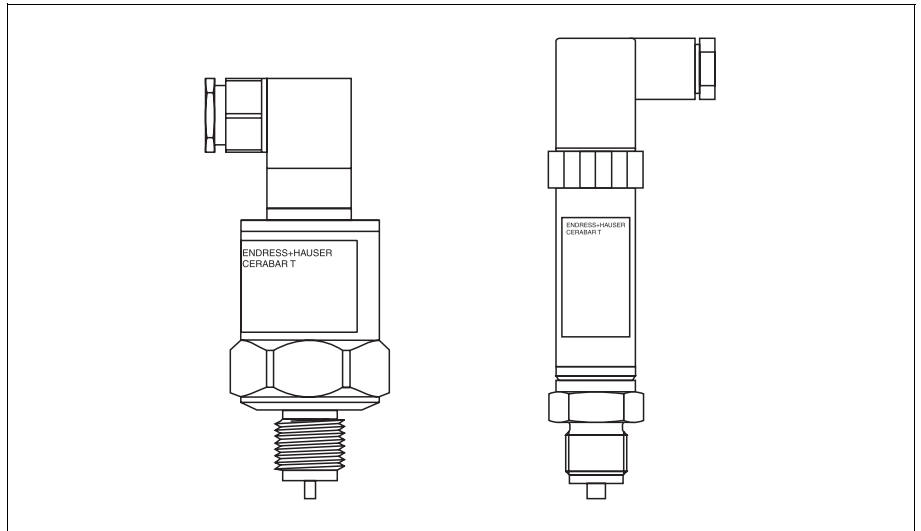


Pressure Transducer *cerabar T PMC 131* *cerabar T PMP 131* with 4...20 mA output signal

Functional safety manual



Application

Pressure measurements (e.g. limit pressure monitoring) to satisfy particular safety systems requirements as per IEC 61508/ IEC 61511-1 (FDIS).

The measuring device fulfils the requirements concerning

- Functional safety as per IEC 61508/IEC 61511-1 (FDIS)
- Explosion protection (depending on the version)
- Electromagnetic compatibility as per EN 61326 and NAMUR recommendation NE 21.

Your benefits

- Used for limit pressure monitoring up to SIL 2, independently evaluated (Functional Assessment) by TÜV Rheinland as per IEC 61508/ IEC 61511-1 (FDIS)
- Continuous measurement
- Easy commissioning

Endress + Hauser

The Power of Know How



Table of contents

SIL declaration of conformity	3
Introduction	4
Abbreviations, standards and terms	4
Determining the Safety Integrity Level (SIL)	5
Safety function with Cerabar T	7
Safety function for limit pressure monitoring	7
Safety function data	7
Supplementary device documentation PMP 131	8
Supplementary device documentation PMC 131	8
Iterative tests	8
Using the Cerabar T for continuous measurements	8
Settings	8
Settings	8
Safety-related parameters	9
Specific safety-related parameters for Cerabar T	9
PFDav dependent on selected maintenance interval	9
TÜV management summary	10

SIL declaration of conformity

SIL-03004a/00/e

SIL Declaration of Conformity

Functional safety of a pressure transducer according to IEC 61508/IEC 61511-1 (FDIS)

Endress+Hauser GmbH+Co. KG, Hauptstrasse 1, D-79689 Maulburg



declares as manufacturer, that the pressure transducers

Cerabar T PMP131, PMC131 (4...20 mA)



are suitable for the use in a safety instrumented system up to SIL2 according to the standard IEC 61508 resp. IEC 61511-1 (FDIS), if the enclosed safety instructions are observed.



The analysis of safety critical and dangerous faults provides under the assumption of an annual functional test cycle the following parameters:



	<u>PMP131</u>	<u>PMC131</u>
SIL (Safety integrity level)	SIL2	SIL 2
HFT (Hardware fault tolerance)	0 ¹⁾ (single channel use)	
SFF (Safe failure fraction)	81.5 %	89.7 %
PFD _{av} (Average probability of failure on demand) ²⁾	2.58x10 ⁻⁵	1.10x10 ⁻⁴
MTBF _{tot} (Mean time between total failures)	> 150 years	> 150 years
λ _{safe} + λ _{DD} (Sum of safe and dangerous detected failure rates)	25.9 FIT	220.7 FIT
λ _{DU} (Dangerous undetected failure rate)	5.9 FIT	25.2 FIT

¹⁾ according to clause 11.4 of IEC 61511-1 (FDIS)

²⁾ The PFD_{av} values are also within the range for SIL2 according to ISA S84.01.

The assessment of the proven-in-use demonstration covers the device including the modification process.

Maulburg, Februar 10, 2003

Endress+Hauser GmbH+Co. KG

i.V. 
 Leiter Zertifizierung
 Manager Certification


 Projektleiter
 Project Manager

Endress + Hauser
 The Power of Know How



Introduction

Abbreviations, standards and terms

Abbreviations

Abbreviation	Explanation
HFT	Hardware Fault Tolerance <i>Ability of a functional unit (hardware) to continue to perform a required function in the presence of faults or errors.</i>
MTBF	Mean Time Between Failures
MTTR	Mean Time To Repair
PFD	Probability of Failure on Demand
PVD _{av}	Average Probability of Failure on Demand
SIL	Safety Integrity Level <i>The international standard IEC 61508 defines four discrete Safety Integrity Levels (SIL 1 to SIL 4). Each level corresponds to a range of probability for the failure of a safety function. The higher the Safety Integrity Level of the safety-related systems, the lower the probability that they will not perform the requested safety function.</i>
SFF	Safe Failure Fraction <i>Fraction of failures which do not have the potential to put the safety-related system in a hazardous or fail-to-function state.</i>
TI	Test interval between life testing of the safety function
XooY	"X out of Y" voting <i>Classification and description of the safety-related system with regard to redundancy and selection procedure used.</i> <i>"Y" specifies how often the safety function is performed (redundancy).</i> <i>"X" determines how many channels have to work properly.</i> <i>Pressure measurement example: 1oo2 architecture – A safety-related system decides that a predefined pressure limit is exceeded when one of two pressure sensor reaches this limit. If a 1oo1 architecture is used, there is only one pressure sensor available.</i>

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)

Safety Integrity Level PMP 131 (Type A)

The following table displays the achievable "Safety Integrity Level" (SIL) of the entire-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, sensors 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 %	SIL 2	SIL 3	SIL 4
90...< 99 %	SIL 3	SIL 4	SIL 4
≥ 99 %	SIL 4	SIL 4	SIL 4

Safety Integrity Level PMC 131 (Type B)

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

Safe Failure Fraction (SFF)	Hardware Fault Tolerance (HFT)		
	0	1 (0) ¹	2 (1) ¹
<60%	not permitted	SIL 1	SIL 2
60 ...<90%	SIL 1	SIL 2	SIL 3
90 ...<99%	SIL 2	SIL 3	–
≥ 99 %	SIL 3	–	–

- 1) In accordance with IEC 61511-1 (FDIS), Clause 11.4.4, the "Hardware Fault Tolerance" (HFT) can be reduced by one (values in brackets), if the following conditions are true for devices using sensors and actuators with complex components:
- The device is "proven in use".
 - The device allows adjustment of process-related parameters only (not available).
 - The adjustment level of the process-related parameters of the device is protected (not available).
 - The function has a "Safety Integrity Level" (SIL) requirement less than 4.

Safety function with Cerabar T

Safety function for limit pressure monitoring

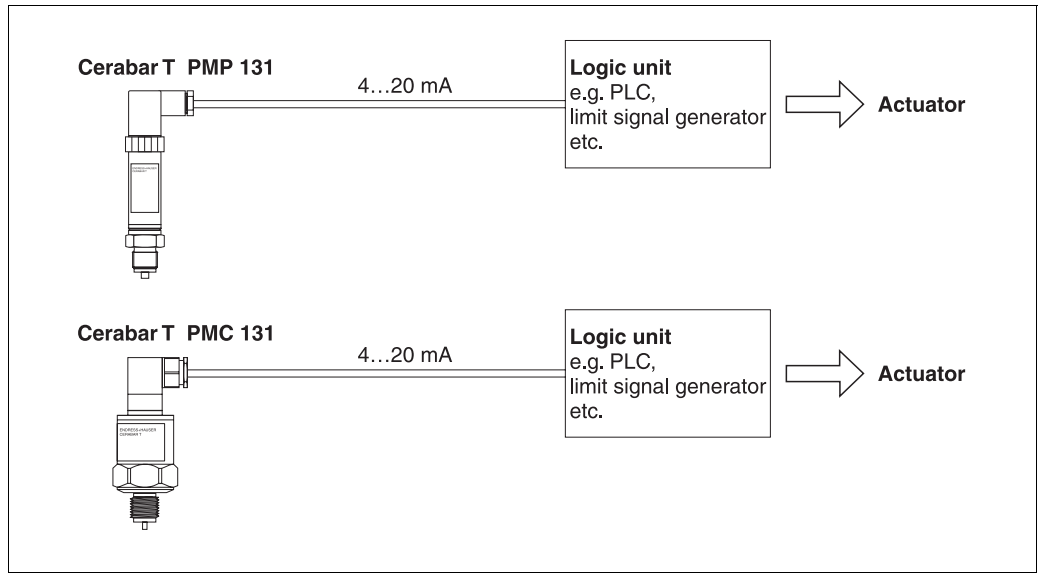


Fig. 2: safety function (e.g. for limit pressure monitoring) with Cerabar T as sub-system

The Cerabar T transmitter generates an analogue signal (4...20 mA) proportional to the pressure. The analogue signal is fed 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. In order to monitor for faults, the logic unit must be able to detect both HI-alarms > 20 mA and LO-alarms < 3.6 mA.

Safety function data

Caution!

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

For the rise time of the transmitter, see Technical Information TI 291P (PMP 131) or Technical Information TI 279P (PMC 131).

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.

Supplementary device documentation PMP 131

Depending on the version, the following documentation must be available for the pressure transducer PMP 131:

Explosion protection/ Certificates	Operating Instructions	Other Ex-Documentation
none	KA 103P	none
ATEX II 1/2 G EEx ib IIC T6	KA 103P	Safety Instructions XA 142P
ATEX II 2 G EEx ib IIC T6	KA 103P	Safety Instructions XA 142P
ATEX II 3 G EEx nA II T6	KA 103P	Safety Instructions XA 191P

Caution!

- The installation and setting instructions, and the technical limit values must be observed in accordance with the Operating Instructions (KA 103P).
- For devices which are used in explosion-hazardous, the supplementary documentation (XA) must also be used in accordance with the table.

Cerabar T PMP 131 supplementary documentation

For further information, see Technical Information TI 291P.

Supplementary device documentation PMC 131

Depending on the version, the following documentation must be available for the pressure transducer PMC 131:

Explosion protection/ Certificates	Operating Instructions	Other Ex-Documentation
none	KA 085P	none
ATEX II 3 G EEx nA II T6	KA 085P	Safety Instructions XA 191P

Caution!

- The installation and setting instructions, and the technical limit values must be observed in accordance with the Operating Instructions (KA 085P).
- For devices which are used in explosion-hazardous, the supplementary documentation (XA) must also be used in accordance with the table.

Cerabar T PMC 131 supplementary documentation

For further information, see Technical Information TI 279P.

Iterative tests

Using the Cerabar T for continuous measurements

The operability of the measuring device must be tested at appropriate time intervals. We recommend carrying out the test at least once a year. It is the responsibility of the user to select the type of check and the intervals in the specified time frame.

Settings

Settings

The zero point can be set for the Cerabar T. If you use the Cerabar T as a sub-system of a safety function, the zero point must not be adjusted during operation.

Safety-related parameters

Specific safety-related parameters for Cerabar T

The table displays the specific safety-related parameters for the Cerabar T.

	PMP 131 (Type A)	PMC 131 (Type B)
SIL	SIL 2 as per IEC 61508	SIL 2 as per IEC 61511 FDIS
HFT	0	0
SFF	81.5 %	89.7 %
PFD _{av}	2.58×10^{-5}	1.10×10^{-4}
TI ¹	annual	annual

1) Complete function test

PFD_{av} dependent on selected maintenance interval

The following diagram presents the dependence of the PFD_{av} on the maintenance interval. The PFD_{av} increases as the maintenance interval increases.

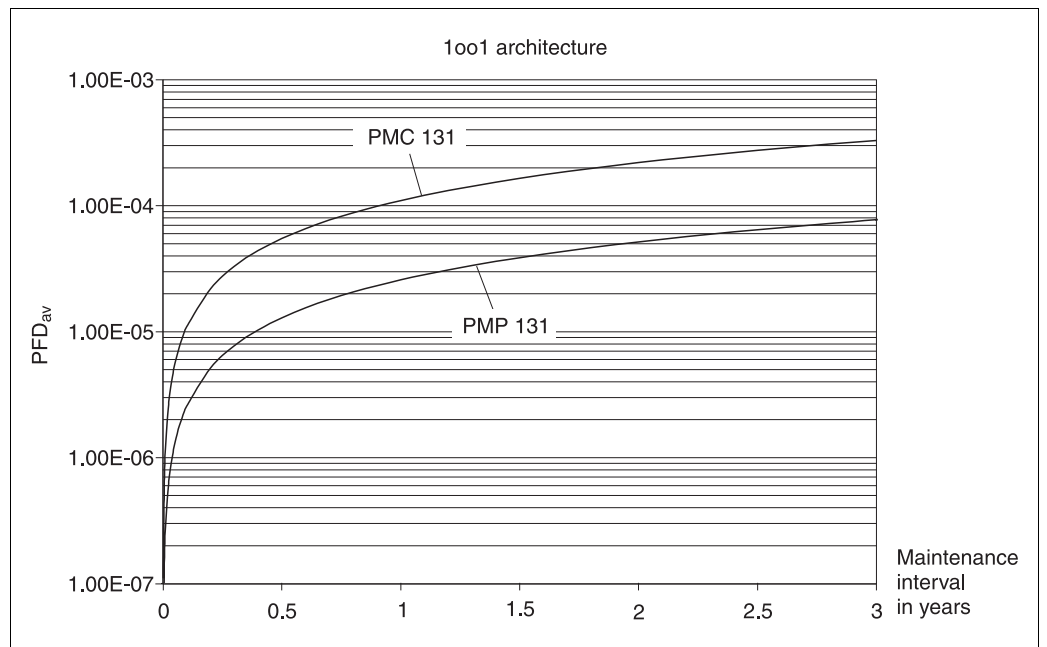



Fig. 4: "Average Probability of Failure on Demand" (PFD_{av}) dependent on the selected maintenance interval

TÜV management summary



TÜV
Rheinland
Berlin Brandenburg

2003-01-27

5. Summary

Based on the submitted manufacturer documents an assessment of safety relevant parameters (failure rates, PFD_{av}, HFT and SFF) has been carried out for different pressure sensors, manufactured by the Endress+Hauser company. The assessment, that covers the pressure instruments type Cerabar S, Deltabar S and Cerabar T, was carried out in compliance with the requirements of IEC 61508 and IEC 61511 (FDIS).

The assessment showed the following results:

Type A component: Cerabar T PMP131

The safety relevant parameters PFD_{av}, HFT and SFF are in compliance with the corresponding requirements for **SIL 2** according to IEC 61508.

Type B components: Cerabar S, Deltabar S, Cerabar T PMC131

The safety relevant parameter PFD_{av} is in compliance with the corresponding requirements for **SIL 2** according to IEC 61508.

The safety relevant parameters HFT and SFF are in compliance with the corresponding requirements for **SIL 1** according to IEC 61508.

The safety relevant parameters HFT and SFF are in compliance with the corresponding requirements for **SIL 2** according to IEC 61511(FDIS).

The user should consider, that the hardware fault tolerance of all inspected devices is zero and that a single fault can lead to a dangerous failure.

NOTES:


The assessment results described in this report only refer to the safety-related parameters PFD_{av}, HFT and SFF according to IEC 61508 and IEC 61511 (FDIS).

This report does not make any statements, that the manufacturer meets all other requirements of the above cited standards for hardware, software, documentation, management of functional safety, verification and validation.

This report does not imply that the examined pressure sensors have been certified for functional safety by the assessor according to IEC 61508 or any other standards.

The pressure sensors are only one part of a complete safety function. It is at the responsibility of the end-user to prepare and to apply an extensive reliability model, that brings out the complete safety function and that meets all requirements of the claimed SIL level according to IEC 61508.


Cologne, 2003-01-27
ASi/Kst. 968 ja-nie

The inspector

Dipl.-Phys. Erich Janoschek

Report-No.: 968/EL 193.00/03

Page 12 of 12

P01-xxxxxxx-02-xx-xx-en-001



TÜV
Rheinland
Berlin Brandenburg

2003-01-27

Automation, Software and Information Technology

Test report about the determination of safety-related parameters according to IEC 61508 and IEC 61511 (FDIS) for the Endress+Hauser smart pressure transmitters Cerabar S, smart differential pressure transmitters Deltabar S and pressure transducers Cerabar T

Report-No.: 968/EL 193.00/03
Date: 2003-01-27

Report-No.: 968/EL 193.00/03

Page 1 of 12

P01-xxxxxxx-02-xx-xx-en-001

Endress+Hauser GmbH+Co.

Instruments International
P.O. Box 2222
D-79574 Weil am Rhein
Germany

Tel. (07621) 975-02
Tx 773926
Fax (07621) 975 345
e-mail: info@ii.endress.com

Internet:

<http://www.endress.com>

Endress + Hauser

The Power of Know How

