 ... < 99 %	SIL 3	SIL 4	SIL 4
≥ 99 %	SIL 4	SIL 4	SIL 4

## Safety function with RN221N

### Safety function for limit monitoring

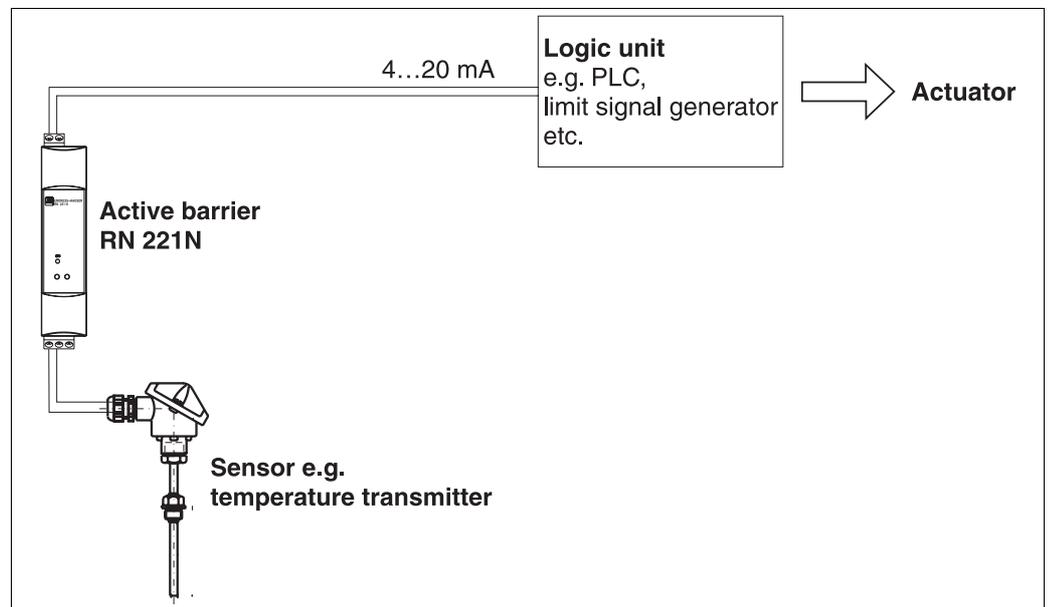


Fig. 2: safety function with RN221N

The sensor powered by the the active barrier RN221N generates an analogue signal (4 to 20 mA) proportional to the measured value. The analogue signal is fed via the active barrier RN221N to a downstream logic unit, such as a PLC or limit signal generator, and there it is monitored to determine whether it exceeds a maximum value.

### Safety function data



Caution!

The data for the safety functions are listed in the "Safety-related parameters" chapter.



Note!

MTTR is set at eight hours.

Safety-related systems without a self-locking function must be monitored or set to an otherwise safe state after carrying out the safety function within MTTR.

### Unit version

SIL from serial number: 5400C00411F, april 2003

### Supplementary device documentation RN221N

Depending on the version, the following documentation must be available for the active barrier RN221N:

Explosion protection/Certificates	Operating instructions	Other Ex-Documentation
none	KA069R	none
ATEX II (1) G EEx ia IIC T4/T5/T6	KA069R	Safety instructions XA005R

Explosion protection/ Certificates	Operating instructions	Control Drawings FM	Control Drawings CSA
none		none	none
FM AIS I-III, 1, A-G CSA [Ex ia], I-III, A-G		02 02 00 111	02 02 00 112



#### Caution!

- The installation and setting instructions, and the technical limit values must be observed in accordance with the Operating Instructions (KA069R).
- For devices which are used in explosion-hazardous, the supplementary documentation (XA) resp. Control Drawings must also be used in accordance with the table.

#### RN221N supplementary documentation

For further information, see Technical Information TI073R.

## Commissioning and iterative tests

#### Using the RN221N in a safety installation

The operability of the safety installation must be tested at appropriate time intervals. It is the responsibility of the user to select the type of check and the intervals in the specified time frame. The test must be completed in such a way that the fault free function of the safety installation combined with all components can be validated.

## Safety-related parameters

#### Specific safety-related parameters for RN221N

The table displays the specific safety-related parameters for the RN221N.

	RN221N
SIL	SIL 2
HFT	0
SFF	> 83 %
PFD <sub>AVG</sub>	$2.76 \times 10^{-4}$
TI <sup>1)</sup>	annual

1) Complete function test

#### PFD<sub>AVG</sub> dependent on selected maintenance interval

The following diagram presents the dependence of the PFD<sub>AVG</sub> on the maintenance interval. The PFD<sub>AVG</sub> increases as the maintenance interval increases.

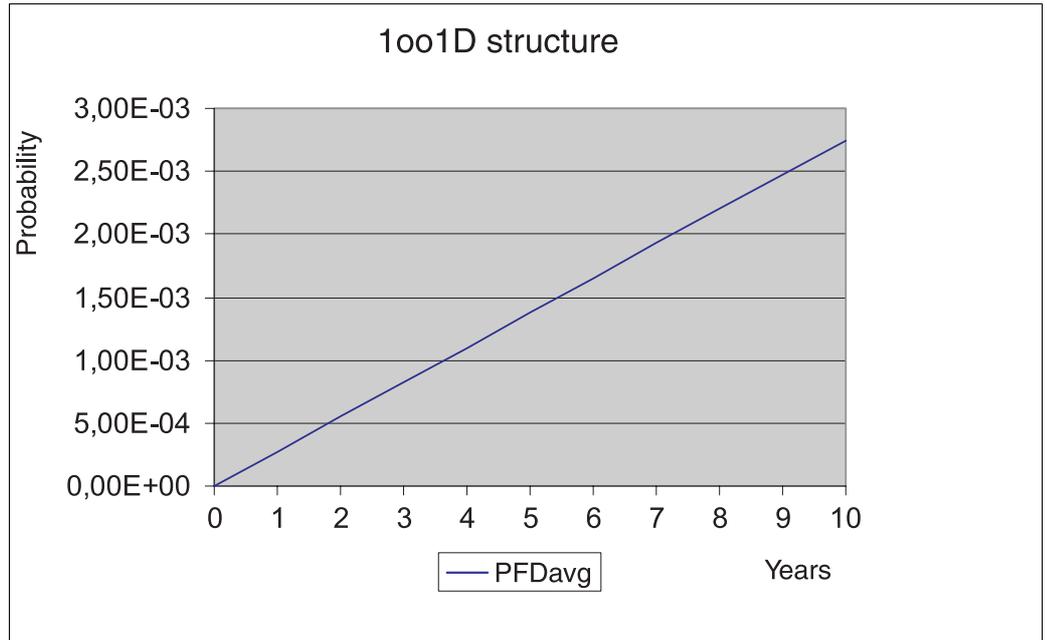


Fig. 4: "Average Probability of Failure on Demand" ( $PFD_{AVG}$ ) dependent on the selected maintenance interval

## Repair

### Repair



#### Note!

Together with the failed, SIL-marked E+H device, having been operated in a functional safety application, the form "Declaration of Hazardous Material and De-Contamination" containing the appropriate information " Used as SIL device in a Safety Instrumented System" has to be returned.

The "Declaration of Hazardous Material and De-Contamination" can be found in the Appendix at the end of this Functional Safety Manual.

## Exida.com management summary



### 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 Active Barrier preline RN 221N.

The hardware assessment consists of a Failure Modes, Effects and Diagnostics Analysis (FMECA). A FMECA is one of the steps taken to achieve functional safety assessment of a device per IEC 61508. From the FMECA, 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.

The failure rates used in this analysis are based on 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. However, as the module under consideration is only one part of an entire safety function it should not claim more than 10% of this range. For a SIL 2 application the total PFD<sub>avg</sub> value of the SIF should be smaller than 1,00E-02, hence the maximum allowable PFD<sub>avg</sub> value for the active barrier would then be 1,00E-03.

The Active Barrier preline RN 221N is considered to be a Type A<sup>1</sup> component with a hardware fault tolerance of 0.

For Type A components with a SFF of 60% to  $< 90\%$  a hardware fault tolerance of 0 according to table 2 of IEC 61508-2 is sufficient for SIL 2 (sub-) systems.

As the Active Barrier preline RN 221N is supposed to be a proven-in-use device, an assessment of the hardware with additional proven-in-use demonstration for the device was carried out. According to the requirements of IEC 61511-1 First Edition 2003-01 section 11.4.4 and the assessment described in section 5.1 the device is considered to be suitable for use in SIL 2 safety functions.

Assuming that a connected logic solver can detect both over-range (fail high) and under-range (fail low), high and low failures can be classified as safe detected failures or dangerous detected failures depending on whether the Active Barrier preline RN 221N is used in an application for "low level monitoring", "high level monitoring" or "range monitoring". For these applications the following tables show how the above stated requirements are fulfilled.

Type A component: "Non-complex" component (all failure modes are well defined); for details see 7.4.3.1.2 of IEC 61508-2.

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Stephan Aschenbrenner  
e+H 03-2-15-r012 v1 r1.1, July 30, 2003  
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### FMECA and Proven-in-use Assessment

Project:  
Active Barrier preline RN 221N

Customer:  
Endress+Hauser Wetzler GmbH + Co. KG  
Nesselwang  
Germany

Contract No.: E+H 03/2-15  
Report No.: E+H 03/2-15 R012  
Version V1, Revision R1.1, July 2003  
Stephan Aschenbrenner

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Table 1: Summary for RN 221N – PFD<sub>AVG</sub> values

T[Proof] = 1 year PFD <sub>AVG</sub> = 2,76E-04	T[Proof] = 5 years PFD <sub>AVG</sub> = 1,38E-03	T[Proof] = 10 years PFD <sub>AVG</sub> = 2,76E-03
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Table 2: Summary for RN 221N – Failure rates

Failure Categories	$\lambda_{sd}$	$\lambda_{su}$	$\lambda_{nd}$	$\lambda_{au}$	SFF	DC <sub>s</sub> <sup>2</sup>	DC <sub>D</sub>
$\lambda_{low} = \lambda_{sd}$	122 FIT	122 FIT	72 FIT	63 FIT	> 83%	50%	53%
$\lambda_{high} = \lambda_{sd}$	72 FIT	122 FIT	122 FIT	63 FIT	> 83%	37%	66%
$\lambda_{low} = \lambda_{sd}$	194 FIT	122 FIT	0 FIT	63 FIT	> 83%	61%	0%
$\lambda_{high} = \lambda_{sd}$							

A user of the Active Barrier preline RN 221N 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). The complete list of failure rates is presented in section 5.2 along with all assumptions.

The boxes marked in yellow (☐) mean that the calculated PFD<sub>AVG</sub> 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 10% of this range, i.e. to be better than or equal to 1,00E-03. The boxes marked in green (☑) mean that the calculated PFD<sub>AVG</sub> values are within the allowed range for SIL 2 according to table 2 of IEC 61508-1 and table 3.1 of ANSI/ISA-84.01-1996 and do fulfill the requirement to not claim more than 10% of this range, i.e. to be better than or equal to 1,00E-03.

The functional assessment according to IEC 61508 has shown that the Active Barrier preline RN 221N has a PFD<sub>AVG</sub> within the allowed range for SIL 2 according to table 2 of IEC 61508-1 and table 3.1 of ANSI/ISA-84.01-1996 and a Safe Failure Fraction (SFF) of > 83%. Based on the verification of "prior use" it can be used as a single device for SIL2 Safety Functions in terms of IEC 61511-1 First Edition 2003-01.

<sup>2</sup> DC means the diagnostic coverage (safe or dangerous) of the safety logic solver for RN 221N.



## Appendix

**Endress+Hauser** 

People for Process Automation

### Declaration of Hazardous Material and De-Contamination *Erklärung zur Kontamination und Reinigung*

**RA No.**

Please reference the Return Authorization Number (RA#), obtained from Endress+Hauser, on all paperwork and mark the RA# clearly on the outside of the box. If this procedure is not followed, it may result in the refusal of the package at our facility.

*Bitte geben Sie die von E+H mitgeteilte Rücklieferungsnummer (RA#) auf allen Lieferpapieren an und vermerken Sie diese auch außen auf der Verpackung. Nichtbeachtung dieser Anweisung führt zur Ablehnung ihrer Lieferung.*

Because of legal regulations and for the safety of our employees and operating equipment, we need the "Declaration of Hazardous Material and De-Contamination", with your signature, before your order can be handled. Please make absolutely sure to attach it to the outside of the packaging.

*Aufgrund der gesetzlichen Vorschriften und zum Schutz unserer Mitarbeiter und Betriebseinrichtungen, benötigen wir die unterschriebene "Erklärung zur Kontamination und Reinigung", bevor Ihr Auftrag bearbeitet werden kann. Bringen Sie diese unbedingt außen an der Verpackung an.*

Type of instrument / sensor  
*Geräte-/Sensortyp* \_\_\_\_\_

Serial number  
*Seriennummer* \_\_\_\_\_

Used as SIL device in a Safety Instrumented System / *Einsatz als SIL Gerät in Schutzeinrichtungen*

Process data / *Prozessdaten*

Temperature / *Temperatur* \_\_\_\_\_ [°C]

Pressure / *Druck* \_\_\_\_\_ [ Pa ]

Conductivity / *Leitfähigkeit* \_\_\_\_\_ [ S ]

Viscosity / *Viskosität* \_\_\_\_\_ [mm<sup>2</sup>/s]

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