SD01361O/09/EN/02.15

Special Documentation

Dual-Input Temperature Head Transmitter T82

Functional Safety Manual

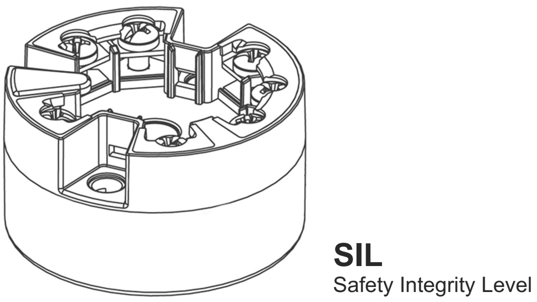

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Table of contents

SIL key figures

General			
Safety-related output signal	4...20mA		
Fault current	3.58 mA		
Process variable/function	Temperature, voltage, resistance		
Safety function(s)	min., max., range		
Device type acc. to IEC 61508-2	☐ Type A	☑ Type B	
Operating mode	☑ Low Demand Mode	☑ High Demand	☐ Continuous Mode
Valid Hardware-Version	Head transmitter: 01.00.06 or higher DIN Rail transmitter: 01.00.04 or higher		
Valid Software-Version	01.01.08 or higher (Dev.Rev.:2 or higher)		
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	TÜV SÜD Product Service GmbH, Germany		
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
FMEDA			
Safety function	min., max., range		
λ_{DU} 1)	40 FIT		
λ_{DD} 1)	258 FIT		
λ_{SU} 1)	129 FIT		
λ_{SD} 1)	4 FIT		
SFF - Safe Failure Fraction	91%		
PFD_{avg} T1 = 1 year 2) (single channel architecture)	$1.75 \cdot 10^{-4}$		
PFD_{avg} T1 = 5 years 2) (single channel architecture)	$8.76 \cdot 10^{-4}$		
PFH	$4.0 \cdot 10^{-8} \cdot 1/h$		
PTC 3)	96%		
MTBF 4)	71 years		
Diagnostic test interval 5)	32 min		
Fault reaction time 6)	< 10.7 s		
Process safety time 7)	53 h		

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

1) FIT = Failure In Time, Number of failures per 10^9 h
2) Valid for average ambient temperature up to +40 °C (+104 °F)
For continuous operation at ambient temperature close to +60 °C (+140 °F), a factor of 2.1 should be applied
3) PTC = Proof Test Coverage
4) MTBF (Mean time between failures) is the predicted elapsed time between inherent failures of a system during operation in accordance to Siemens SN29500
5) All diagnostic functions are performed at least once within the Diagnostic test interval
6) Maximum time between error recognition and error response
7) The Process safety time is: Diagnostic test interval x 100 (calculated acc. to IEC 61508)

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Document information

Document function

The document is part of the Operating Instructions and serves as a reference for application-specific parameters and notes.

Using this document

Information on the document structure

For the arrangement of the parameters according to the menu structure of the **Operation** menu, **Setup** menu, **Diagnostics** menu, along with short descriptions, see the Operating Instructions for the device

Symbols used

Safety symbols

Symbol	Meaning
DANGER A0011189-EN	**DANGER!** This symbol alerts you to a dangerous situation. Failure to avoid this situation will result in serious or fatal injury.
CAUTION A0011191-EN	**CAUTION!** This symbol alerts you to a dangerous situation. Failure to avoid this situation can result in minor or medium injury.
NOTICE A0011192-EN	**NOTE!** This symbol contains information on procedures and other facts which do not result in personal injury.

Symbols and notation for certain types of information

Symbol	Meaning
A0011193	**Tip** Indicates additional information.
A0011194	**Reference to documentation** Refers to the corresponding device documentation.
A0011195	**Reference to page** Refers to the corresponding page number.
A0011196	**Reference to graphic** Refers to the corresponding graphic number and page number.
1., 2., 3.	**Series of steps**

Symbols and notation in graphics

Symbol	Meaning
1,2,3 ...	Item numbers
A, B, C, ...	Views
A-A, B-B, C-C, ...	Sections
EX A0011187	**Hazardous area** Indicates a hazardous area.
EX A0011188	**Safe area (non-hazardous area)** Indicates the non-hazardous area.

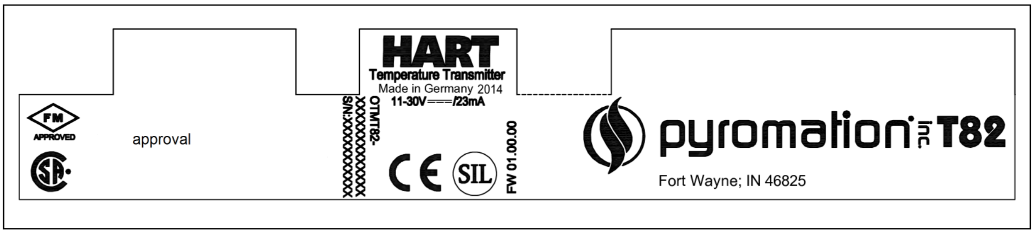
Permitted devices types

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 instrumented systems.

ℹ A modification process according to IEC 61508 is applied for any device modifications.

Order code:

Valid firmware version	as of 01.01.07
Valid hardware version (electronics)	as of 01.00.06
Valid device drivers	DTM as of version 1.0.2.1 DD as of revision 03



1 *Identifying the device with the SIL mode option*

ℹ SIL certified devices are marked with the SIL symbol on the nameplate.

The SIL logo on the transmitter's nameplate distinguishes the SIL transmitter from versions that are not SIL compliant.

Safety functions

Definition of the safety function

Permitted safety functions of the device are:
- Limit value monitoring
- Safe measurement

Safety-related output signal

The safety-related signal of the device is the analog output signal 4 to 20 mA according to the NAMUR NE43. All safety precautions refer to this signal exclusively.

The safety-related output signal will be relayed to a downstream logic unit (e.g. PLC, limit signal switch) where it is monitored on:
- ascertain whether it exceeds or drops below predefined limit value.
- occuring an error, e. g. error current (≤ 3.6 mA, ≥ 21 mA, cable open circuit or short circuit of the signal wires).

ℹ In the SIL mode the transmitter cannot be configured for inverse value display at the current output.

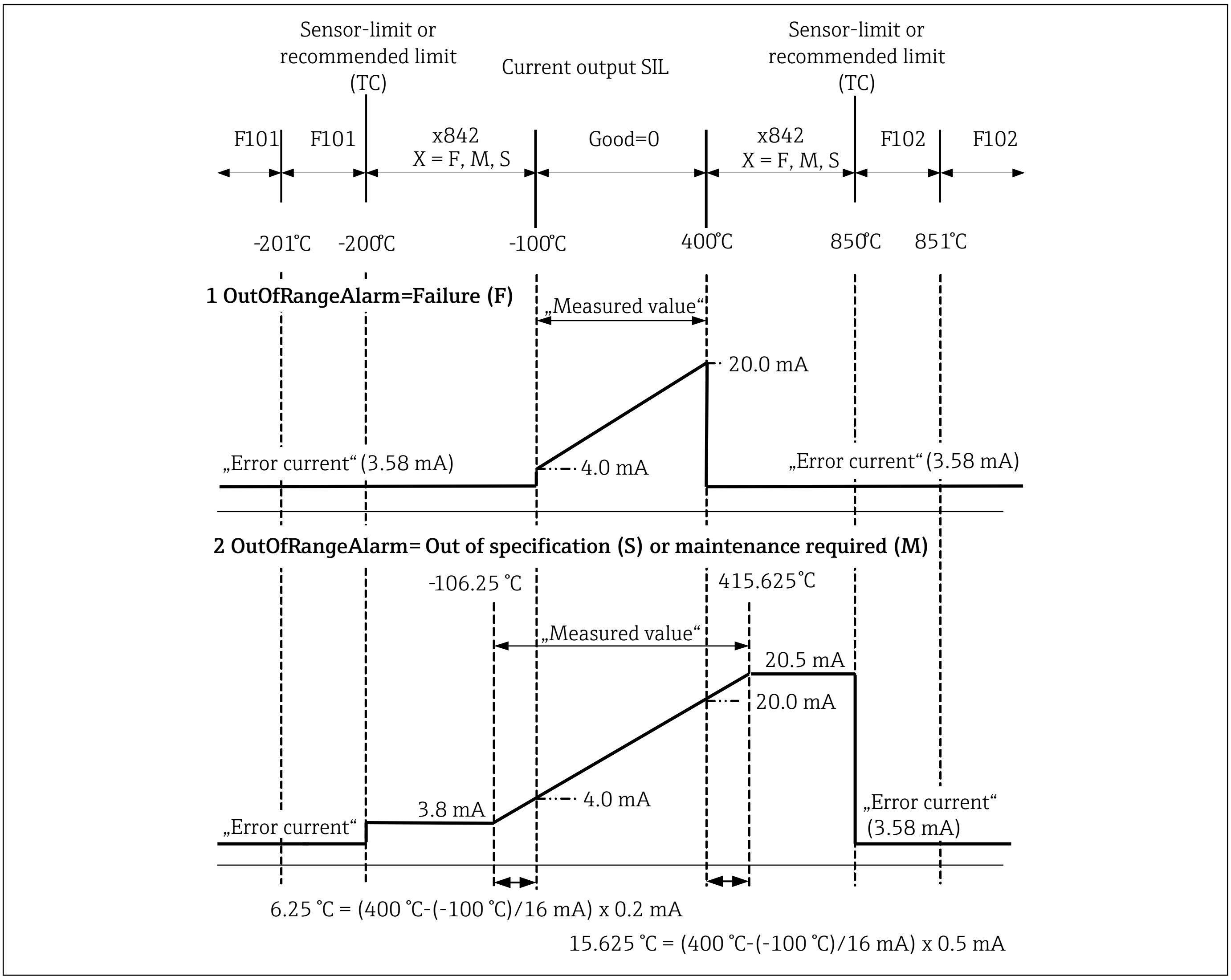
Dangerous undetected failures in this scenario

An incorrect output signal that deviates from the value specified in this functional safety manual but is still in the range of 4 to 20 mA, is considered a dangerous, undetected failure. → 📄 7

Limit value monitoring

This safety function provides the monitoring of the measured value. In the SIL mode, an error current is output in the event of a measurement outside a user-defined temperature interval (X_{min} … X_{max}). This error current depends on the configuration of the parameter „Out of range category“ (F, S, M).

Here for example: I_{min} = -100 °C, I_{max} = 400 °C



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1 *Curve OutOfRangeAlarm = status signal for failure (F)*
2 *Curve OutOfRangeAlarm = status signal for out of specification (S) or maintenance required (M)*

Safe measurement

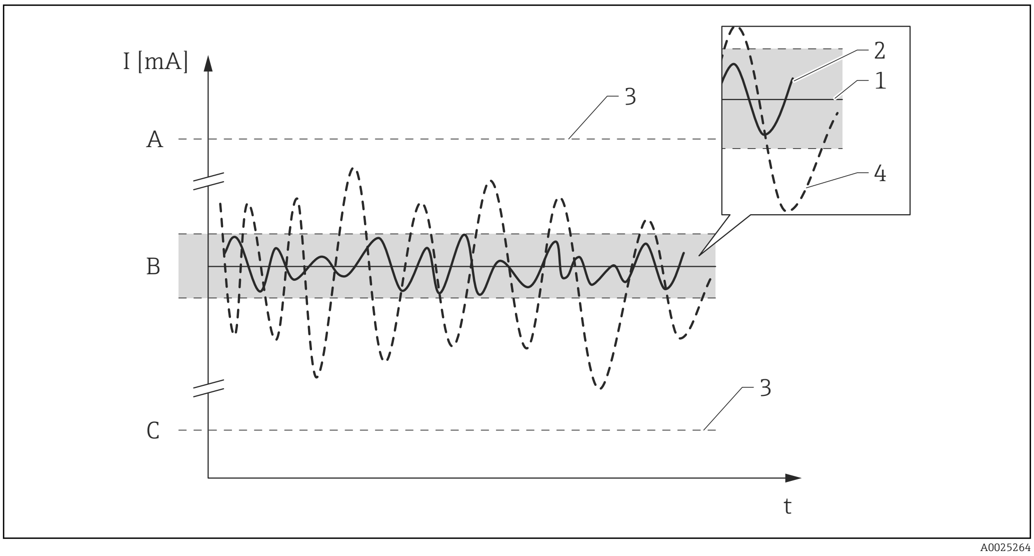
The safety function comprises an transmitted current output signal proportional to the voltage, resistance or temperature value. To be able to use this safety function, the device must be parameterized safely via a operating tool and set to the SIL-mode. → 11

All safety functions can be used in combination with all sensor configurations from the section 'Structure of the measuring system' → 23. 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. A limit value monitoring can be set up for both inputs seperately.

Restrictions for use in safety-related applications

- Pay attention to a designated use of the measuring system in consideration of the medium properties and the environmental conditions. Carefully follow instructions from the Operating Instructions pertaining to critical process situations and installation conditions. The application-specific limits have to be observed.
- Information to the safety-related signal. → 🗎 5
- The technical specifications from the Operating Instructions must not be exceeded.
- The following restrictions also applies to safety-related use:
  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 includes all influental factors described in the technical data of the associated Operating Instructions (non-linearity, non-repeatability, hysteresis, zero drift, temperature drift, EMC influences).
  According to IEC / EN 61508 the safety related failures are classified into different categories, see the following table. The table shows the implications for the safety related output signal and the measuring uncertainty.

Safety related error	Description	Implications for the safety related output signal (position, see following figure)
No device error	Safe: No error	1 Is within the specification
λ_{SD}	Safe detected: Safe failure which can be detected	3 The output signals an error (→ 🗎 10)
λ_{SU}	Safe undetected: Safe failure which cannot be detected	2 Is within the defined error range (→ 🗎 8)
λ_{DD}	Dangerous detected: Dangerous failure which can be detected (Diagnostic within the device)	3 The output signals an error (→ 🗎 10)
λ_{DU}	Dangerous undetected: Dangerous failure which cannot be detected	4 May be outside the defined error range (→ 🗎 10)



A High-alarm ≥ 21 mA
B Error range → 🗎 10
C Low-alarm ≤ 3.6 mA

Safety measured error

Thermocouples

Standard	Designation	Min. span	Limited safety measuring range	Measured error (+A/D), −40 to +70 °C (−40 to +158 °F)	Measured error (D/A)	Long-term drift in °C/ year or µV/ year [1)]
IEC 60584-1	Type A (W5Re-W20Re) (30)	50 K (90 °F)	0 to +2 500 °C (+32 to +4 532 °F)	12 K (21.6 °F)	0.5 % of the span	1.42
	Type B (PtRh30-PtRh6) (31)	50 K (90 °F)	+500 to +1 820 °C (+932 to +3 308 °F)	5.1 K (9.2 °F)		2.01
	Type E (NiCr-CuNi) (34)	50 K (90 °F)	−150 to +1 000 °C (−238 to +1 832 °F)	4.9 K (8.8 °F)		0.43
	Type J (Fe-CuNi) (35)	50 K (90 °F)	−150 to +1 200 °C (−238 to +2 192 °F)	4.9 K (8.8 °F)		0.46
	Type K (NiCr-Ni) (36)	50 K (90 °F)	−150 to +1 200 °C (−238 to +2 192 °F)	5.1 K (9.2 °F)		0.56
	Type N (NiCrSi-NiSi) (37)	50 K (90 °F)	−150 to +1 300 °C (−238 to +2 372 °F)	5.5 K (9.9 °F)		0.73
	Type R (PtRh13-Pt) (38)	50 K (90 °F)	+50 to +1 768 °C (+122 to +3 214 °F)	5.6 K (10.1 °F)		1.58
	Type S (PtRh10-Pt) (39)	50 K (90 °F)	+50 to +1 768 °C (+122 to +3 214 °F)	5.6 K (10.1 °F)		1.59
	Type T (Cu-CuNi) (40)	50 K (90 °F)	−150 to +400 °C (−238 to +752 °F)	5.2 K (9.4 °F)		0.52
IEC 60584-1; ASTM E988-96	Type C (W5Re-W26Re) (32)	50 K (90 °F)	0 to +2 000 °C (+32 to +3 632 °F)	7.6 K (13.7 °F)		0.94
ASTM E988-96	Type D (W3Re-W25Re) (33)	50 K (90 °F)	0 to +2 000 °C (+32 to +3 632 °F)	7.1 K (12.8 °F)		1.14
DIN 43710	Type L (Fe-CuNi) (41)	50 K (90 °F)	−150 to +900 °C (−238 to +1 652 °F)	4.2 K (7.6 °F)		0.42
	Type U (Cu-CuNi) (42)		−150 to +600 °C (−238 to +1 112 °F)	5.0 K (9 °F)		0.52
GOST R8.8585-2001	Type L (NiCr-CuNi) (43)	50 K (90 °F)	−200 to +800 °C (−328 to +1 472 °F)	8.4 K (15.1 °F)		0.53
Voltage transmitter (mV)		5 mV	−20 to 100 mV	200 µV		27.39

1) Values at 25 °C, values may need to be extrapolated to other temperatures.

RTD sensors

Standard	Designation	Min. span	Limited safety measuring range	Measured error (+A/D), −40 to +70 °C (−40 to +158 °F)	Measured error (D/A)	Long-term drift in °C/ year or Ω/ year [1)]
IEC 60751:2008	Pt100 (1)	10 K (18 °F)	−200 to +600 °C (−328 to +1 112 °F)	1.1 K (2.0 °F)	0.5 % of the span	0.23
	Pt200 (2)	10 K (18 °F)	−200 to +600 °C (−328 to +1 112 °F)	1.6 K (2.9 °F)		0.92
	Pt500 (3)	10 K (18 °F)	−200 to +500 °C (−328 to +932 °F)	0.9 K (1.6 °F)		0.38
	Pt1000 (4)	10 K (18 °F)	−200 to +250 °C (−328 to +482 °F)	0.6 K (1.1 °F)		0.19
JIS C1604:1984	Pt100 (5)	10 K (18 °F)	−200 to +510 °C (−328 to +950 °F)	1.0 K (1.8 °F)		0.32

Standard	Designation	Min. span	Limited safety measuring range	Measured error (+A/D), −40 to +70 °C (−40 to +158 °F)	Measured error (D/A)	Long-term drift in °C/ year or Ω/ year [1]
DIN 43760 IPTS-68	Ni100 (6)	10 K (18 °F)	−60 to +250 °C (−76 to +482 °F)	0.4 K (0.7 °F)		0.22
	Ni120 (7)		−60 to +250 °C (−76 to +482 °F)	0.3 K (0.54 °F)		0.18
GOST 6651-94	Pt50 (8)	10 K (18 °F)	−180 to +600 °C (−292 to +1 112 °F)	1.3 K (2.34 °F)		0.61
	Pt100 (9)	10 K (18 °F)	−200 to +600 °C (−328 to +1 112 °F)	1.2 K (2.16 °F)		0.34
OIML R84: 2003, GOST 6651-2009	Cu50 (10)	10 K (18 °F)	−180 to +200 °C (−292 to +392 °F)	0.7 K (1.26 °F)		0.46
	Cu100 (11)	10 K (18 °F)	−180 to +200 °C (−292 to +392 °F)	0.5 K (0.9 °F)		0.23
	Ni100 (12)	10 K (18 °F)	−60 to +180 °C (−76 to +356 °F)	0.4 K (0.72 °F)		0.21
	Ni120 (13)	10 K (18 °F)	−60 to +180 °C (−76 to +356 °F)	0.3 K (0.54 °F)		0.18
OIML R84: 2003, GOST 6651-94	Cu50 (14)	10 K (18 °F)	−50 to +200 °C (−58 to +392 °F)	0.7 K (1.26 °F)		0.45
Resistance transmitter Ω	400 Ω	10 Ω	10 to 400 Ω	0.5 Ω		0.096
	2 000 Ω	100 Ω	10 to 2 000 Ω	2.1 Ω		0.51

1) Values at 25 °C, values may need to be extrapolated to other temperatures.

For these values no deviations caused by EMC interference are considered. In the event of non-negligible EMC interference, an additional error of 0.5% must be added to the values above.

Validity of information on the safety measured errors:
- Total temperature range of the transmitter in the SIL-mode.
- Defined range of the supply voltage.
- Limited safety measuring range of the sensor element.
- The accuracy already contains all the round-off errors in the software due to linearization and calculations.
- Follow the minimum span for each sensor.
- The values are 2σ values, i.e. 95.4 % of all the measured values are within the specifications.

Restrictions of the device specifications for the safety operation

- Compliance with the ambient conditions as per IEC 61326-3-2, appendix B is mandatory.
- The permitted voltage range for the SIL-mode:
  Head transmitter: V_{cc} = 11 to 32 V
- The power supply must be short-circuit proof and ensure that the upper error current can still be output at any time.
- It is not permitted to use the transmitter in a radioactive environment (except naturally occurring radioactivity).
- Generally it is advised to use shielded sensor cables.
- The head transmitter mustn't be operated as a substituted DIN rail device (DIN-rail clip) with remote sensor installation.
- Permitted storage temperature:
  Head transmitter = −50 to +100 °C (−58 to +212 °F)
- Permitted ambient temperature −40 to +70 °C (−40 to +158 °F)
- The safe parameterization is only possible via HART® communication.
- The mains frequency filter must be set correctly to either 50 Hz or 60 Hz.
- Maximum permitted sensor cable resistance in the event of voltage measurement: 1 000 Ω.

NOTICE

HART® communication

▶ The transmitter also communicates via HART® in the SIL mode. This comprises all the HART® features with additional device information. HART® communication is **not** part of the safety function.

It is advisable to only use shielded power supply cables (see also the associated Operating Instructions).

Use in protective systems

Behavior of device during operation and in case of error

Behavior of device during power-up

After power-up, the device runs through a diagnostic phase. The current output is set to the error current (low alarm) during this time.

During the diagnostic phase, no communication is possible via the service interface (CDI) or via HART®.

Behavior of device during power-up depending on device parameterization

'SIL HART mode' parameter	'SIL startup modus' parameter	
	On	Off
On	Approx. 30 s start time → SIL measuring mode	Wait to enter SIL checksum
Off	Approx. 120 s start time → SIL measuring mode During this time, it is possible to cancel the SIL mode by entering a SIL checksum = 0.	Wait to enter SIL checksum

Behavior of device during normal operation (SIL measuring mode)

The device outputs a current value which corresponds to the measured value to be monitored. This value must be monitored and processed further in an attached automation system.

Device behavior in safety function demand mode

In the demand mode, the current is ≤ 3.6 mA (low alarm - safe state)

Safe states

Safe state	
Active safe state	Passive safe state
Output error current, ≤ 3.6 mA (= low alarm)	Output error current, ≤ 3.6 mA (= low alarm) System reset is triggered automatically.
In the active safe state it is still possible to communicate with the transmitter via HART® but the current output permanently outputs an error current. This state remains until the transmitter is rebooted. All the parameters can be read and non-safety-related parameters can be modified.	In the passive safe state it is not possible to communicate with the transmitter via HART®. The system stops immediately and reboots after 0.5 seconds at the very latest. The device does not display any more error messages. Parameters can no longer be modified.

The system assumes one of the two states depending on the error detected. The active safe state is the only state in which the system continues working without a restart being triggered automatically.

Behavior of device in event of alarms and warnings

In an alarm condition the output current is ≤ 3.6 mA. In some cases, (e.g. short-circuit in the supply line) output currents ≥ 21 mA occur irrespective of the error current defined. The downstream logic unit must be able to detect high alarms (≥ 21 mA) and low alarms (≤ 3.6 mA) for alarm monitoring.

Alarm and warning messages

The alarm and warning messages output on the device display or in the operating tool in the form of diagnostic events and the associated event text are additional information.

An overview of the diagnostic events can be found in the associated Operating Instructions.

The following diagnostic events, which can be configured in the normal mode, result in the active safe state in the SIL mode and therefore in the error current being output:
- Permitted device ambient temperature exceeded/undershot (diagnostic message F925)
- Sensor corrosion (diagnostics F042)

NOTICE

When the device switches to the SIL mode, additional diagnostics are activated (e.g. the output current that is read back is compared against the rated value). An error current is output if one of these diagnostics causes an error message (e.g. F041 Sensor failure). The device must be restarted once the error has been eliminated.
- ▶ For this, briefly disconnect the device from the power supply or
- ▶ Send a command to this effect via HART® or run a comparable function in the operating tool.

When the device is then restarted, a self-check is carried out, and the error message is reset where applicable.

Parameter configuration for safety-related applications

Configuration of the measuring point

The transmitter is configured using guided safe parameterization with a limited parameter set which is performed with a suitable operating tool such as Endress+Hauser FieldCare, for instance.

Safe parameterization

The user interface can differ from the screens shown here depending on the operating tool used and the selected language.

NOTICE

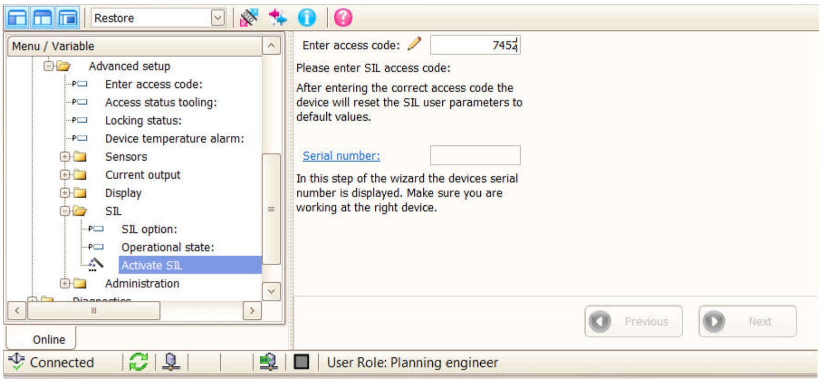
If safe parameterization is performed it must be documented! The 'Commissioning or proof test report' is suitable for documenting this information. A master copy of this document can be found at the end of this manual.
- ▶ Enter the configured parameters in the 'Set value' column. The date, time and the SIL checksum of the safe parameterization that is subsequently displayed **must** be documented. The time stamp entered at the end of safe parameterization can be called via the **Timestamp SIL configuration** parameter. → 26
- ▶ Each parameter, having been transmitted to the device, is read out anew and displayed. Afterwards it is necessary to confirm that the value displayed matches the value entered. The value that is read back also contains the text '#END' at the end. A table with the assignment of the code numbers to the parameters is provided in the Appendix to this Safety Manual. → 35
- ▶ Prior to commencing safe parameterization, make sure that the device is not in the Burst mode.

The transmitter outputs an error current ≤ 3.6 mA (low alarm) during the safe parameterization process. If an error occurs during safe parameterization, or if parameter verification returns a negative result, safe parameterization has not been performed successfully and must be repeated.

Safe parameterization: sequence of steps

1. Safe parameterization can only be performed in the online mode. In the submenu **Setup → Extended setup → SIL**, start safe parameterization **Activate SIL**.
   - ↳ The **Access code** window opens

2.



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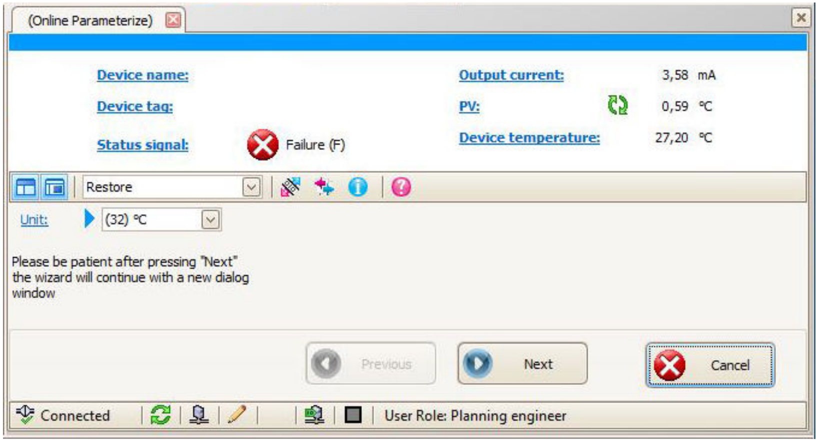
In the **Enter access code** input window, enter **7452** and press ENTER to confirm. Then press NEXT to continue.

↳ The parameters that are relevant for safety are reset to the factory setting. See the 'Parameters and default settings for safe parameterization' table in the Appendix. → 29

After this, the input windows for device settings open, starting with the unit of the measured variables. The order of how these windows open is fixed.

3.



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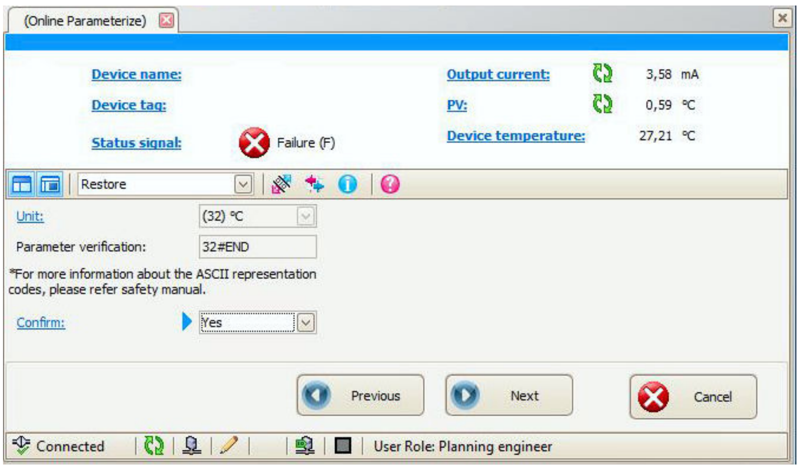

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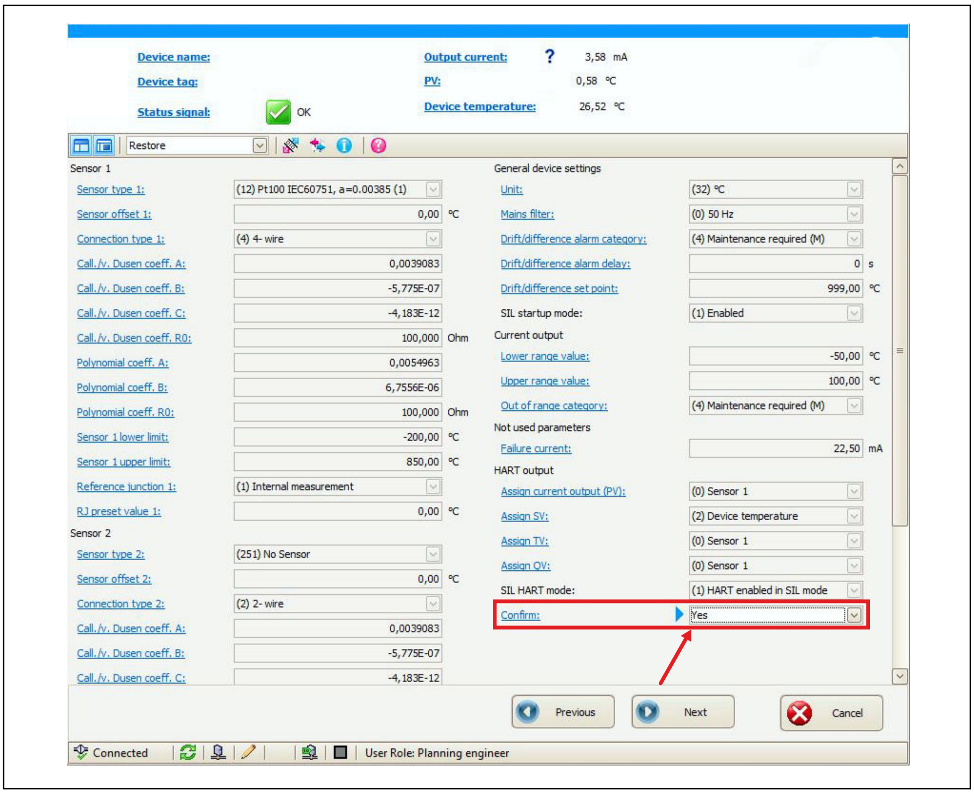
Verify the parameters entered in the subsequent window. If the parameters are correct, select YES for **Confirm** and press ENTER to confirm. Press 'NEXT' to continue.

NOTICE

- If the Fahrenheit (°F) or Rankine (°R) unit is selected for Callendar/Van Dusen or polynomial copper/nickel sensors, during parameter verification the saved parameter value may deviate by 0.01 °F or °R from the parameter value entered. This deviation can occur with the following parameters: lower measuring range (4 mA), upper measuring range (20 mA), sensor offset, drift/difference mode, upper sensor limit and lower sensor limit.

Once all the safety-related parameters have been entered, an overview of all the uneditable default values appears. Following confirmation, all the safety-related parameters that have been entered are displayed so the user can check them once again.

1.



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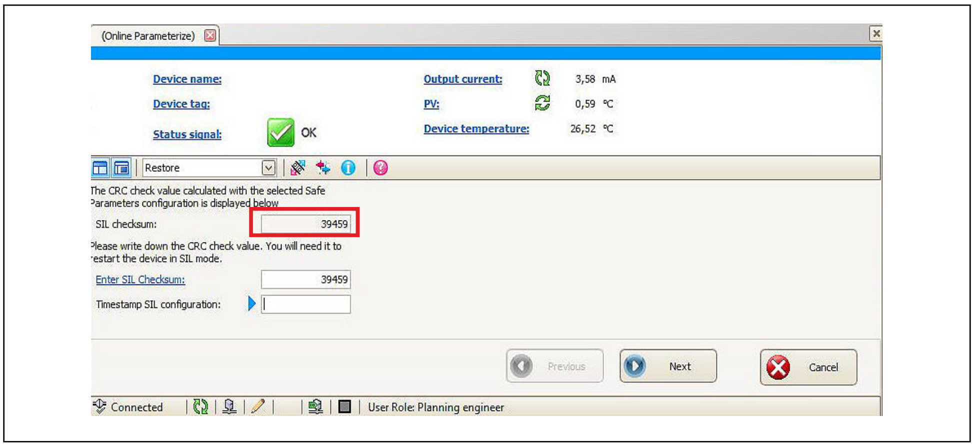
If all the settings are correct select YES for **Confirm** and press ENTER to confirm. Press 'NEXT' to continue.

2.



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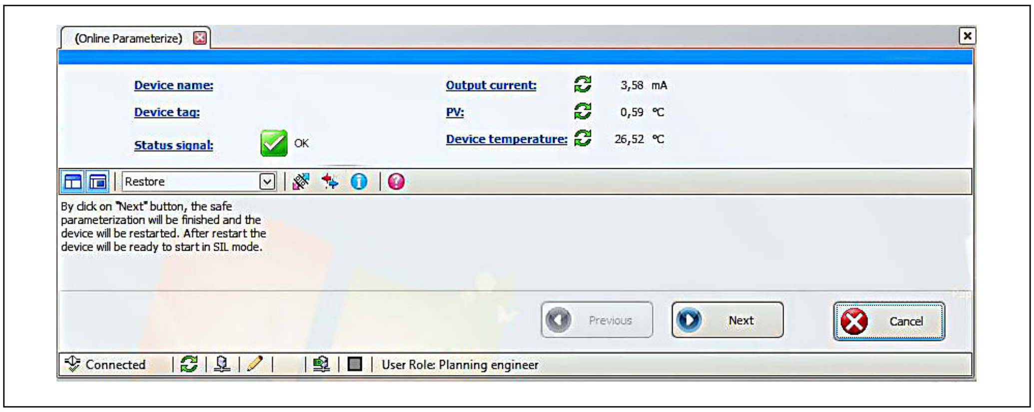
NOTICE

This value displayed for the SIL checksum is needed to activate the SIL mode if the 'SIL startup mode' parameter has been set to DISABLED.

▶ Make sure to jot down the value displayed for the SIL checksum in the documentation for this measuring point.

Enter the SIL checksum displayed in the **Enter SIL checksum** field and fill in the current date and time in the **Timestamp SIL configuration** field. Press ENTER to confirm your entries. Press 'NEXT' to continue.



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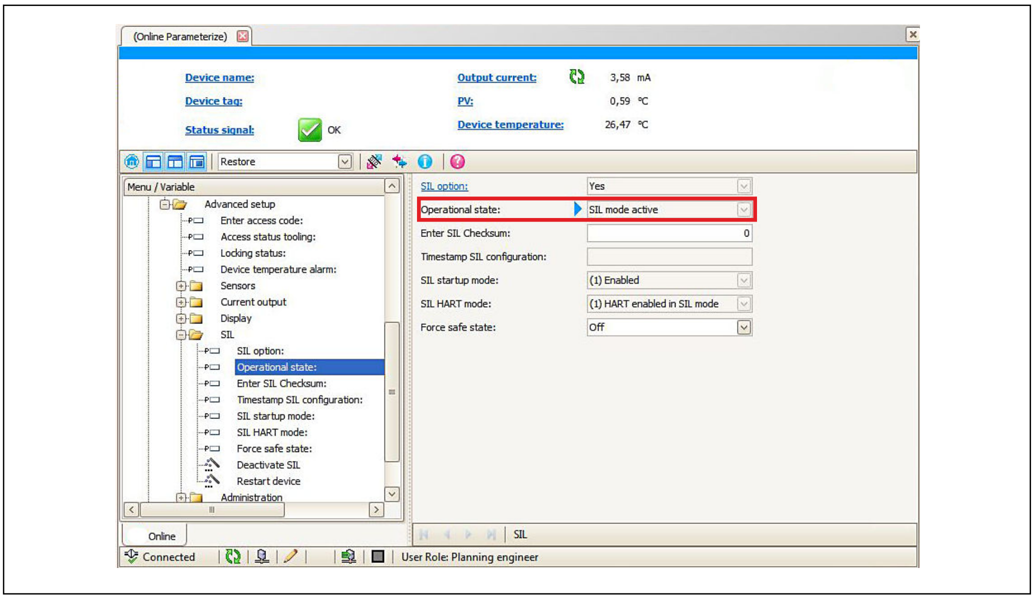
Safe parameterization is completed. Once the 'Next' button is pressed, the device automatically restarts in the SIL mode. → 📄 10

Check the operational state of the transmitter (active SIL mode) before use!



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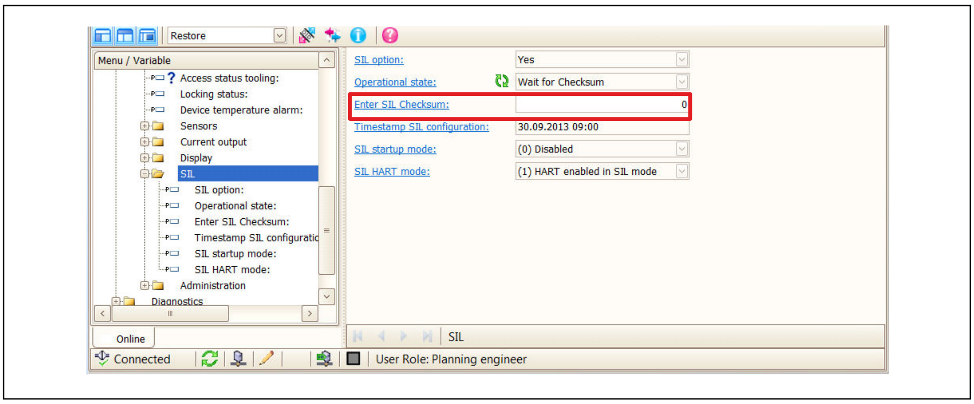
3 *Operational state displayed*

Disabling the SIL mode

There are two ways (A or B) to disable the SIL mode. Switch off transmitter hardware write protection where necessary.

The procedure for doing so is described in the associated Operating Instructions.

1. 

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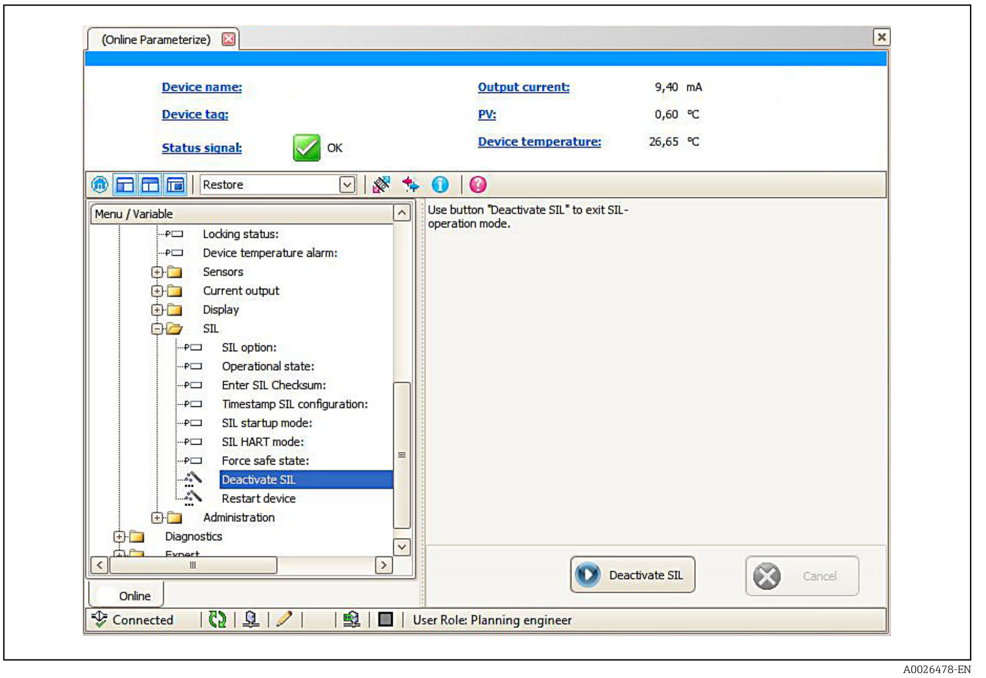
   A) Enter the number **0** in the **Enter SIL checksum** field.
2. Press ENTER to confirm.
3. Restart the device: run the **Restart device** function or interrupt the supply voltage for the transmitter.

After rebooting, the device is in the unsafe mode (normal mode). To switch back to the SIL mode, on the other hand, the user must start safe parameterization once again. → 11

1. 

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B) Start the **Deactivate SIL** function in the submenu: **Setup → Extended setup → SIL**.

2. Activate the **Deactivate SIL** field once again.
   ↳ After automatic rebooting, the device is in the unsafe mode (normal mode).

NOTICE

When the SIL mode is ended, diagnostics are disabled and the device can no longer perform the safety function. Therefore suitable measures must be taken to ensure that no danger can occur during the time the SIL mode is disabled.

▶ If HART communication is switched off in the SIL mode, ('SIL HART mode' parameter = disabled), restart the device. In the transmitter startup phase, deactivation methods A and B are available for 90 seconds. (HART is active during this time). To return to the SIL mode, the user must perform safe parameterization once again. → 11

Commissioning test and proof testing

The functional integrity of the transmitter in the SIL mode must be verified during commissioning and at appropriate intervals.

NOTICE

The safety function is not guaranteed during a commissioning or proof test. Suitable measures must be taken to guarantee process safety during the test.

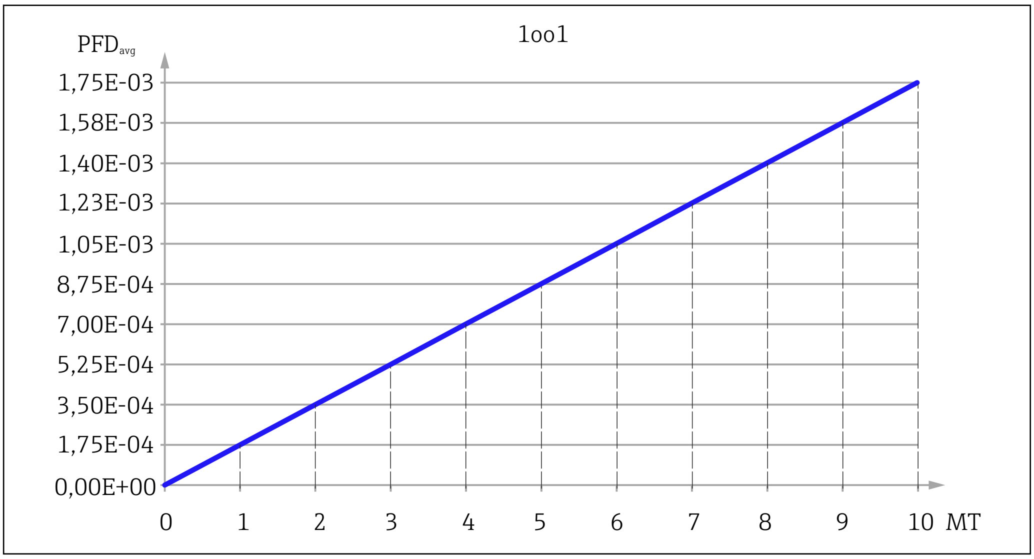
- The safety-related output signal 4 to 20 mA may not be used for the protective system during the test.
- Any test performed must be documented. The template in the Appendix can be used for this purpose. → 26

Proof testing the safety function

1. Check the functional integrity of the safety function at appropriate intervals.
2. The operator specifies the testing interval and this must be taken into account when determining the probability of failure PFD_{avg} of the sensor system.
   - ↳ In the case of a single-channel system architecture, the average probability of failure (PFD_{avg}) of the sensor is derived from the proof-test interval T_i, the failure rate for dangerous undetected failures λ_{du}, the proof test coverage PTC and the assumed mission time by close approximation as follows:
     $PFD_{avg} \approx \lambda_{du} \times (PTC/2 \times T_i + (1 - PTC) / 2 \times MT)$ [1)]
3. The operator also specifies the procedure for proof-testing.

NOTICE

- According to IEC 61511, an independent proof-test of subsystems - such as the transmitter - is permitted as an alternative to checking the safety function of the entire system. Average probability of failure and mission time PFDavg for single-channel system (without performing proof testing).



MT:	Mission time in years
PFD_{avg}:	Average probability of dangerous failure on demand
1oo1:	Single-channel architecture

Transmitter commissioning or proof test

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. The individual proof test coverages (PTC) that can be used for calculation are specified for the test sequences described below.

1) with MT = Mission Time, PTC = Proof Test Coverage and T_i = Test Interval

The device can be tested as follows:
- Test sequence A: complete test with HART operation
- Test sequence B: complete test without HART operation (with attachable plug-in display)
- Test sequence C: simplified test with or without HART operation

NOTICE

Note the following for the test sequences:
- ▶ The transmitter can be tested without a sensor using an appropriate sensor simulator (resistance decade, reference voltage source, etc.). Changing the connection triggers a sensor error which causes the transmitter to go to the safe state and the transmitter must be restarted.
- ▶ The accuracy of the measuring device used must meet the transmitter specifications.
- ▶ If both transmitter input channels are used, the test for the second sensor must be repeated accordingly.
- ▶ A three-point calibration must be performed when customized linearization (e.g. with CvD coefficients) is used.

Test sequence A

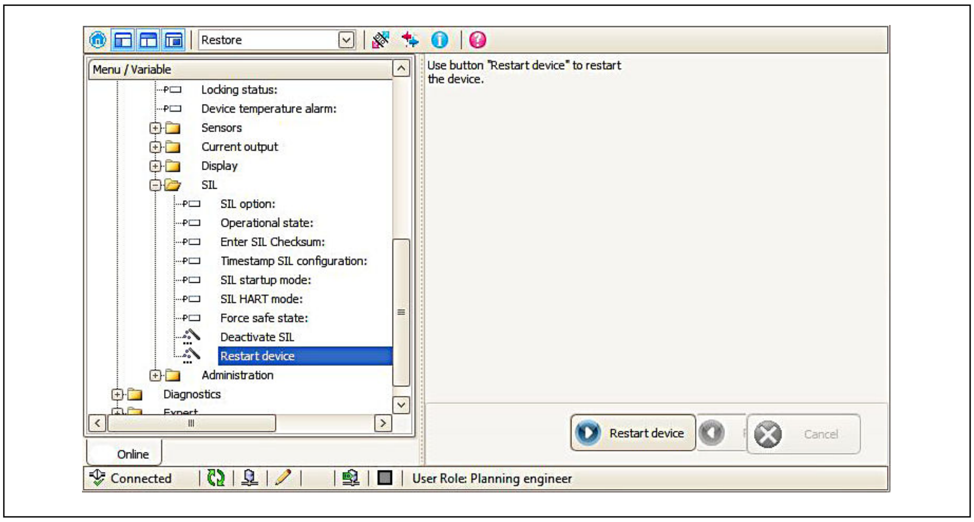
1. Two-point calibration

   Test the current output by applying the reference temperature at the sensor or a corresponding reference signal (resistance, voltage) at 2 points. For the lower range value, select **4 mA to +20 % of the span** and for the upper range value, select **20 mA to up to –20 % of the span**.

   ↳ The measurement results must be within the specified safety inaccuracy range. Otherwise the test has not been passed.

2. Check the safe state (low alarm)

   Provoke a sensor error to force the transmitter safe state (e.g. by a cable open circuit or by short-circuiting the sensor cables). Check whether the current output at the current output corresponds to the low alarm (≤ 3.6 mA).

3. 

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   Trigger a device restart using the appropriate function in the operating tool used or via HART command 42.

96% of dangerous, undetected failures are detected using this test (proof test coverage, PTC = 0.96). During the test sequence, the device current output typically behaves as illustrated in → 6, 20.

Test sequence B

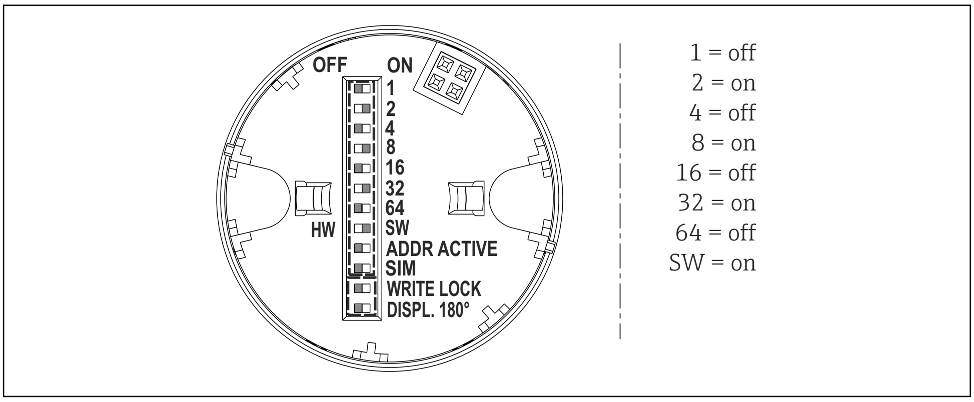
1. Two-point calibration

   Test the current output by applying the reference temperature at the sensor or a corresponding reference signal (resistance, voltage) at 2 points. For the lower range value, select **4 mA to +20 % of the span** and for the upper range value, select **20 mA to up to –20 % of the span**.

   ↳ The measurement results must be within the specified safety inaccuracy range. Otherwise the test has not been passed.

2. Check the safe state (low alarm)
   Provoke a sensor error to force the transmitter safe state (e.g. by a cable open circuit or by short-circuiting the sensor cables). Check whether the current output at the current output corresponds to the low alarm (≤ 3.6 mA).
3. NOTICE

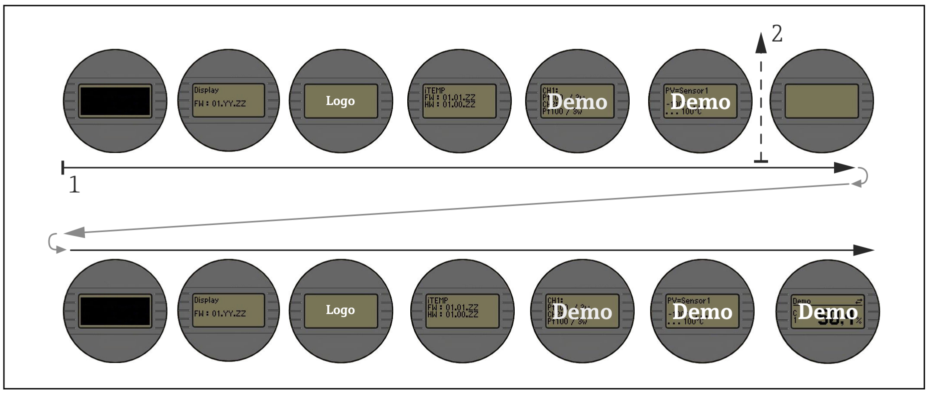
   ▶ If the display will remain attached to the transmitter for the rest of the application, the setting of the DIP switches must be changed again after the test sequence.



4 *Setting for the DIP switches on the plug-in display*

Trigger a device restart by plugging in a display and setting the DIP switches at the back to the appropriate position.

↳ When the device is restarted the following start-up sequence appears on the plug-in display:

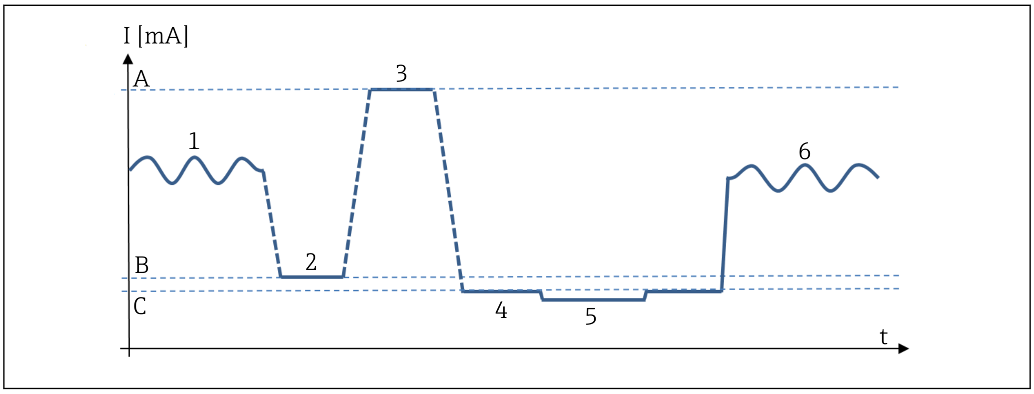


5 *Device start-up sequence on the display*

1 *Start of sequence*
2 *Device restart*

The start-up sequence on the display indicates whether the restart is being performed correctly.

94% of dangerous, undetected failures are detected using this test (proof test coverage, PTC = 0.94). During the test sequence, the device current output typically behaves as illustrated in → 6, 20.



6 *Current pattern during proof test A and B*

A 20 mA
B 4 mA
C ≤ 3.6 mA
1 Operation
2 Lower range value adjustment (two-point calibration)
3 Upper range value adjustment (two-point calibration)
4 Low alarm test
5 Transmitter restart (via HART or plug-in display)
6 Operation

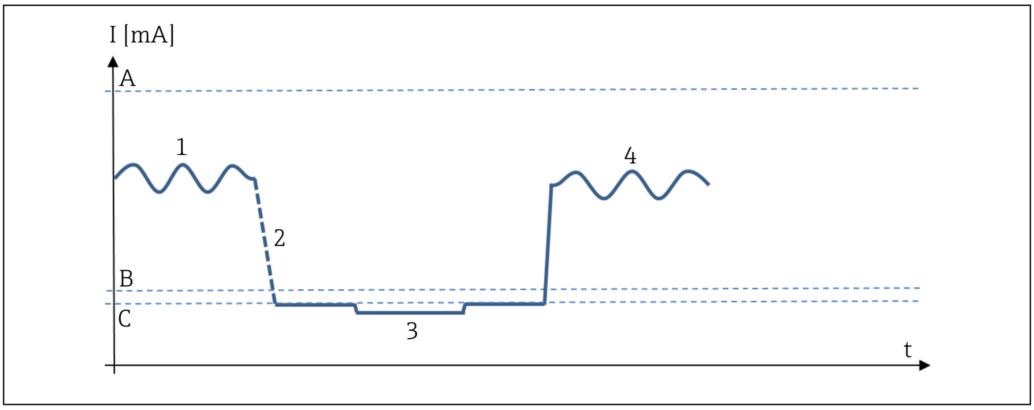
Test sequence C

1. Check the plausibility of the current measuring signal. The measured value must be assessed on the basis of empirical values deriving from the operation of the device. This is the responsibility of the operator.
2. NOTICE

   Setting of the DIP switches on the plug-in display.
   - ▶ If the display will remain attached to the transmitter for the rest of the application, the setting of the DIP switches must be changed again after the test sequence.

   Trigger a device restart by plugging in a display and setting the DIP switches at the back to the appropriate position (→ 4, 19). The sequence on the display indicates whether the restart is being performed correctly. (see test sequence B, point 3.) **Alternatively:** Trigger a device restart using the appropriate function in the operating tool used or via HART command 42.
3. Check whether the current output at the current output corresponds to the low alarm (≤ 3.6 mA). See the following diagram.

58% of dangerous, undetected failures are detected using this test (proof test coverage, PTC = 0.58). Test sequence C is not permitted for a commissioning test.



7 Current pattern during proof test C

A 20 mA
B 4 mA
C ≤ 3.6 mA
1 Operation
2 Transmitter restart (via HART or plug-in display)
3 Low alarm test
4 Operation

NOTICE

For test sequences A, B, C: the plug-in display can only be used in conjunction with the head transmitter design! The influence of systematic errors on the safety function is not fully covered by the test. Systematic faults can be caused, for example, by medium properties, operating conditions, build-up or corrosion.

- Take measures to reduce systematic errors.
- If one of the test criteria from the test sequences described above is not fulfilled, the transmitter may no longer be used as part of a protective system.

Life cycle

Requirements for personnel

The personnel for installation, commissioning, diagnostics and maintenance must meet the following requirements:

- Trained, qualified specialists must have a relevant qualification for this specific function and task
- Are authorized by the plant owner/operator
- Are familiar with federal/national regulations
- Before starting work, read and understand the instructions in the manual and supplementary documentation as well as the certificates (depending on the application)
- Follow instructions and comply with basic conditions

The operating personnel must meet the following requirements:

- Are instructed and authorized according to the requirements of the task by the facility's owner-operator.
- Follow the instructions in this manual.

Installation

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

Commissioning

The commissioning of the device is described in the Operating Instructions pertaining to the device. A commissioning check must be performed before operating the device in a safety system.

Operation

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

Maintenance

Maintenance instructions are provided in the Operating Instructions associated with the device. Alternative monitoring measures must be taken to ensure process safety during configuration, proof-testing and maintenance work on the device.

Repair

The following components may be replaced by the customer's technical staff if genuine spare parts are used and the appropriate installation instructions are followed:

Component	Checking the device after repair
Display	Visual inspection as to whether all the parts are present and mounted correctly and whether the device is in a proper condition.
Housing cover	
Seal kits for housing covers	
Safety clamps, housing	

The replaced component must be sent to the manufacturer for the purpose of fault analysis if the device has been operated in a protective system and a device error cannot be ruled out. In this case, always enclose the "Declaration of Hazardous Material and Decontamination" with the note "Used as SIL device in protection system" when returning the defective device. Please refer to the "Return" section in the Operating Instructions.

Modification

Modifications are changes to SIL devices that are already delivered or installed. Modifications to SIL devices are usually performed in the manufacturing center. Modifications to SIL devices on site at the user's premises are possible if approved beforehand by the manufacturer. In this case, the modifications must be performed and documented by a service technician of the manufacturer.

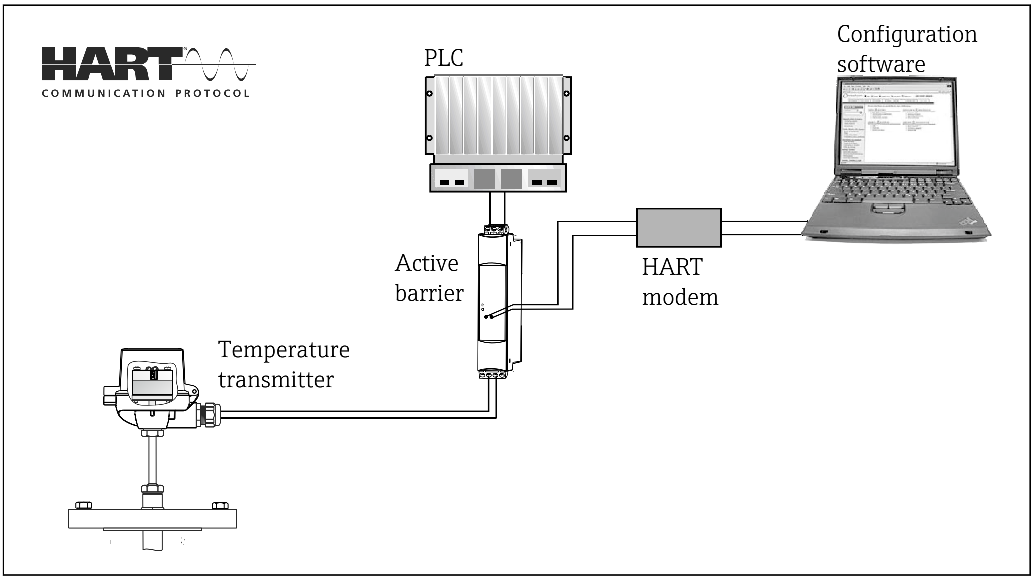
NOTICE

- Modifications to SIL devices by the user are not permitted.

Appendix

Structure of the measuring system

The measuring system's devices are displayed in the following diagram (example).



8 *Device architecture for HART® communication. The safety-related descriptions in this document refer exclusively to the transmitter, and not the entire measuring point.*

An analog signal (4 to 20 mA), which is proportional to the sensor value, is generated in the transmitter and relayed to a downstream logic unit (e.g. PLC, limit signal switch) where it is monitored to ascertain whether it exceeds or drops below a predefined limit value. For fault monitoring, the logic unit must recognize both high alarms (≥ 21.0 mA) and low alarms (≤ 3.6 mA).

NOTICE

- The optional attachable display is not part of the safety function. Neither the hardware nor the software of the display have a verifiable influence on the defined safety functions of the transmitter. The CDI interface is not safe and therefore may not be used in safety-related applications. The interface cannot be used for the safe parameterization of the system.

Measurement function

The following connection versions and functional possibilities of the transmitter can be used for the SIL mode as part of a safety function: [1)]

Sensor input 2	Sensor input 1		
	RTD or resistance transmitter, 3-wire	RTD or resistance transmitter, 4-wire	Thermocouple (TC), voltage transmitter, always 2-wire
RTD or resistance transmitter, 3-wire	☑	-	☑
Thermocouple (TC), voltage transmitter	☑	☑	☑
Inactive	☑	☑	☑

1) Two-wire resistance sensors are not supported in the SIL mode.

NOTICE

Galvanic isolation

▶ When two sensors are connected to the transmitter, make sure the sensors are galvanically isolated from one another.

Two-channel functions

Two sensors can be connected to the transmitter and the transmitter can be operated in the following safe functions:

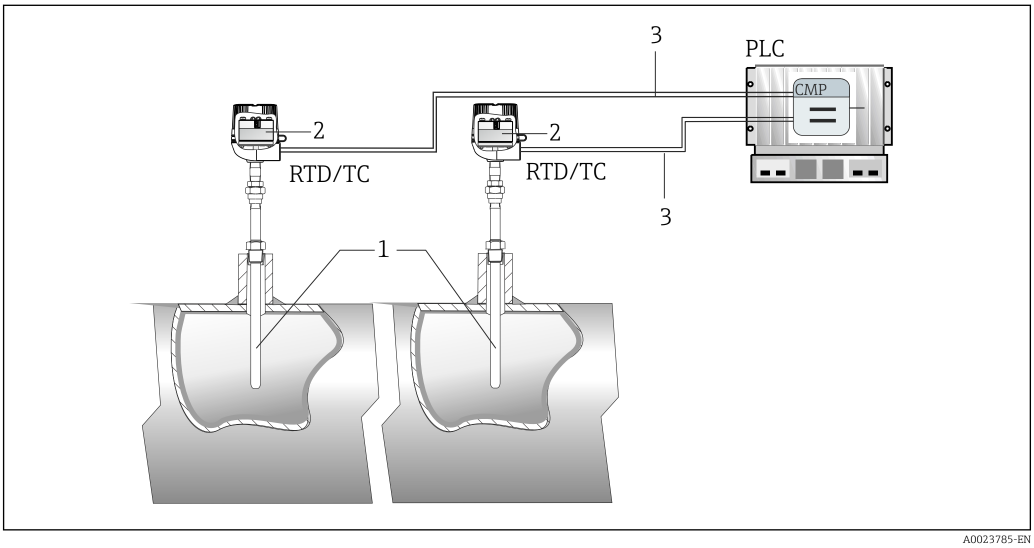
- Two independent measurements:
  Here, two (possibly different) sensors are connected to the transmitter, e.g. TC and 3-wire RTD. The two measuring channels can be used for safety-related functions.
- **Averaging** function:
  The measured values M1, M2 of the two sensors are output as an arithmetic 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.
  Therefore the following types of sensor are 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.

The measured values can be transmitted via the 4 to 20 mA signal.



9 Example with current output at the first and at the second transmitter. PCS voting of the two sensor values: SIL 3

1 2 temperature sensors
2 2 temperature transmitters
3 4 to 20 mA current output

Commissioning or proof test report

Company / contact person	/
Tester	

Device information	
Facility	Measuring point/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 of customer	Signature of tester

Type of safety function
☐ Limit value monitoring MIN ☐ Limit value monitoring MAX ☐ Safe measurement

Commissioning / proof test
☐ Test sequence A ☐ Test sequence B ☐ Test sequence C ☐ Commissioning

Proof test report			
Test step	Set point	Actual value	Passed
1. Lower range value adjustment			☐ Passed ☐ Failed
2. Upper range value adjustment			☐ Passed ☐ Failed
3. Current value alarm			☐ Passed ☐ Failed
4a. Restart via HART			☐ Passed ☐ Failed
4b. Restart via plug-in display			☐ Passed ☐ Failed

Comment:

Parameter settings for safe parameterization

Parameter name	Factory setting	Set value	Tested
Lower measuring range (4 mA)	0		
Upper measuring range (20 mA)	100		
Out of range category	Maintenance required (M)		
Sensor type 1	Pt100 IEC60751		
Sensor type 2	No sensor		
Upper sensor limit 1 [1)]	+850 °C		
Lower sensor limit 1 [1)]	−200 °C		
Upper sensor limit 2 [1)]	-		
Lower sensor limit 2 [1)]	-		
Sensor offset 1	0		
Sensor offset 2	0		
Connection type 1	4-wire (RTD)		
Connection type 2	2-wire (TC)		
Reference junction 1,2	Internal measurement (TC)		
RJ preset value 1,2	0 (for setting **preset value**)		
Call./v. Dusen coeff. A, B and C sensor 1 [1)]	A: 3.910000e-003 B: -5.780000e-007 C: -5.780000e-007		
Call./v. Dusen coeff. A, B and C sensor 2 [1)]	A: 3.910000e-003 B: -5.780000e-007 C: -5.780000e-007		
Call./v. Dusen coeff. R0 sensor 1 [1)]	100 Ω		
Call./v. Dusen coeff. R0 sensor 2 [1)]	100 Ω		
Polynomial coeff. A, B sensor 1 [1)]	A = 5.49630e-003		
Polynomial coeff. A, B sensor 2 [1)]	B = 5.49630e-003		
Polynomial coeff. R0 sensor 1 [1)]	100 Ω		
Polynomial coeff. R0 sensor 2 [1)]	100 Ω		
Unit	°C		
Mains filter	50 Hz		
Drift/difference mode	Off		
Drift/difference alarm category	Maintenance required (M)		
Drift/difference set point	999		
SIL HART mode	HART active		
SIL startup mode	Active		
Assign current output (PV)	Sensor 1		
Assign SV	Device temperature		
Assign TV	Sensor 1		
Assign QV	Sensor 1		

1) Only for Call./v. Dusen or polynomial Cu/Ni sensors

Other

Parameters and default settings for safe parameterization

Parameters and default settings for safe parameterization	
Firmware version	Use this function to view the device firmware version installed. Max. 6-digit character string in the format xx.yy.zz. The firmware version that is currently valid can be taken from the nameplate or the Operating Instructions associated with the device.
Serial number	Use this function to display the serial number of the device. It can also be found on the nameplate. Max. 11-digit character string comprising letters and numbers.
Enter access code	Use this function to enable the service parameters via the operating tool. Factory setting: **0**
Device reset	Use this function to reset the device configuration - either entirely or in part - to a defined state. Factory setting: **not active**
Hardware revision	Use this function to display the hardware revision of the device.
Simulation current output	Use this function to switch simulation of the current output on and off. The display alternates between the measured value and a diagnostics message of the "function check" category (C) while simulation is in progress. Factory setting: **off** (cannot be changed in safe parameterization)
Value simulation current output	Use this function to set a current value for the simulation. In this way, users can verify the correct adjustment of the current output and the correct function of downstream switching units. Factory setting: **3.58 mA** (cannot be changed in safe parameterization)
Current trimming 20 mA	Use this function to set the correction value for the current output at the end of the measuring range at 20 mA . Factory setting: **20.000 mA** (cannot be changed in safe parameterization)
Current trimming 4 mA	Use this function to set the correction value for the current output at the start of the measuring range at 4 mA . Factory setting: **4 mA** (cannot be changed in safe parameterization)
Lower range value	Use this function to assign a measured value to the current value 4 mA. Factory setting: **0**
Upper range value	Use this function to assign a measured value to the current value 20 mA. Factory setting: **100**
Failure current	Use this function to set the value the current output adopts in an alarm condition. SIL mode: **3.58 mA** (cannot be changed in safe parameterization)
Failure mode	Use this function to select the signal on alarm level of the current output in the event of an error. Factory setting: **min** (cannot be changed in safe parameterization)
Out of range category	Use this function to select the category (status signal) as to how the device reacts when the value is outside the set measuring range. Factory setting: **maintenance required (M)**
Minimum span	A span is the difference between the temperature at 4 mA and 20 mA. The minimum span is the minimum permitted setting or the setting that makes sense for a sensor type with this difference in the transmitter.
HART® address	Definition of the HART® address of the device. Factory setting: **0** (cannot be changed in safe parameterization)
Device revision	Use this function to view the device revision with which the device is registered with the HART® Communication Foundation. It is needed to assign the appropriate device description file (DD) to the device. Factory setting: **2** (fixed value)
Measuring mode	Possibility of inverting the output signal. Options: standard (4 to 20 mA) or inverse (20 to 4 mA). Factory setting: **standard** (cannot be changed in safe parameterization)

Parameters and default settings for safe parameterization	
Sensor type n	Use this function to select the sensor type for the sensor input n in question: ▪ Sensor type 1: settings for sensor input 1 ▪ Sensor type 2: settings for sensor input 2 Factory setting: ▪ **Sensor type 1: Pt100 IEC751** ▪ **Sensor type 2: no sensor**
Sensor n upper limit	Displays the maximum physical full scale value. Factory setting: ▪ For sensor type 1 = Pt100 IEC751: **+850 °C (+1 562 °F)** ▪ Sensor type 2 = no sensor
Sensor n lower limit	Displays the minimum physical full scale value. Factory setting: ▪ For sensor type 1 = Pt100 IEC751: **−200 °C (−328 °F)** ▪ Sensor type 2 = no sensor
Sensor offset n	Use this function to set the zero point correction (offset) of the sensor measured value. The value indicated is added to the measured value. Factory setting: **0.0**
Connection type n	Use this function to select the connection type for the sensor. Factory setting: ▪ Sensor 1 (connection type 1): **4-wire** ▪ Sensor 2 (connection type 2): **2-wire**
Reference junction n	Use this function to select reference junction measurement for temperature compensation of thermocouples (TC). Factory setting: **Internal measurement**
RJ preset value n	Use this function to define the fixed preset value for temperature compensation. The **Preset value** parameter must be set if the **Reference junction n** option is selected. Factory setting: **0.00**
Call./v. Dusen coeff. A, B and C	Use this function to set the coefficients for sensor linearization based on the Callendar/Van Dusen method. Prerequisite: the RTD platinum (Callendar/Van Dusen) option is enabled in the **Sensor type** parameter. Factory setting: ▪ **Coefficient A: 3.910000e-003** ▪ **Coefficient B: -5.780000e-007** ▪ **Coefficient C: -4.180000e-012**
Call./v. Dusen coeff. R0	Use this function to set the R0 Value only for linearization with the Callendar/Van Dusen polynomial. Prerequisite: the RTD platinum (Callendar/Van Dusen) option is enabled in the **Sensor type** parameter. Factory setting: **100 Ω**
Polynomial coeff. A, B	Use this function to set the coefficients for sensor linearization of copper/nickel resistance thermometers. Prerequisite: The RTD poly nickel or RTD copper polynomial option is enabled in the **Sensor type** parameter. Factory setting: ▪ **Polynomial coeff. A = 5.49630e-003** ▪ **Polynomial coeff. B = 6.75560e-006**

Parameters and default settings for safe parameterization	
Polynomial coeff. R0	Use this function to set the R0 Value only for linearization of nickel/ copper sensors. Prerequisite: The RTD poly nickel or RTD copper polynomial option is enabled in the **Sensor type** parameter. Factory setting: **100 Ω**
Sensor trimming	Use this function to select the linearization method to be used for the connected sensor. Factory setting: **FactoryTrim** (cannot be changed in safe parameterization)
Unit	Use this function to select the engineering unit for all the measured values. Factory setting: **°C**
Mains filter	Use this function to select the mains filter for A/D conversion. Factory setting: **50 Hz**
Drift/difference mode	Use this function to choose whether the device reacts to the drift/ difference limit value being exceeded or undershot. Can only be selected for 2-channel operation. Factory setting: **Off**
Drift/difference alarm category	Use this function to select the category (status signal) as to how the device reacts when a drift/difference is detected between sensor 1 and sensor 2. Prerequisite: The **Drift/difference mode** parameter must be activated with the **Out band (drift)** or **In band** option. Factory setting: **Maintenance required (M)**
Drift/difference set point	Use this function to configure the maximum permissible measured value deviation between sensor 1 and sensor 2 which results in drift/difference detection. Prerequisite: The **Drift/difference mode** parameter must be activated with the **Out band (drift)** or **In band** option. Factory setting: **999.0**
Drift/difference alarm delay	Alarm delay for drift detection monitoring. Prerequisite: The **Drift/difference mode** parameter must be activated with the **Out band (drift)** or **In band** option. Factory setting: **0 s** (cannot be changed in safe parameterization)
Device temperature alarm	Use this function to select the category (status signal) as to how the device reacts when the electronics temperature of the transmitter is exceeded or undershot < −40 °C (−40 °F) or > +82 °C (+180 °F) Factory setting: **Failure (F)** (cannot be changed in safe parameterization)
SIL HART mode	Setting for HART® communication in the SIL mode. The setting **HART not active in SIL mode** disables HART® communication in the SIL mode (only 4 to 20 mA communication is active). Factory setting: **HART active in SIL mode**
SIL startup mode	Setting for repeated automatic device startup in the SIL mode, e.g. after a power-cycle. Factory setting: **Active**

Parameters and default settings for safe parameterization	
Force safe state	During the commissioning or proof test, this parameter is used to test error detection and the safe state of the device. Prerequisite: The **Operational state** parameter displays **SIL mode active**. Factory setting: **Off**
Assign current output (PV)	Use this function to assign a measured variable to the primary HART® value (PV). Factory setting: **Sensor 1**
Assign SV	Use this function to assign a measured variable to the secondary HART® value (SV) Factory setting: **Device temperature**
Assign TV	Use this function to assign a measured variable to the tertiary HART® value (TV). Factory setting: **Sensor 1**
Assign QV	Use this function to assign a measured variable to the quaternary HART® value (QV). Factory setting: **Sensor 1**
Damping	Use this function to set the time constant for current output damping. Factory setting: **0.00 s** (cannot be changed in safe parameterization)
Burst mode	Activation of the HART® burst mode for burst message X. Message 1 has the highest priority, message 2 the second-highest priority, etc. Factory setting: **Off** (cannot be changed in safe parameterization)

Use as a safe measuring system

The temperature transmitter must be combined with a suitable sensor to implement a safe measuring system. The code numbers required for the system design must be taken from the following tables.

Single channel operation

	λ_{du}	λ_{dd}	λ_{su}	λ_{sd}	SFF	PFD_{avg}	Device type
Transmitter	40.0 FIT	258.0 FIT	129.0 FIT	4.0 FIT	91%	1.8E-04	B

Sensor elements (thermocouple / resistance thermometer)

	closed coupled, low stress		closed coupled, high stress		extention wire, low stress		extention wire, high stress		Device type
	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	
Thermocouple	94%	2.6E-05	94%	5.2E-04	89%	4.8E-04	89%	9.5E-03	A
RTD 3-wire	81%	3.9E-05	81%	7.9E-04	79%	4.3E-04	79%	8.7E-03	A
RTD 4-wire	94%	1.2E-05	94%	1.2E-05	94%	1.4E-04	94%	2.8E-03	A

Sensor combined with transmitter (validation type B)

	closed coupled, low stress		closed coupled, high stress		extention wire, low stress		extention wire, high stress		Device type
Transmitter + Thermocouple	SIL2	2.0E-04	SIL2	7.0E-04	SIL2	6.5E-04	SIL1	9.7E-03	B
Transmitter + RTD 3-wire	SIL2	2.1E-04	SIL2	9.7E-04	SIL2	6.1E-04	SIL1	8.8E-03	B
Transmitter + RTD 4-wire	SIL2	1.9E-04	SIL2	1.9E-04	SIL2	3.2E-04	SIL1	3.0E-03	B

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

PFD_{avg}
- (green) $< 2.5 \times 10^{-3}$
- (yellow) $> 2.5 \times 10^{-3}$
- (red) $> 1 \times 10^{-2}$

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Two channel operation

	λ_{du}	λ_{dd}	λ_{su}	λ_{sd}	SFF	PFD$_{avg}$	Device type
Transmitter	40.0 FIT	258.0 FIT	129.0 FIT	4.0 FIT	91%	1.8E-04	B

Sensor elements (thermocouple / resistance thermometer)

	closed coupled				extention wire					
	low stress		high stress		low stress		high stress			
	SFF	PFD$_{avg}$	SFF	PFD$_{avg}$	SFF	PFD$_{avg}$	SFF	PFD$_{avg}$		Device type
2 x TC	95%	4.8E-05	98%	3.3E-04	91%	7.6E-04	91%	1.5E-02	w/o diagnostics	A
	95%	4.4E-05	99%	2.5E-04	94%	5.4E-04	94%	1.1E-02	with diagnostics	A
2 x RTD 3-wire	89%	4.5E-05	89%	9.0E-04	88%	4.9E-04	88%	9.8E-03	w/o diagnostics	A
	98%	7.2E-06	98%	1.4E-04	98%	7.5E-05	98%	1.5E-03	with diagnostics	A
TC + RTD 3-wire	95%	3.2E-05	95%	6.3E-04	92%	5.4E-04	92%	1.1E-02	w/o diagnostics	A
	96%	2.7E-05	96%	5.4E-04	95%	3.2E-04	95%	6.3E-03	with diagnostics	A

Sensor combined with transmitter (validation type B)

Transmitter + 2 x TC	SIL2	2.2E-04	SIL2	5.1E-04	SIL2	9.3E-04	SIL1	1.5E-02	w/o diagnostics	B
		2.2E-04	SIL2	4.2E-04		7.1E-04		1.1E-02	with diagnostics	B
Transmitter + 2 x RTD 3-wire	SIL2	2.2E-04	SIL2	1.1E-03	SIL2	6.7E-04	SIL1	1.0E-02	w/o diagnostics	B
		1.8E-04	SIL2	3.2E-04		2.5E-04		1.7E-03	with diagnostics	B
Transmitter + TC + RTD 3-wire	SIL2	2.1E-04	SIL2	8.1E-04	SIL2	7.1E-04	SIL1	1.1E-02	w/o diagnostics	B
		2.0E-04	SIL2	7.2E-04		4.9E-04		6.5E-03	with diagnostics	B

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- Low stress: < ⅔ utilization of the maximum permissible thermometer acceleration
- High stress: > ⅔ utilization of the maximum permissible thermometer acceleration
- Closed coupled: < 30 cm
- Extension wire: > 30 cm
- Diagnostics: sensor drift

Assignment of code numbers to parameters

Kennzahl (de)/ Integer value (en)	Parameter (de)	Parameterwert (de)	Parameter (en)	Parameter value (en)
8	Bereichsverletzung Kategorie	Außerhalb der Spezifikation (S)	Out of range category	Out of specification (S)
4		Wartungsbedarf (M)		Maintenance required (M)
1		Ausfall (F)		Failure (F)
12	Sensortyp	Pt100 IEC60751, a=0.00385 (1)	Sensor type	Pt100 IEC60751, a=0.00385 (1)
13		Pt200 IEC60751, a=0.00385 (2)		Pt200 IEC60751, a=0.00385 (2)
14		Pt500 IEC60751, a=0.00385 (3)		Pt500 IEC60751, a=0.00385 (3)
15		Pt1000 IEC60751, a=0.00385 (4)		Pt1000 IEC60751, a=0.00385 (4)
22		Pt100 JIS C1604, a=0.003916 (5)		Pt100 JIS C1604, a=0.003916 (5)
72		Ni100 DIN 43760, a=0.00618 (6)		Ni100 DIN 43760, a=0.00618 (6)
73		Ni120 DIN 43760, a=0.00618 (7)		Ni120 DIN 43760, a=0.00618 (7)
248		Ni100 OIML/GOST 6651-09, a=0.00617 (12)		Ni100 OIML/GOST 6651-09, a=0.00617 (12)
249		Ni120 OIML/GOST 6651-09, a=0.00617 (13)		Ni120 OIML/GOST 6651-09, a=0.00617 (13)
246		Typ A (W5Re-W20Re) IEC60584-2013 (30)		Type A (W5Re-W20Re) IEC60584-2013 (30)
131		Typ B (PtRh30-PtRh6) IEC60584 (31)		Type B (PtRh30-PtRh6) IEC60584 (31)
132		Typ C (W5Re-W26Re) IEC60584 (32)		Type C (W5Re-W26Re) IEC60584 (32)
133		Typ D (W3Re-W25Re) ASTM E988-96 (33)		Type D (W3Re-W25Re) ASTM E988-96 (33)
134		Typ E (NiCr-CuNi) IEC60584 (34)		Type E (NiCr-CuNi) IEC60584 (34)
136		Typ J (Fe-CuNi) IEC60584 (35)		Type J (Fe-CuNi) IEC60584 (35)
137		Typ K (NiCr-Ni) IEC60584 (36)		Type K (NiCr-Ni) IEC60584 (36)
138		Typ N (NiCrSi-NiSi) IEC60584 (37)		Type N (NiCrSi-NiSi) IEC60584 (37)
139		Typ R (PtRh13-Pt) IEC60584 (38)		Type R (PtRh13-Pt) IEC60584 (38)
140		Typ S (PtRh10-Pt) IEC60584 (39)		Type S (PtRh10-Pt) IEC60584 (39)
141		Typ T (Cu-CuNi) IEC60584 (40)		Type T (Cu-CuNi) IEC60584 (40)
142		Typ L (Fe-CuNi) DIN43710 (41)		Type L (Fe-CuNi) DIN43710 (41)
148		Typ L (NiCr-CuNi) GOST R8.8585-01 (43)		Type L (NiCr-CuNi) GOST R8.8585-01 (43)
143		Type U (Cu-CuNi) DIN43710 (42)		Type U (Cu-CuNi) DIN43710 (42)
241		Pt50 GOST 6651-94, a=0.00391 (8)		Pt50 GOST 6651-94, a=0.00391 (8)
242		Pt100 GOST 6651-94, a=0.00391 (9)		Pt100 GOST 6651-94, a=0.00391 (9)
243		Cu50 GOST 6651-09, a=0.00428 (10)		Cu50 GOST 6651-09, a=0.00428 (10)
105		Cu100 OIML/GOST 6651-09, a=0.00428 (11)		Cu100 OIML/GOST 6651-09, a=0.00428 (11)
244		Cu50 OIML R84:2003, a=0.00428 (10)		Cu50 OIML R84:2003, a=0.00428 (10)
245		Cu50 OIML/GOST 6651-94, a=0,00426 (14)		Cu50 OIML/GOST 6651-94, a=0,00426 (14)
3		RTD Platin (Callendar/van Dusen)		RTD Platinium (Callendar/van Dusen)
240		RTD Poly Nickel (OIML R84, GOST 6651-94)		RTD Poly Nickel (OIML R84, GOST 6651-94)
247		RTD Polynom Kupfer (OIML R84:2003)		RTD Polynomial Copper (OIML R84:2003)
1		10...400 Ohm		10...400 Ohm
2		10...2000 Ohm		10...2000 Ohm
129		-20...100 mV		-20...100 mV
251		Kein Sensor		No Sensor
2	Anschlussart	2- Leiter	Connection type	2- wire
3		3- Leiter		3- wire
4		4- Leiter		4- wire
0	Vergleichsstelle	Keine Kompensation	Reference junction	No compensation
1		Interne Messung		Internal measurement
3		Vorgabewert		Fixed Value
4		Wert Sensor 2		Sensor 2 value
32	Einheit	°C	Unit	°C
33		°F		°F
35		K		K
34		°R		°R
37		Ohm		Ohm
36		mV		mV
0	Netzfrequenzfilter	50 Hz	Mains filter	50 Hz
1		60 Hz		60 Hz
12	Drift/Differenz-überwachung	Aus	Drift/difference mode	Off
0		Überschreitung (Drift)		Out band (drift)
1		Unterschreitung		In band
0	SIL HART Modus	HART im SIL Mode nicht aktiviert	SIL HART mode	HART disabled in SIL mode
1		HART im SIL Mode aktiviert		HART enabled in SIL mode
0	SIL Startup Modus	Deaktiviert	SIL startup mode	Disabled
1		Aktiviert		Enabled
0	Zuordnung Stromausgang (PV, SV, TV, QV)	Sensor 1	Assign current output (PV, SV, TV, QV)	Sensor 1
1		Sensor 2		Sensor 2
2		Gerätetemperatur		Device temperature
3		Mittelwert		Average
4		Differenz		Difference
5		Sensor 1 (Backup Sensor 2)		Sensor 1 (Backup Sensor 2)
6		Sensorumschaltung		Sensor switching
7		Mittelwert mit Backup		Average with backup

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Version history

Version	changes	Valid as of firmware version
SD01361O/09/EN/01.14	Initial version	01.01.00
SD01361O/09/EN/02.15	Revised version	01.01.08

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