FY01102T/09/EN/01.23-00
71639662
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Functional Safety Manual
iTHERM ModuLine TM131, iTHERM ModuLine TM151

Endress+Hauser
People for Process Automation

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1 Declaration of Conformity

This declaration only applies to the measurement of the sensor temperature itself. As already mentioned in Section 1.2 → 8, the transmitters must be combined with an appropriate sensor; see Section 3.1.1, Feature 110: → 12.

The customer is responsible for avoiding systematic faults between process temperature and sensor temperature. An assessment must be carried out to determine an appropriate combination of features from Section 3.1 → 11.

As mentioned in Section 6.4 → 21, systematic faults are not covered by this document. In addition, dynamic faults (delay between process and sensor temperature) must be taken into account separately.

Section 4.1 on mounting requirements from the Operating Instructions must be observed.

Detailed information:
Operating Instructions iTHERM ModuLine: BA01915T

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Herstellererklärung - Manufacturer Declaration

Funktionale Sicherheit - Functional Safety according to IEC 61508:2010
Beiblatt 1/ NE130 Formblatt B1 - Supplement 1 / NE130 Form B.1

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

erklärt als Hersteller, dass die folgenden Thermometer
declares as manufacturer, that the following thermometers

iTHERM TM131, iTHERM TM151

in Verbindung mit den Transmittern - in combination with the transmitters

iTEMP TMT82 oder - or
iTEMP TMT162

für den Einsatz in sicherheitsrelevanten Anwendungen bis SIL2 (HFT=0) bzw. SIL3 (HFT=1) entsprechend IEC61508:2010 geeignet sind.
are suitable for use in safety-instrumented systems up to SIL2 (HFT=0) or SIL3 (HFT=1) according to IEC61508:2010.

In sicherheitsrelevanten Anwendungen gemäß IEC 61508 und IEC 61511 sind die Angaben des Handbuchs zur Funktionalen Sicherheit zu beachten.
In safety instrumented systems according to IEC 61508 and IEC 61511, the instructions of the Safety Manual have to be followed.

Nesselwang, 17.11.2023
Endress+Hauser Wetzer GmbH+Co. KG

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Director Technology

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Head of Division R&D-Temperature

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1.1 Safety-related characteristic values

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Allgemein				
Gerätebezeichnung und zulässige Ausführungen	TM131, TM151 (Bestellmerkmal "Weitere Zulassungen": Option LA "SIL")			
Sicherheitsbezogenes Ausgangssignal	4...20mA			
Fehlerstrom	≤ 3,6 mA oder ≥ 21,0 mA			
Bewertete Messgröße / Funktion	Temperatur / Spannung / Widerstand			
Sicherheitsfunktion(en)	sichere Messung			
Gerätetyp gem. IEC 61508-2	☑ Typ A	☐ Typ B		
Betriebsart	☑ Low Demand Mode	☑ High Demand	☐ Continuous Mode	
Sicherheitshandbuch	SD02427T/09, SD01172T/09, SD01632T/09			
Art der Bewertung (nur eine Variante wählbar)	☑	Vollständige entwicklungsbegleitende HW/SW Bewertung inkl. FMEDA und Änderungsprozess nach IEC 61508-2, 3		
	☐	Bewertung über Nachweis der Betriebsbewährung HW/SW inkl. FMEDA und Änderungsprozess nach IEC 61508-2, 3		
	☐	Auswertung von Felddaten HW/SW zum Nachweis "Frühere Verwendung" gem. IEC 61511		
	☐	Bewertung durch FMEDA gem. IEC 61508-2 für Geräte ohne Software		
Bewertung durch / Zertifikatsnummer	TM131: internes Assessment TM151: internes Assessment TMT82: Z10 012833 0005 TMT162: Z10 012833 0004			
Prüfungsunterlagen	Entwicklungsdokumente, Testreports, Datenblätter			
SIL - Integrität				
Systematische Sicherheitsintegrität		☐ SIL 2 fähig	☑ SIL 3 fähig	
Hardware Sicherheitsintegrität	Einkanaliger Einsatz (HFT = 0)	☑ SIL 2 fähig	☐ SIL 3 fähig	
	Mehrkanaliger Einsatz (HFT ≥ 1)	☐ SIL 2 fähig	☑ SIL 3 fähig	
Kennzahlen	Thermometer und Transmitter			
TM131, TM151 mit TMT82	siehe Kap. 1.2.1 (FY01102T/09)			
TM131, TM151 mit TMT162	siehe Kap. 1.2.2 (FY01102T/09)			

Erklärung	
☑	Unser firmeninternes Qualitätsmanagement stellt die Information von zukünftig bekanntwerdenden sicherheitsrelevanten systematischen Fehlern sicher.

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General				
Device designation and permissible types	TM131, TM151 (Order code for "Additional approval": Option LA "SIL")			
Safety-related output signal	4...20mA			
Fault current	≤ 3,6 mA oder ≥ 21,0 mA			
Process variable/function	Temperature, Voltage, Resistance			
Safety function(s)	safe measuring			
Device type acc. to IEC 61508-2	☑ Type A	☐ Type B		
Operating mode	☑ Low Demand Mode	☑ High Demand	☐ Continuous Mode	
Safety manual	SD02427T/09, SD01172T/09, SD01632T/09			
Type of evaluation (check only one box)	☑	Complete HW/SW evaluation parallel to development incl. FMEDA and change request acc. to IEC 61508-2, 3		
	☐	Evaluation of "Proven-in-use" performance for HW/SW incl. FMEDA and change request acc. to IEC 61508-2, 3		
	☐	Evaluation of HW/SW field data to verify „prior use" acc. to IEC 61511		
	☐	Evaluation by FMEDA acc. to IEC61508-2 for devices w/o software		
Evaluation through / certificate no.	TM131: internal assessment TM151: internal assessment TMT82: Z10 012833 0005 TMT162: Z10 012833 0004			
Test documents	development documents, test reports, data sheets			
SIL - Integrity				
Systematic safety integrity		☐ SIL 2 capable	☑ SIL 3 capable	
Hardware safety integrity	Single channel use (HFT = 0)	☑ SIL 2 capable	☐ SIL 3 capable	
	Multi-channel use (HFT ≥ 1)	☐ SIL 2 capable	☑ SIL 3 capable	
key figures	**Thermometer and Transmitter**			
TM131, TM151 with TMT82	see Chapter 1.2.1 (FY01102T/09)			
TM131, TM151 with TMT162	see Chapter 1.2.2 (FY01102T/09)			

Declaration	
☑	Our internal company quality management system ensures information on safety-related systematic faults which become evident in the future

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1.2 Use as a safe measuring system

To implement a safe measuring system, you must combine the temperature transmitter with a suitable sensor (see Section 3.1.1 → 12). The code numbers required for the system design for one year can be found in the following tables.

1.2.1 Code number for TM131/TM151 with TMT82/TMT162

Single channel operation

Transmitter

λ_{du}	λ_{dd}	λ_{su}	λ_{sd}	SFF	PFD_{avg}
40 FIT	258 FIT	129 FIT	4 FIT	91%	$1.8 \cdot 10^{-4}$

		low stress closed coupled		high stress closed coupled		low stress extention wire		high stress extention wire	
		Sensor	Sensor + Field Transmitter	Sensor	Sensor + Field Transmitter	Sensor	Sensor + Field Transmitter	Sensor	Sensor + Field Transmitter
Thermocouple	λ_{du}	6 FIT	46 FIT	119 FIT	159 FIT	109 FIT	149 FIT	2180 FIT	2220 FIT
	λ_{dd}	94 FIT	352 FIT	1881 FIT	2139 FIT	891 FIT	1149 FIT	17820 FIT	18078 FIT
	λ_{su}	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT
	λ_{sd}	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT
	SFF	94%	94% / 91%	94%	94% / 91%	89%	89% / 91%	89%	89% / 91%
	PFD_{avg}		$2.0 \cdot 10^{-4}$		$7.0 \cdot 10^{-4}$		$6.5 \cdot 10^{-4}$		$9.7 \cdot 10^{-3}$
RTD 2/3 wire	λ_{du}	9 FIT	49 FIT	181 FIT	221 FIT	99 FIT	139 FIT	1976 FIT	2016 FIT
	λ_{dd}	39 FIT	297 FIT	779 FIT	1037 FIT	376 FIT	634 FIT	7524 FIT	7782 FIT
	λ_{su}	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT
	λ_{sd}	0 FIT	4 FIT	0 FIT	0 FIT	0 FIT	0 FIT	0 FIT	4 FIT
	SFF	81%	81% / 91%	81%	81% / 91%	79%	79% / 91%	79%	79% / 91%
	PFD_{avg}		$2.1 \cdot 10^{-4}$		$9.7 \cdot 10^{-4}$		$6.1 \cdot 10^{-4}$		$8.8 \cdot 10^{-3}$
RTD 4 wire	λ_{du}	6 FIT	46 FIT	129 FIT	169 FIT	74 FIT	114 FIT	1486 FIT	1526 FIT
	λ_{dd}	44 FIT	302 FIT	871 FIT	1129 FIT	426 FIT	684 FIT	8514 FIT	8772 FIT
	λ_{su}	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT
	λ_{sd}	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT
	SFF	87%	87% / 91%	87%	87% / 91%	85%	85% / 91%	85%	85% / 91%
	PFD_{avg}		$2.0 \cdot 10^{-4}$		$7.4 \cdot 10^{-4}$		$5.0 \cdot 10^{-4}$		$6.7 \cdot 10^{-3}$

SFF	Typ	A			B		
	HFT	0	1	2	0	1	2
< 60%		SIL1	SIL2	SIL3	---	SIL1	SIL2
60% - < 90%		SIL2	SIL3	SIL4	SIL1	SIL2	SIL3
90% - < 99%		SIL3	SIL4	SIL4	SIL2	SIL3	SIL4
>99%		SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

1 FIT = $1 \cdot 10^{-9}$ h

PFD_{avg}

- < $2.5 \cdot 10^{-3}$
- > $2.5 \cdot 10^{-3}$
- > $1 \cdot 10^{-2}$

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Two channel operation

	λ_{du}	λ_{dd}	λ_{su}	λ_{sd}	SFF	PFD_{avg}
Transmitter	40 FIT	258 FIT	129 FIT	4 FIT	91%	$1.8 \cdot 10^{-4}$

		low stress closed coupled		high stress closed coupled		low stress extention wire		high stress extention wire	
		Sensor	Sensor + Transmitter	Sensor	Sensor + Transmitter	Sensor	Sensor + Transmitter	Sensor	Sensor + Transmitter
2 x Thermo-couple	λ_{du}	11 FIT	51 FIT	70 FIT	110 FIT	158 FIT	198 FIT	3160 FIT	3200 FIT
	λ_{dd}	189 FIT	447 FIT	3786 FIT	4044 FIT	1842 FIT	2100 FIT	36840 FIT	37098 FIT
	λ_{su}	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT
	λ_{sd}	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT
	SFF	95%	95% / 91%	98%	98% / 91%	92%	92% / 91%	92%	92% / 91%
	PFD_{avg}		$2.2 \cdot 10^{-4}$		$4.8 \cdot 10^{-4}$		$8.7 \cdot 10^{-4}$		$1.4 \cdot 10^{-2}$
2 x RTD 2/3-wire	λ_{du}	8 FIT	48 FIT	154 FIT	194 FIT	84 FIT	124 FIT	1672 FIT	1712 FIT
	λ_{dd}	88 FIT	346 FIT	1662 FIT	2024 FIT	866 FIT	1124 FIT	17328 FIT	17586 FIT
	λ_{su}	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT
	λ_{sd}	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT
	SFF	92%	92% / 91%	92%	92% / 91%	91%	91% / 91%	91%	91% / 91%
	PFD_{avg}		$2.1 \cdot 10^{-4}$		$8.5 \cdot 10^{-4}$		$5.4 \cdot 10^{-4}$		$7.5 \cdot 10^{-3}$
RTD 2/3-wire + TC	λ_{du}	9 FIT	49 FIT	184 FIT	224 FIT	121 FIT	161 FIT	2416 FIT	2456 FIT
	λ_{dd}	139 FIT	397 FIT	2776 FIT	3034 FIT	1354 FIT	1612 FIT	27084 FIT	27342 FIT
	λ_{su}	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT	0 FIT	129 FIT
	λ_{sd}	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT	0 FIT	4 FIT
	SFF	94%	94% / 91%	94%	94% / 91%	92%	92% / 91%	92%	92% / 91%
	PFD_{avg}		$2.2 \cdot 10^{-4}$		$9.8 \cdot 10^{-4}$		$7.0 \cdot 10^{-4}$		$1.1 \cdot 10^{-2}$

SFF	Typ	A			B		
	HFT	0	1	2	0	1	2
< 60%		SIL1	SIL2	SIL3	---	SIL1	SIL2
60% - < 90%		SIL2	SIL3	SIL4	SIL1	SIL2	SIL3
90% - < 99%		SIL3	SIL4	SIL4	SIL2	SIL3	SIL4
>99%		SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

1 FIT = $1 \cdot 10^{-9}$ h

PFD_{avg}

- < $2.5 \cdot 10^{-3}$
- > $2.5 \cdot 10^{-3}$
- > $1 \cdot 10^{-2}$

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2 About this document

2.1 Document function

This supplementary Safety Manual applies in addition to the Operating Instructions, Technical Information and ATEX Safety Instructions. The supplementary device documentation must be observed during installation, commissioning and operation. The requirements specific to the protection function are described in this safety manual.

General information on functional safety (SIL) is available at:
www.endress.com/SIL

2.2 Symbols used

2.2.1 Safety symbols

DANGER
This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.

WARNING
This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in serious or fatal injury.

⚠ CAUTION
This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.

NOTICE
This symbol contains information on procedures and other facts which do not result in personal injury.

2.2.2 Symbols for certain types of information and graphics

Tip
Indicates additional information

Reference to documentation

Reference to graphic

▶
Notice or individual step to be observed

1., 2., 3.
Series of steps

Result of a step

1, 2, 3, ...
Item numbers

A, B, C, ...
Views

2.3 Supplementary device documentation

For an overview of the scope of the associated Technical Documentation, refer to the following:
- *Device Viewer* (www.endress.com/deviceviewer): Enter the serial number from the nameplate
- *Endress+Hauser Operations app*: Enter serial number from nameplate or scan matrix code on nameplate.

The following document types are available in the download area of the Endress+Hauser website (www.endress.com/downloads):

2.3.1 Further applicable documents

- BA01915T, Modular thermometers
- TI01373T, TM131
- TI01707T, TM151
- XA00044R, TM1x1
- XA01799T, TM1x1
- XA01817T, TM111 + TM131
- SD01172T/FY01105T, TMT82
- SD01632T/FY01106T, TMT162
- SD02427T, TM131

2.3.2 Technical Information (TI)

Planning aid
The document contains all the technical data on the device and provides an overview of the accessories and other products that can be ordered for the device.

2.3.3 Brief Operating Instructions (KA)

Guide that takes you quickly to the 1st measured value
The Brief Operating Instructions contain all the essential information from incoming acceptance to initial commissioning.

2.3.4 Operating Instructions (BA)

Your reference guide
These Operating Instructions contain all the information that is required in various phases of the life cycle of the device: from product identification, incoming acceptance and storage, to mounting, connection, operation and commissioning through to troubleshooting, maintenance and disposal.

2.3.5 Safety Instructions (XA)

Depending on the approval, the following Safety Instructions (XA) are supplied with the device. They are an integral part of the Operating Instructions.

The nameplate indicates the Safety Instructions (XA) that are relevant to the device.

2.3.6 Functional Safety Manual (FY)

Depending on the SIL approval, the Functional Safety Manual (FY) is an integral part of the Operating Instructions and applies in addition to the Operating Instructions, Technical Information and ATEX Safety Instructions.

The different requirements that apply for the protective function are described in the Functional Safety Manual (FY).

3 Design

3.1 Permitted device types

The details pertaining to functional safety in this manual relate to the device versions listed below and are valid as of the specified firmware and hardware versions.

Unless otherwise specified, all subsequent versions can also be used for safety functions.

A modification process according to IEC 61508 is applied for device changes.

Valid device versions for safety-related use:

3.1.1 Ordering features

Product root: TM131-	Product root: TM151-
Feature: 010 "Approval" Version: all	**Feature: 010 "Approval"** Version: all
Feature: 020 "Thermowell" Version: all	**Feature: 020 "Thermowell"** Version: all
Feature: 030 "Thermometer structure" Version: all	**Feature: 030 "Thermometer structure"** Version: all
Feature: 050 "Process connection; material" Version: all	**Feature: 040 "Thermowell material"** Version: all
Feature: 060 "Thermowell diameter; material" Version: all	**Feature: 050 "Process/thermowell connection"** Version: all
Feature: 070 "Shape of tip" Version: all	**Feature: 060 "Immersion length U"** Version: all
Feature: 080 "Immersion length U" Version: all	**Feature: 070 "Geometry of parts in contact with medium"** Version: all
Feature: 090 "Removable extension neck, length E" Version: all	**Feature: 080 "Thermowell lagging, length T"** Version: all
Feature: 100 "Thermowell lagging, length T" Version: all	**Feature: 090 "Removable extension neck, length E"** Version: all
Feature: 110 "Sensor type; measuring range; material" Version: all except Y	**Feature: 100 "Sensor type; measuring range; material"** Version: all except Y
Feature: 130 "Sensor standard; classification" Version: all	**Feature: 110 "Sensor standard; classification"** Version: all
Feature: 140 "Electrical connection" Version: only 2E, 2G, 3D, 3F	**Feature: 120 "Electrical connection"** Version: only 2E, 2G, 3D, 3F
Feature: 150 "Terminal head; material; degree of protection" Version: all	**Feature: 130 "Terminal head; material; degree of protection"** Version: all
Feature: 170 "Cable entry terminal head" Version: all	**Feature: 140 "Cable entry terminal head"** Version: all
Feature: 480 "Device model" Version: all	**Feature: 480 "Device model"** Version: all
Feature: 560 "Second transmitter (mounted)" Version: only 2E, 2G, 3D, 3F	**Feature: 500 "Additional design options"** Version: all
Feature: 570 "Service" Version: all	**Feature: 520 "Special Root Diameter D1"** Version: all
Feature: 580 "Test, certificate, declaration" Version: all	**Feature: 530 "Special Tip Diameter D2"** Version: all
Feature: 590 "Additional approval" Version: only LA	**Feature: 540 "Special Bore Diameter Di"** Version: all
Feature: 600 "Additional option" Version: all	**Feature: 545 "Special Tip Thickness B"** Version: all
Feature: 610 "Accessory mounted" Version: all	**Feature: 550 "Thermometer Connection Ge1"** Version: all
Feature: 630 "Thermometer calibration" Version: all	**Feature: 560 "Second transmitter (mounted)"** Version: only 2E, 2G, 3D, 3F
Feature: 640 "Calibration points >= 0 oC" Version: all	**Feature: 570 "Service"** Version: all
Feature: 650 "Calibration points <= 0 oC" Version: all	**Feature: 580 "Test, certificate, declaration"** Version: all
Feature: 850 "Firmware version" Version: none	**Feature: 590 "Additional approval"** Version: only LA
Feature: 895 "Marking" Version: all	**Feature: 600 "Additional option"** Version: all

Product root: TM131-	Product root: TM151-
	Feature: 610 "Accessory mounted" Version: all **Feature: 630 "Thermometer calibration"** Version: all **Feature: 640 "Calibration points >= 0 oC"** Version: all **Feature: 650 "Calibration points <= 0 oC"** Version: all **Feature: 850 "Firmware version"** Version: none **Feature: 895 "Marking"** Version: all

Valid firmware version:

- TMT162 from 04.01.00 or higher
- TMT82 from 01.02.00 or higher

Valid hardware version (electronics):

- TMT162 from 04.01.00 or higher
- TMT82 head transmitter from 01.00.07 or higher
- TMT82 DIN rail transmitter from 01.00.04 or higher

3.2 Identification marking

SIL-certified devices are marked with the SIL logo ㊎ on the nameplate.

3.3 Safety function

The device's safety function is that of carrying out safe measurement. The safety function involves measuring the temperature of a medium.

3.3.1 Safety-related output signal

The device's safety-related signal is the 4 to 20 mA analog output signal as per NAMUR NE43. All safety measures refer to this signal exclusively.

In addition, the device also communicates via HART® for information purposes and comprises all the HART® features with additional device information. HART® communication is not part of the safety function.

The safety-related output signal is fed to a downstream logic unit, e.g. a programmable logic controller or a limit signal transmitter, where it is monitored for the following:

- Overshooting and/or undershooting of a specified limit value
- To establish the occurrence of a fault, e.g. failure current (≤ 3.6 mA, ≥ 21 mA), signal cable disconnection or short-circuit

In the event of a fault, it must be ensured that the equipment under control achieves or maintains a safe state.

3.3.2 Safe measurement

The transmitter's safety function comprises a transmitted current output signal that is proportional to the temperature value.

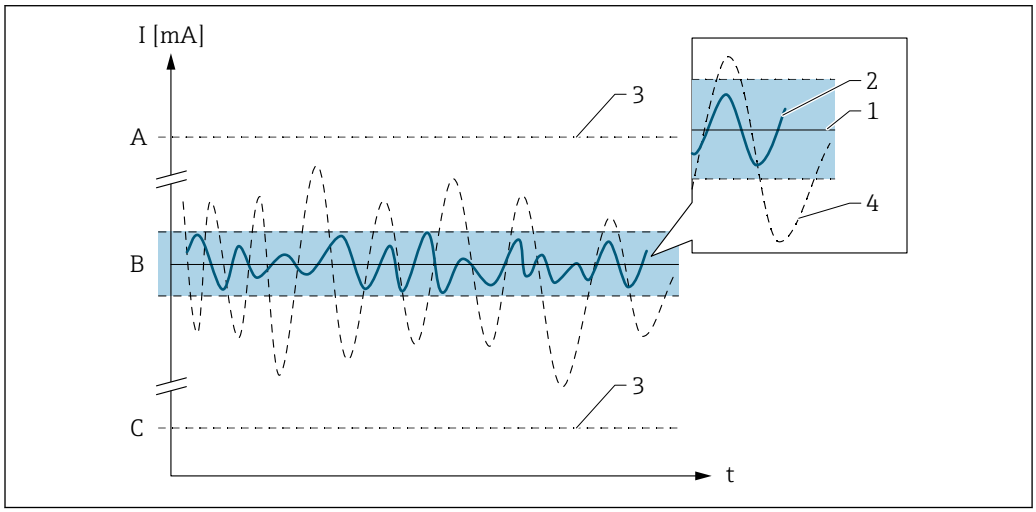
All safety functions can be used in combination with all sensor configurations from the "Structure of the measuring system" section→ 🖹 23. Note here that only the measured

value of one sensor or the output of a function (e.g. the averaging or differential function) can ever be displayed via the current output.

3.4 Basic conditions for use in safety-related applications

The measuring system 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 Operating Instructions. The application-specific limits must be observed. The specifications in the Operating Instructions and the Technical Information must not be exceeded.

3.4.1 Safety-related failures according to IEC/EN 61508



A High alarm ≥ 21 mA
B SIL error range ±2%
C Low alarm ≤3.6 mA

No device error
- No error
- Implications for the safety-related output signal: none
- Impact on the measurement uncertainty:
  1 – Within the specification, For detailed information, see TI/BA

λS (Safe)
- Safe failure
- No impact on the safety-related output signal:
  2 – Moves within the specified SIL error range
- Output signal enters the safe state
- Impact on the measurement uncertainty:
  2 – Moves within the specified SIL error range
  3 – Has no effect

λ_{DD} (Dangerous detected)
- Dangerous failure which can be detected
- Impact on the safety-related output signal: results in a failure mode at the output signal
- Impact on the measurement uncertainty:
  3 – Has no effect

λ_{DU} (Dangerous undetected)
- Dangerous failure which cannot be detected
- Implications for the safety-related output signal: can be outside the defined error range
- Impact on the measurement uncertainty:
  4 – May be outside the specified error range

3.4.2 Restrictions for safety-related use

Basic conditions and restrictions for the device:

Sensors, wiring scheme and temperature ranges
- StrongSens resistance sensor
  - Temperature range −50 to +400 °C, 4-wire connection
  - Range of validity of accuracy classes:
    Class B: −50 to +400 °C
    Class A: −30 to +300 °C
    Class AA: 0 to +150 °C
- Wire wound (WW) resistance sensor
  - Temperature range −200 to +400 °C,
    Single sensor element, 4-wire connection,
    Double sensor element, 2x3-wire connection,
  - Range of validity of accuracy classes:
    Class B: −200 to +400 °C
    Class A: −100 to +400 °C
    Class AA: −50 to +250 °C
- Thermocouple type J
  Single or double elements 0 to +600 °C
- Thermocouple type K or N
  Single or double elements 0 to +800 °C
- Acceleration from vibrations at the measuring element, maximum 2g

The following restriction also applies for safety-related use:
- Strong, pulse-like EMC interference on the power supply line can cause transient (<1 s) deviations in the output signal (≥±1 %). For this reason, filtering with a time constant of ≥ 1 s should be performed in the downstream logic unit.
- The specified error range (safety measured error,) is sensor-specific and is defined according to FMEDA (Failure Modes, Effects and Diagnostic Analysis) on delivery. It already includes all influencing factors described in the Technical Information TI (non-linearity, non-repeatability, hysteresis, zero drift, temperature drift). The safety-related failures are classified into different categories according to IEC/EN 61508 (see the following table). The table shows the implications for the safety-related output signal and the measurement uncertainty.

Response times:
- The information regarding typical response times is based on a measurement according to DIN EN 60751 in water with a flow velocity of 0.4 m/s.
- The response time t90 is indicated. This is the time the temperature sensor needs to indicate 90 % of the temperature increase.
- The total response time comprises the response time of the temperature sensor including the thermowell and the response time of the temperature transmitter, and is indicated in the Operating Instructions (Supplementary Documentation) of the transmitters and thermometers ("Technical data" section).

Comments:

These are typical values from standard design (according to DIN 43772, for example) and should be used as reference values.

Prior to using the thermometer, the user must check whether the entire response time for the particular application guarantees the safe shutdown of the entire system.

3.5 Dangerous undetected failures in this scenario

An incorrect output signal that deviates from the value specified in this manual but is still in the range of 4 to 20 mA, is considered a "dangerous, undetected failure".

3.6 Safety measured error

Permitted temperature ranges for resistance sensors in conjunction with SIL:

Temperature ranges

Sensor type	Class B	Class A	Class AA
Pt100 (TF) iTHERM® StrongSens	−50 to +400 °C (−58 to +752 °F)	−30 to +300 °C (−22 to +572 °F)	0 to 150 °C (−58 to +302 °F)
Wire wound sensor (WW)	−200 to 400 °C (−328 to 752 °F)	−100 to 400 °C (−328 to 742 °F)	−50 to 250 °C (−58 to 482 °F)

Permitted temperature ranges for thermocouples in conjunction with SIL:

Sensor type according to IEC 60584 / ASTM E230 / ANSI MC96.1	Class 1 and 2 / special and standard
J (Fe-CuNi)	0 to 600 °C (32 to 1 112 °F)
K (NiCr-NiAl) N (NiCrSi-NiSi)	0 to 800 °C (32 to 1 472 °F)

Detailed information:
- Technical Information iTHERM ModuLine TM131: TI01373T
- Technical Information iTHERM ModuLine TM151: TI01707T

Detailed information:
- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

These values do not take into account deviations caused by EMC. In the event of non-negligible EMC interference, an additional deviation of 1% from the span must be added to the values above.

Validity of data for safety measured error:

- Total permitted temperature range of the transmitter in the SIL mode
- Defined range of the supply voltage
- Limited safety measuring range of sensor element
- Accuracy includes all linearization and rounding errors
- Observe the minimum measuring span of each sensor.
- Values are 2σ values, i.e. 95.4 % of all measured values are within the specifications

3.7 Useful lifetime of electrical components

The established failure rates of electrical components apply within the useful lifetime as per IEC 61508-2:2010 section 7.4.9.5 note 3.

In accordance with DIN EN 61508-2:2011 section 7.4.9.5 (national footnote N3), appropriate measures taken by the manufacturer and operator can extend the useful lifetime.

However, the useful lifetime may be significantly shorter if the device is operated at higher temperatures or outside specifications.

Detailed information:
- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

As the maximum application temperature influences the drift behavior of the sensors, a recalibration should be performed or the inserts should be replaced at defined intervals for reliable and accurate temperature measurement. Typical intervals are listed in the following table:

Max. application temperature	Resistance thermometer	Thermocouple
200 °C (392 °F)	5 years	5 years
400 °C (752 °F)	2 years	2 years
600 °C (1 112 °F)	-	2 years
800 °C (1 472 °F)	-	1 year

The testing intervals indicated here are suggestions. Special conditions at the place of use may require the user to significantly shorten the application duration.

4 Commissioning (installation and configuration)

4.1 Requirements for personnel

The personnel for installation, commissioning, diagnostics and maintenance must fulfill the following requirements:
- Trained, qualified specialists must have a relevant qualification for this specific function and task.
- Personnel must be authorized by the plant owner/operator.
- Be familiar with federal/national regulations.
- Before starting work: personnel must read and understand the instructions in the manual and supplementary documentation as well as the certificates (depending on the application).
- Personnel must follow instructions and comply with general policies.

The operating personnel must fulfill the following requirements:
- Personnel are instructed and authorized according to the requirements of the task by the facility's owner-operator.
- Personnel follow the instructions in this manual.

4.2 Installation

The mounting and wiring of the device and the permitted orientations are described in the Operating Instructions pertaining to the device.

Correct installation is a prerequisite for safe operation of the device.

4.3 Commissioning

The commissioning of the device is described in the Operating Instructions pertaining to the device.

Prior to operating the device in a safety instrumented system, verification must be performed by carrying out a test sequence as described in **Section 6 Proof testing**.

4.4 Operation

The operation of the device is described in the Operating Instructions pertaining to the device.

Detailed information:

- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

4.5 Parameter configuration for safety-related applications

4.5.1 Adjustment of the measuring point

Adjustment of the measuring point is described in the Operating Instructions.

Check that the factory settings for the parameters are correct to suit the desired measuring range and correct if necessary.

Detailed information:

- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

Device protection

The devices can be protected against external influences as follows:

- Hardware write protection
- Software write protection

The use of these methods is described in the following documents.

Detailed information:

- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

4.5.2 Locking in Expert mode

The procedure for activating SIL locking on a device is described in the following documents.

Detailed information:

- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

4.5.3 Unlocking a SIL device

When SIL locking is active on a device, the device is protected against unauthorized operation by means of a locking code and, as an additional option, by means of a hardware write protection switch. The device must be unlocked to change parameter configuration.

⚠ CAUTION

▶ Unlocking the device deactivates diagnostic functions, and the device may not be able to carry out its safety function when unlocked. Therefore, independent measures must be taken to ensure that there is no risk of danger while the device is unlocked.

The procedure for unlocking the device is described in the following documents.

Detailed information:

- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

5 Operation

5.1 Device behavior during power-up

The behavior of the device when powered up is described in the relevant Operating Instructions.

Detailed information:

- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

5.2 Device behavior when safety function is requested

The device outputs a current value corresponding to the limit value to be monitored. This value must be monitored and processed further in a connected logic unit.

Detailed information:

- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

5.3 Safe states

The system adopts the safe state depending on the error detected. The behavior of the device is described in the corresponding Safety Manuals:

Detailed information:

- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

Safe state / output current:

- I ≤ 3.6 mA (Low alarm)
  or
- I ≥ 21.5 mA (High alarm)

5.4 Behavior of device in the event of an alarm and warnings

The output current on alarm can be set to a value of ≤ 3.6 mA or ≥ 21 mA. In some cases (e.g. failure of power supply, a cable open circuit and faults in the current output itself, where the failure current ≥ 21 mA cannot be set), output currents ≤ 3.6 mA can occur irrespective of the configured failure current.

In some other cases (e.g. short circuit of cabling), output currents ≥ 21 mA occur irrespective of the configured failure current.

For alarm monitoring, the downstream logic unit must therefore be able to detect HI alarms (≥ 21 mA) and LO alarms (≤ 3.6 mA).

5.5 Alarm and warning messages

The behavior of the device in the event of an alarm and warnings is described in the relevant Operating Instructions.

Detailed information:

- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

Additional information is provided by the alarm and warning messages in the form of error codes and associated plain text messages. The relationship between the error code and diagnostic behavior is described in the table in the "Diagnostics and troubleshooting" chapter in the corresponding transmitter operating instructions.

Detailed information:

- Operating Instructions iTEMP TMT82: BA01028T, Section 12.2.2
- Operating Instructions iTEMP TMT162: BA01801T, Section 9.3

6 Proof testing

The safety-related functionality of the device in the SIL mode must be verified during commissioning, when changes are made to safety-related parameters, and also at appropriate time intervals. This enables this functionality to be verified within the entire safety instrumented system. The time intervals must be specified by the operator.

⚠ CAUTION

The safety function is not guaranteed during a proof test

Suitable measures must be taken to guarantee process safety during the test.

- ▶ The safety-related output signal 4 to 20 mA must not be used for the safety instrumented system during testing.
- ▶ A completed test must be documented; the reports provided in the Appendix can be used for this purpose (see Section 8.2).
- ▶ The operator specifies the test interval and this must be taken into account when determining the probability of failure PFD_{avg} of the sensor system.

If no operator-specific proof testing requirements have been defined, the following is a possible alternative for testing the transmitter depending on the measured variable used for the safety function.

For information on the test procedures for the transmitters, refer to the associated safety documents.

Detailed information:

- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

The following inspections are recommended at regular intervals for the device:

Component: terminal head

Visual inspection of the head and gaskets for damage and wear

Component: insert

The insulation resistance of the measuring circuit in relation to the protection fitting must be measured every 12 months (only for non-grounded sensors in the case of thermocouples; in the case of several sensors the insulation check must also be performed between the individual circuits). The minimum insulation resistance at room temperature should be 100 MΩ at 100 V.

Component: thermometer thermowell
- Visual inspection of the thermowell and extension neck for damage, leaks, corrosion and wear.
- Visual inspection of sealing points for leaks.

6.1 Test sequence A

Proof testing procedure

The procedure for performing the proof test is described in the following documents.

Detailed information:
- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

6.2 Test sequence B

Proof testing procedure

The procedure for performing the proof test is described in the following documents.

Detailed information:
- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

6.3 Test sequence C

Proof testing procedure

The procedure for performing the proof test is described in the following documents.

Detailed information:
- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

6.4 Verification criterion

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 safety instrumented system.
- The purpose of proof-testing is to detect dangerous undetected device failures (λ_{DU}).
- This test does not cover the impact of systematic faults on the safety function, which must be assessed separately.
- Systematic faults can be caused, for example, by process material properties, operating conditions, build-up or corrosion.
- As part of the visual inspection, for example, ensure that all of the seals and cable entries provide adequate sealing and that the device is not visibly damaged.

7 Repair and error handling

7.1 Maintenance

Maintenance instructions and instructions regarding calibration may be found in the Operating Instructions pertaining to the device.

Alternative monitoring measures must be taken to ensure process safety during configuration, proof-testing and maintenance work on the device.

7.2 Repair

Repair means restoring functional integrity by replacing defective components.

Components may be repaired/replaced by the customer's technical staff if **original spare parts** from Endress+Hauser are used (they can be ordered by the end user) and the appropriate installation instructions are followed.

A proof test must always be performed after every repair.

Spare parts are grouped into logical kits with the associated replacement instructions.

Document the repair with the following information:
- Serial number of the device
- Date of the repair
- Type of repair
- Person who performed the repair

Sensor with or without process connection
Device inspection following repair: proof test, test sequence A or B

Seal sets for the sensor
Device inspection following repair: proof test, test sequence A or B

Display
Device inspection following repair: visual inspection to establish if all parts are present and mounted correctly and to verify that the device is in the "OK" state.

Electronic insert (transmitter)
Device inspection following repair: proof test, test sequence A or B

Housing cover
Device inspection following repair: visual inspection to establish if all parts are present and mounted correctly and to verify that the device is in the "OK" state.

Cable gland
Device inspection following repair: proof test, test sequence A or B

Seal kits for housing covers
Device inspection following repair: visual inspection to establish if all parts are present and mounted correctly and to verify that the device is in the "OK" state.

Securing clamps, housing
Device inspection following repair: visual inspection to establish if all parts are present and mounted correctly and to verify that the device is in the "OK" state.

Installation Instructions are supplied with the original spare part and can also be accessed in the Download Area at www.endress.com

Send in replaced components to Endress+Hauser for fault analysis.

When returning the defective component, always enclose the "Declaration of Hazardous Material and Decontamination" with the note "Used as SIL device in a safety instrumented system.

Information on returns: http://www.endress.com/support/return-material

7.3 Modification

Modifications are changes to SIL devices that are already delivered or installed. Modifications to SIL devices by the user are not permitted.

7.4 Decommissioning

When decommissioning, the requirements according to IEC 61508-1:2010 section 7.17 must be observed.

7.5 Disposal

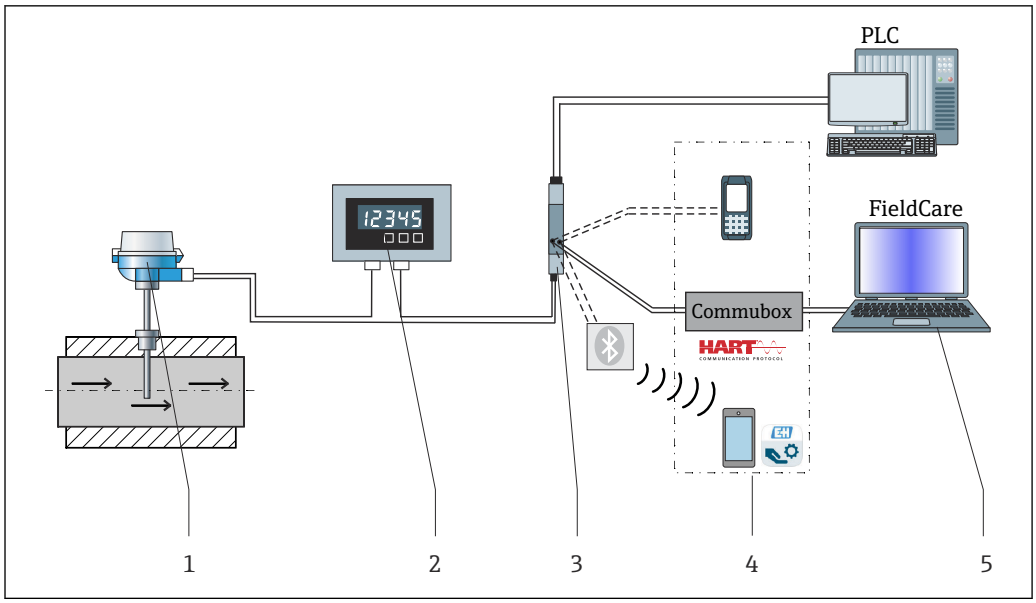
In accordance with the European Directive 2012/19/EC on Waste Electrical and Electronic Equipment (WEEE), our products may not be disposed of as unsorted municipal waste and can be returned to Endress+Hauser for disposal under our General Terms and Conditions or individually agreed conditions.

8 Appendix

8.1 Structure of the measuring system

8.1.1 System components

An example of the devices in the measuring system is shown in the following graphic.



1 *Example of application, measuring point layout with additional Endress+Hauser components*

1 *Installed iTHERM ModuLine thermometer with HART® communication protocol*
2 *RIA15 loop-powered process indicator - The process indicator is integrated in the current loop and displays the measuring signal or HART® process variables in digital form. The process indicator does not require an external power supply, It is powered directly from the current loop. More detailed information on this is provided in the device documentation.*
3 *RN Series active barrier - The active barrier (24 V_{DC}, 30 mA) has a galvanically isolated output for supplying voltage to loop-powered transmitters. The universal power supply works with an input supply voltage of 20 to 250 V DC/AC, 50/60 Hz, which means that the active barrier can be used in all international power grids. More detailed information on this is provided in the device documentation.*
4 *Communication examples: HART® Communicator (handheld terminal), FieldXpert, Commubox FXA195 for intrinsically safe HART® communication with FieldCare via the USB interface, Bluetooth® technology with SmartBlue App.*
5 *FieldCare is an FDT-based plant asset management tool from Endress+Hauser.*

An analog signal (4 to 20 mA) in proportion to the relevant sensor value is generated in the thermometer with a transmitter. This is sent to a downstream logic unit (e.g. PLC, limit signal transmitter) where it is monitored to determine whether it is above or below a specified limit value.

For fault monitoring, the logic unit must recognize both HI alarms (≥21 mA) and LO alarms (≤3.6 mA).

NOTICE

- The optional display is not part of the safety function. Neither the hardware nor the software of the display has a verifiable influence on the defined safety functions of the transmitter.

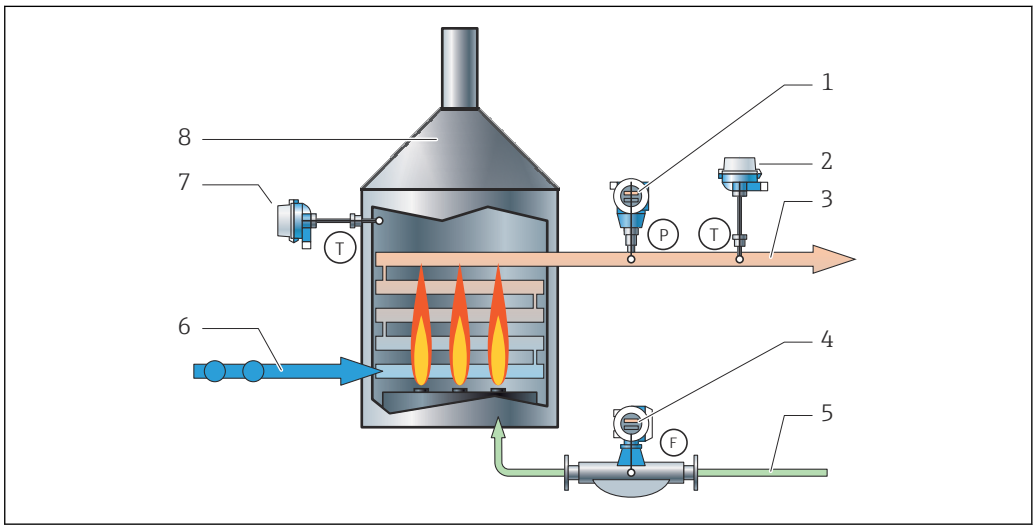
8.1.2 Description of use as a safety instrumented system

The device applies the **resistance sensor RTD** and **thermocouple TC** measuring principles. These resistance thermometers use a Pt100 temperature sensor according to IEC 60751. The temperature sensor is a temperature-sensitive platinum resistor with a resistance of 100 Ω at 0 °C (32 °F) and a temperature coefficient α =0.003851 $°C^{-1}$.

Thermocouples are comparatively simple, robust temperature sensors which use the Seebeck effect for temperature measurement: When two electrical conductors made of different materials are connected at a point, a weak electrical voltage can be measured between the two open conductor ends if there are temperature gradients along the conductors. This voltage is called thermoelectric voltage or electromotive force (emf.). Its magnitude depends on the type of conducting materials and the temperature difference

between the "measuring point" (the junction of the two conductors) and the "cold junction" (the open conductor ends).

Accordingly, thermocouples primarily only measure differences in temperature. The absolute temperature at the measuring point can be determined from these if the associated temperature at the cold junction is known or is measured separately and compensated for. The material combinations and associated thermoelectric voltage/ temperature characteristics of the most common types of thermocouple are standardized in the IEC 60584 and ASTM E230/ANSI MC96.1 standards. The device's safety-related signal is the analog 4 to 20 mA output signal in accordance with NAMUR NE43. All safety measures refer to this signal exclusively. In addition, the device also communicates via HART® for information purposes and comprises all the HART® features with additional device information.



2 *Example of the measuring arrangement*

1 *Pressure sensor*
2 *iTHERM ModuLine TM131/TM151 thermometer*
3 *Finished product*
4 *Flow sensor*
5 *Fuel*
6 *Starting material*
7 *iTHERM ModuLine TM131/TM151 thermometer*
8 *Furnace*

In safety instrumented systems, the device can be used in this arrangement for MAX temperature and range monitoring.

Correct installation is a prerequisite for safe operation of the device.

8.1.3 Measurement function

Galvanic isolation
When two sensors are connected to the transmitter, make sure the sensors are galvanically isolated from one another; this does not apply to grounded thermocouples, however.

Two-channel functions
Two sensors can be connected to the transmitter and the transmitter can be operated in the following safe functions:
- **Averaging** function
  The measured values M1, M2 of the two sensors are output as an arithmetic average (M1+M2)/2.
- **Difference** function
  The measured values M1, M2 of the two sensors are output as a difference (M1-M2).
- **Backup** function
  If one of the sensor fails, the transmitter automatically switches to the other measuring channel. For this the sensor types must be identical, e.g. two 3-wire RTD Pt100 sensors. The backup function is used to increase availability or improve the diagnostic capabilities.
  The following sensor types are therefore permitted in the SIL mode:
  - 2x thermocouple (TC)
  - 2x RTD, 3-wire
- **Sensor drift** function
  If redundant sensors are used, the long-term drift of a sensor can be detected, for instance. This is a diagnostic measure as the signal of the second sensor is only used for this diagnostic. If identical sensors are used, the backup function can also be used.

The configured drift/difference limit value should be at least twice the safety accuracy value.

SIL 3 configuration: homogeneous redundancy
Two temperature transmitters with one sensor per transmitter are required for a SIL 3 measuring point. The measured values of the two transmitters are evaluated in a logic unit using a safe voter.

8.1.4 Limit value monitoring

The safety function is used to monitor the measured value. In the SIL mode, a failure current or saturation current is output in the event of a measurement outside a user-defined measuring range (Xmin to Xmax). This current depends on the configuration of the "Diagnostic behavior" parameter (alarm, warning).

Detailed information:
- Functional Safety Manual TMT82: SD01172T/FY01105T
- Functional Safety Manual TMT162: SD01632T/FY01106T

8.2 Commissioning or proof test report

The following device-specific test report acts as a print/master template and can be replaced or supplemented any time by the customer's own SIL reporting and testing system.

8.2.1 Test Report - Page 1 -

Company/contact person
Tester

Device information
System
Measuring points/TAG No.
Device type/order code
Serial number
Firmware version
Access code (if individual to each device)
SIL checksum

Verification information
Date/time
Performed by

Verification result	
Overall result	
☐ Passed	☐ Failed

Comment

Date	Signature	Signature of tester

8.2.2 Test Report - Page 2 -

Type of safety function
☐ Safe measurement

Commissioning check
☐ Device parameter configuration via SIL mode activation (SiMA)
☐ Commissioning check, test sequence A
☐ Commissioning check, test sequence B

Proof testing
☐ Test sequence A
☐ Test sequence B
☐ Test sequence C

Proof test report			
Test stage	**Set point**	**Actual value**	**Result**
1 Terminal head			☐ Pass ☐ Fail ☐ Not applicable
2 Insert			☐ Pass ☐ Fail ☐ Not applicable
3 Thermometer thermowell			☐ Pass ☐ Fail ☐ Not applicable
4 Lower range value adjustment, sensor 1			☐ Pass ☐ Fail
5 Upper range value adjustment, sensor 1			☐ Pass ☐ Fail
6 Lower range value adjustment, sensor 2			☐ Pass ☐ Fail ☐ Not applicable
7 Upper range value adjustment, sensor 2			☐ Pass ☐ Fail ☐ Not applicable
8 Current value alarm			☐ Pass ☐ Fail
9 Restart via HART			☐ Pass ☐ Fail ☐ Not applicable
10 Restart via plug-in display			☐ Pass ☐ Fail ☐ Not applicable

8.2.3 Test Report - Page 3 -

Protocol for commissioning check			
Test stage	**Set point**	**Actual value**	**Result**
1 Lower range value adjustment, sensor 1			☐ Passed ☐ Failed
2 Upper range value adjustment, sensor 1			☐ Passed ☐ Failed
3 Lower range value adjustment, sensor 2			☐ Passed ☐ Failed ☐ Not applicable
4 Upper range value adjustment, sensor 2			☐ Passed ☐ Failed ☐ Not applicable
5 Two-channel function, sensor drift			☐ Passed ☐ Failed ☐ Not applicable
6 Two-channel function, backup			☐ Passed ☐ Failed ☐ Not applicable
7 Channel assignment, current output			☐ Passed ☐ Failed ☐ Not applicable
8 Out of range category			☐ Passed ☐ Failed ☐ Not applicable
9 RJ / preset value			☐ Passed ☐ Failed ☐ Not applicable
10 Current value alarm			☐ Passed ☐ Failed
11 Restart via HART			☐ Passed ☐ Failed ☐ Not applicable
12 Restart via plug-in display			☐ Passed ☐ Failed ☐ Not applicable

8.2.4 Parameter settings for the SIL mode

Parameter name	Factory setting	Set value	Tested
Enter access code	0		
Lower measuring range (4 mA)	0		
Upper measuring range (20 mA)	100		
Failure current	22.5 mA		
Failsafe mode	Low alarm		
Sensor type 1	Pt100 IEC60751		
Sensor type 2	No sensor		
Upper sensor limit 1	+850 °C		
Lower sensor limit 1	−200 °C		
Upper sensor limit 2	-		
Lower sensor limit 2	-		
Sensor offset 1	0		
Sensor offset 2	0		
Connection type 1	4-wire (RTD)		
Connection type 2	2-wire (TC)		

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