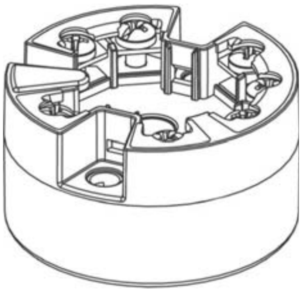
Instruction

MI 020-584
November 2014

2-Channel Temperature Transmitter RTT80, HART® Protocol

Functional Safety Manual



SIL
Safety Integrity Level

Application
Operation is safety-related system in accordance with the requirements of IEC 61508, ed. 2.0.

The device meets the following requirements:

- Functional safety in accordance with IEC 61508, ed. 2.0
- Explosion protection
- Electromagnetic compatibility in accordance with the EN
- 61326 Series and NAMUR Recommendation NE21
- Electrical safety in accordance with IEC/EN 61010-1
- IP20 ingress protection (protection class) in accordance with DIN EN 60529 - head transmitter module only

Your Benefits

- Can be used for measuring points with one sensor or two sensors up to SIL 2
- Creation of two measuring points up to SIL 3
- Functional Safety Assessment by TÜV Süd in accordance with IEC 61508, ed. 2.0
- Permanent self-monitoring
- Permanent monitoring

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1. Hardware and Software Configuration

This manual applies to the following device versions with the following hardware and software versions and higher:

Valid Hardware Version	Head transmitter: 01.00.06 or higher
Valid Firmware/Software Version	Head transmitter: 01.01.00 or higher

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

All versions can be displayed via an operating unit or via the optional display of the head transmitter (unsafe). Please refer to the Operating Instructions for the device for a definition of the version information displayed. When the device is operated in the SIL mode, the system checks the versions itself and denies measurement if not all the versions are correct.

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

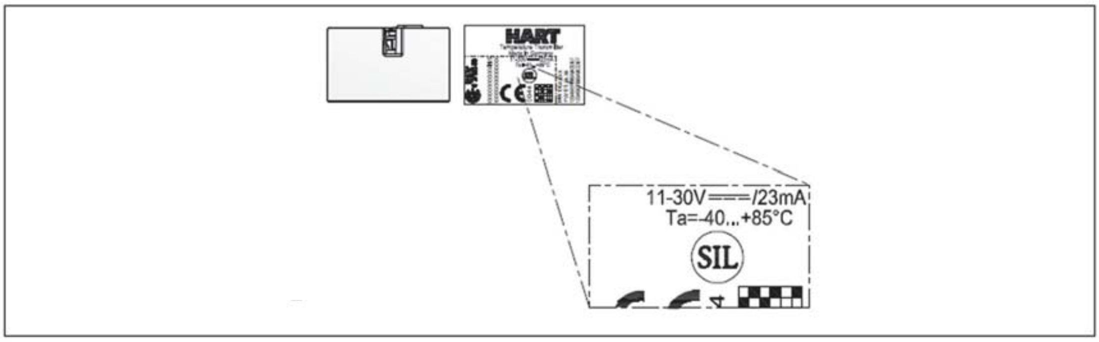

Figure 1. Identifying the Device with the SIL Mode Option(1)

NOTE
When modifying the transmitter the manufacturer applies a change process that complies with IEC 61508, ed. 2.0.

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(1) SIL logo on the exemplary nameplate of the head transmitter version.

2. Definitions

Designation	Meaning
Defined measuring range/**permitted operating temperature range** or **interval (TR)**, different for every sensor element	Maximum range in which a sensor element is defined (see corresponding standard for element) and can be used as measuring equipment (i.e. manufacturer restrictions).
Transmitter measuring range limits / r**estricted operating temperature range (rOTR)**, different for every sensor element	A restriction of the transmitter system. The limits are within the **interval (TR)** for the most part.
Restricted **safety operating temperature range (rSOTR)**, different for every sensor element	Permitted measuring range for use as a safety system, forming the basis for calculations for total safety accuracy ratings. The temperature range is within the **rOTR** for the most part.
Span of the current output	Difference between the measured values (temperature, voltage or resistance) at 4 mA and 20 mA.
Current output limits of the current output	The measured values (e.g. temperature in °C, voltage or resistance) that are indicated at the current output for 4 mA or 20 mA.
Ambient temperature of the transmitter	Ambient temperature range in which the full functionality of the device is guaranteed. See Chapter 4, “Restrictions for the Safe Function”.
Supply voltage range of the transmitter	Voltage supplied to device at which the full functionality can be guaranteed. See Chapter 4, “Restrictions for the Safe Function”.
Base measuring range of the A/D converter raw measured value	The feasible range of raw data from the A/D converter. The base measuring ranges are: ▸ 10 to 400 Ω ▸ 10 to 2 000 Ω ▸ –20 to 100 mV
Long-term drift/drift, different for every sensor element	Behavior over lifetime, depends on the temperature and is usually given at 25 °C (77 °F).
Total safety accuracy	When measuring with the transmitter the total error that occurs from the transmitter input to the current output or HART® protocol. Effects such as temperature drift, voltage drift, measuring uncertainty, etc. are taken into consideration here.
SAF	Safety Function
RTD	Resistance Temperature Detector
TC	Thermocouple

3. Structure of the Measuring System, Measurement and Safety Function

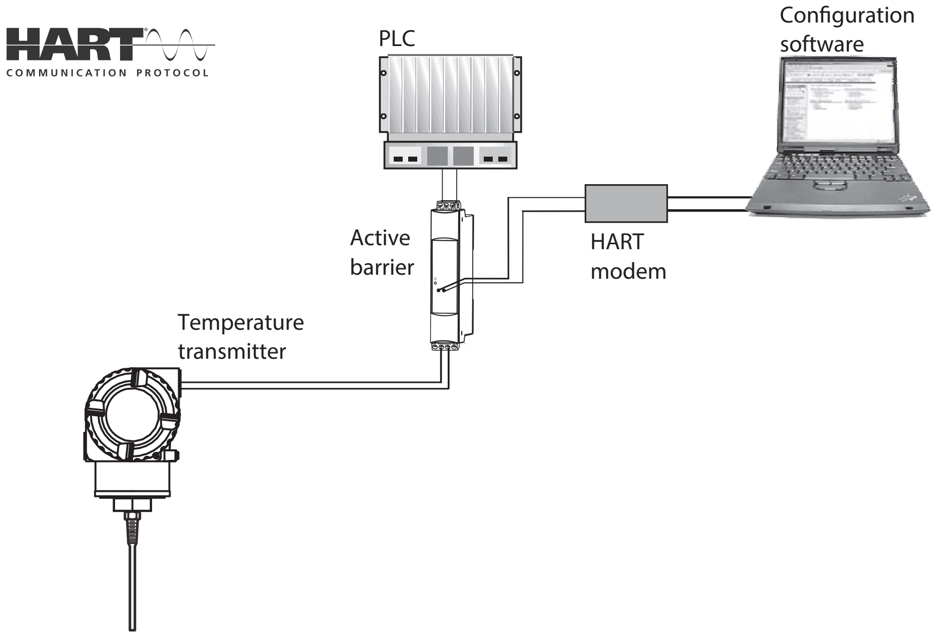

Figure 2. Device Architecture for HART® Communication

The safety-related descriptions in this document refer exclusively to the transmitter, and not the entire measuring point.

The transmitter generates an analog signal (4 to 20 mA) that is proportional to the measured voltage at the sensor. The signal must be processed by a logic component (e.g. a programmable logic controller according to SIL 2 or higher). This logic component might use actuators in order to fully implement the safety function.

The optional attachable display is not safe. For this reason all operations where the display is deployed as the user interface may not be used for safety-related procedures. Neither the hardware nor the software of the display have a verifiable influence on the defined safety functions of the device. **The DIP switches on the display are not relevant for the SIL system.**

The CDI interface is not safe and therefore may not be used in safety-related applications. The CDI service interface cannot be used for the safe parameterization of the system. See Chapter 7, “Operation and Parameterization”.

The transmitter is always an integral part of a complete safety function. The transmitter is a component that is in compliance with IEC 61508, ed. 2.0.

Measurement Functions

Versions of the Transmitter System and Sensors Permitted for the Safe Mode

NOTE

Not all the connection versions and possible functions of the transmitter in the normal measuring mode are approved for the SIL mode and can be used within the framework of a safety function. The function settings and versions that are permitted for the safe mode are listed in the following section.

The following connections combinations are possible when both sensor inputs are assigned:

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	☑	☑	☑

A pure resistance or voltage measurement can be used in the same safety-related manner as in the case of a measurement using just one RTD sensor or TC. 2-wire RTD sensors are not supported in the SIL mode. Only 3-wire or 4-wire RTD sensors are supported.

NOTE

The transmitter does not detect errors that are caused by shared cables (i.e. galvanic coupling)! For all the function settings of the transmitter with two sensors, an error that cannot be clearly assigned to one of the sensors or input channels will cause the failure of both sensors.

- If connecting two sensors to the transmitter make sure that both sensors are galvanically isolated from the terminals onwards, regardless of the 2-channel function that is configured!

NOTE

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

Two-Channel Functions

Two sensors can be connected to the transmitter. The transmitter can be operated in the following safe functions depending on whether the configuration in the SIL mode is safe (see the table above):

- 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. See “Displaying Values at the Transmitter Current Output” on page 14.

- Averaging function:

  Measured values M1, M2(1) of the two sensors are output as the arithmetic mean, i.e. (M1+M2)/2.

- Differential measurement function:

  The measured values M1, M2 of the two sensors are subtracted (M1-M2) and output.

- Backup function:

  The transmitter maintains the safe measuring mode as long as at least one functioning sensor is connected to one of the two sensor channels. If one of the sensor fails, the transmitter automatically switches to the other measuring channel. Here, the two sensors must be identical: only two 3-wire RTD sensors may be used as a backup, for instance. The sensor type must also be the same (e.g. Pt100). The backup function does not allow Pt100 and Pt1000 sensor types to be used at the same time. Therefore the following types of sensor are permitted in the SIL mode:

  - 2x thermocouple (TC)
  - 2x RTD, 3-wire

The backup function is therefore used to increase the availability or to improve diagnostics with regard to a "sensor drift" diagnostic event. See “Sensor Drift Diagnostic Event” on page 15.

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1. The sensors do not need to be identical. The specific application will dictate whether this function is feasible or not.

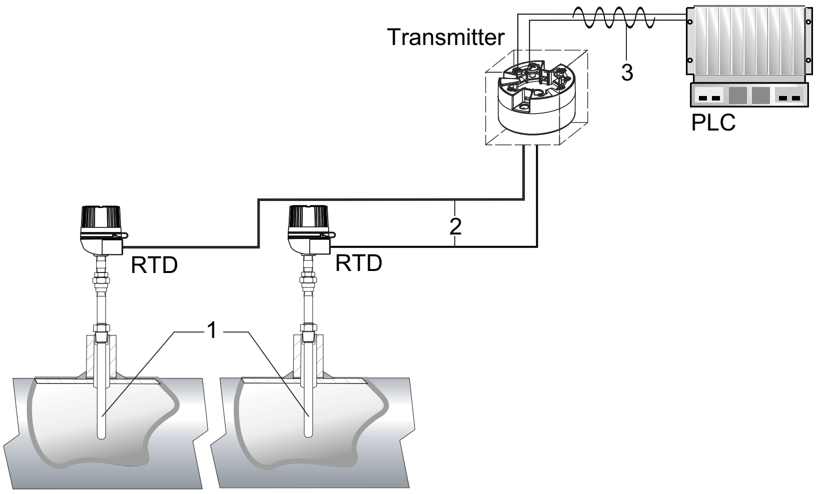

Figure 3. Sensor Connection to Transmitter for Backup Function

PCS - no voting, 1 or 2 safe measured values:

1: Identical temperature sensors (e.g. 2x RTD, 3-wire
2: Sensor signal cable
3: 4 to 20 mA output with HART® signal (not safe)

Displaying Values at the Transmitter Current Output

Only the measured value of one sensor can ever be displayed via the current output. You can configure which sensor's measured value is output at the current output. It is also possible to output the functions indicated above (e.g. the averaging or differential function) instead of the measured value.

SIL 3 Configuration When Using Two Temperature Transmitters

To be able to set up a SIL 3 measuring point, two temperature transmitters are used and one sensor is connected to one transmitter in each case. The measured values of the two transmitters are read in via a logic unit where they are evaluated using a safe voter. See Figure 4 on page 15.

Possibility for read-in:
Both measured values using the current output.

The choice of sensor dictates which deviations are permitted in these two SIL 2 sensor measuring chains, e.g. time offset of the measured values, deviation of the measured values themselves. This must be calculated accordingly and configured in the voter.

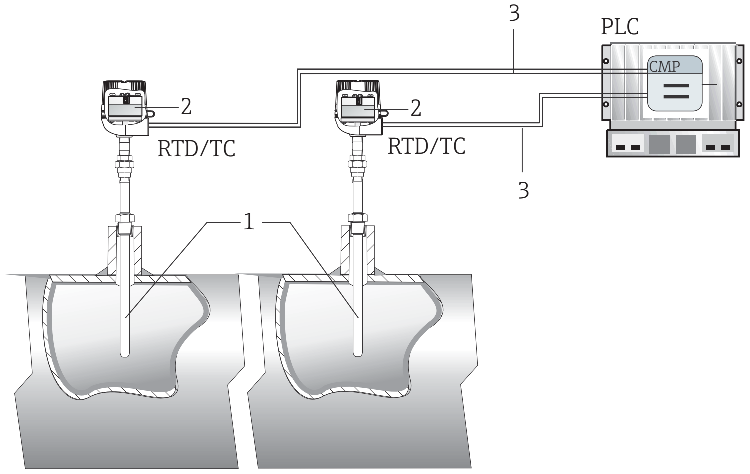

Figure 4. Example with Current Output at the First and at the Second Transmitter

PCS Voting of the Two Sensor Values: SIL 3

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

Sensor Drift Diagnostic Event

If redundant sensors are used, sensor drift detection can be performed, e.g. long-term drift if the sensor is used for a year. This is a diagnostic measure for the measuring chain as a whole, i.e. sensor with transmitter, and is made available by the transmitter as a safety-related diagnostic event. However the diagnosis is not relevant for the safety of the transmitter itself as the signal of the second sensor is used exclusively for this special diagnosis. The application dictates whether identical sensors are used here. If identical sensors are used, the **backup function** can also be used. Here it must be noted, however, that the error detection quality as regards the sensor drift can be affected as the two sensors are identical and can have a similar drift pattern.

The diagnostic coverage (DC) to be achieved must be calculated manually. Sensor drift diagnostics can be executed safely by the transmitter. It might be necessary to use the characteristic curves of the sensors from the standards for this purpose.

NOTE

In the following example the aim is to demonstrate that there are no common cause errors between the two sensors and their wiring. This could prove difficult for identical sensors, however. Identical sensors can cause the drift to have the same pattern. Drift diagnostics will not always be able to detect a drift for identical sensors. While the transmitter itself is a common cause, the self-tests it performs detect these errors automatically and therefore the transmitter can be ignored in this case. All errors that can cause one of the sensors to fail on account of the operating conditions must be recorded. For each of these errors it is necessary to determine the probability of the occurrence of deviation ΔT per time unit. This information must be used to make the setting for ΔT with regard to diagnostics performed by the transmitter. The accuracy of the individual values must be taken into consideration here (see “Precision and Timing of SAF 1 and SAF 2” on page 20). The drift differential limit value that is set should be at least twice the value for the total safety accuracy (TSA).

Example: the drift is 0 (not the drift of the transmitter) if no error occurs in one of the sensors. If there is a 90% probability of an error of ±10.0 K per year occurring for each of the sensors used, the drift caused by the transmitter is 2.0 K per year and the TSA per sensor is 5.0 K, it is advisable to set the drift limit at 10.0 K. Therefore there is a 90% probability of detecting this error. **As these detailed data are usually not available, it is advisable to select the value as TSA1 + TSA2, i.e. the sum of the total safety accuracy ratings of the two sensors deployed.**

Furthermore, for redundant measurement there is a configurable limit ΔT in Kelvin, which can be set as required in increments of 0.1 K in the interval range 1.0 to 999.0 K. The factory setting is **999.0 K**. If the drift difference exceeds this limit for longer than the set time (0 to 255 s), the system adopts the active safe state as it is not possible to determine which sensor has the drift.

NOTE

Only the drift difference between the two sensors can be measured. If the two sensors drift in a uniform manner, this is not detected by this diagnostic event.

This application does not increase the availability as sensor switchover between the redundant sensors is not configured. If a sensor fails, the entire system stops. This also applies if two identical sensors are used in a backup function. The drift for a type-B thermocouple sensor can be up to 38 K per year, for example.

HART® Configuration

NOTE

Measured value transmission via HART® protocol is not safe in SIL-Mode.

After switching to the SIL mode, the following configurations are possible in the operating phase with regard to HART®:

- No HART® communication, only current output is active → modem in the transmitter is switched off.
- HART® communication (unsafe) → modem in the transmitter is active.

NOTE

To improve the accuracy at the current output, it is advisable to always use a HART® filter at the current output in the SIL mode.

The transmitter can also be used in the SIL mode without a HART® filter and with an active HART® modem or HART® measured values. Please ensure that the additional "errors" (max. ±.6 mA at the current output) are taken into consideration by the HART® messages when the measured values are evaluated.

Use as Safety-Related System

The temperature transmitter and a sensor supported by the transmitter for safety functions are needed to be able to use the safety-related system. The transmitter must be connected to a safe PLC via the analog current output. The transmitter signal can then be processed directly in the safe PLC. The PCS (logic component) must be able to process LOW alarms and HIGH alarms.

NOTE

The safety functions are only active if the transmitter is in the SIL measuring mode. If the system is not switched to the SIL measuring mode it is not safe and therefore does not perform any safety functions.

System Operating Modes	Functions
Normal mode (= unsafe measuring mode)	The system works like a temperature transmitter without the SIL mode. It does **not perform any** safety-related functions and cannot be used in a safety chain in this mode!
Safe measuring mode (= SIL mode or SIL measuring mode)	The system performs the safety function. Only in this mode, the system functions in a safe manner. To be able to enable this mode, the system must have been configured correctly via safe parameterization.
SIL mode – active safe state	In the active safe state, the system generates the error current (always LOW alarm). The system waits for a reboot.

Safety Functions

Safety Requirements and Boundary Conditions

The safe output values at the current output are always supplied in accordance with NAMUR NE43.

The device has several safety functions:

- SAF 1: limit value monitoring
- SAF 2: safe measurement
- SAF 3: safe parameterization (see “Safe Parameterization” on page 33)

NOTE

None of the safety functions takes into consideration the physical or chemical effects of medium on the sensor element, and therefore on the measured value, caused by the medium coming into contact with the sensor. This means that in terms of safety functions in this manual the accuracy is indicated as a precision as per DIN 55350-13!

- Assess physical and chemical effects of the medium on the measured value in the individual application yourself.

NOTE

To be able to use the safety functions, the device must be set to the safe SIL mode using an operating tool. For this purpose the system must be parameterized safely (SAF 3) and set to the SIL mode. See“Switching to the SIL Mode” on page 45. In the safe SIL measuring mode the device is able to run safety functions SAF 1 and SAF 2.

Unless otherwise indicated, the comments, notices, restrictions etc. in this manual refer to safety functions SAF 1 and SAF 2. SAF 3 is a special safety function which, in contrast to SAF 1/SAF 2, is only used to prepare for SAF 1/SAF 2 and therefore does not need to be executed continuously by the device.

All the safety functions can be used with all the sensor configurations in the '**Structure of the measuring system**' (see page 11) section. Please note that only the measured value of one sensor can ever be output at the current output. SAF 1 can be set separately for both sensors. The safety functions (SAF 1 or SAF 2 for each sensor) do not mutually influence one another!

Safety Function 1 (SAF 1) - Limit Value Monitoring

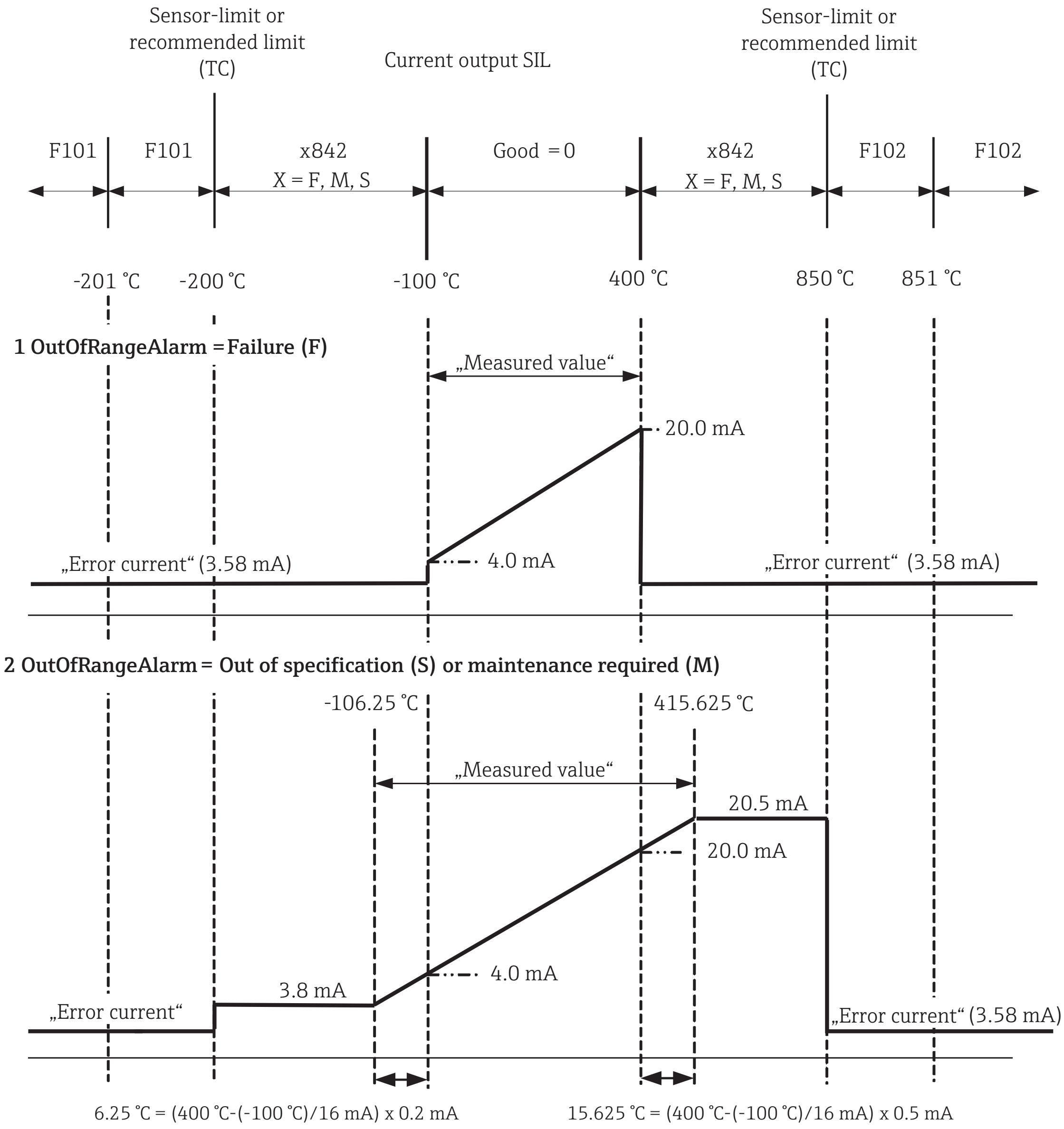

Figure 5. Monitoring of the Measured Value

In the SIL Mode, an error current is output in the event of a measurement outside a user-defined temperature interval [I_{min} to I_{max}]. Instead of an interval it is also possible to define either only an upper limit value or only a lower limit value. In this case, the other limit value is equal to the possible minimum (= 4.0 mA) or maximum (= 20.0 mA) measured value. Here for example: I_{min} = -100 °C, I_{max} = 400 °C. The total safety accuracy therefore depends on the configuration of the current output turndown or saturation.

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

Safety function 2 (SAF 2) - Safe Measurement

The measuring chain's safety function involves outputting the voltage, resistance or temperature value at the current output. Measured value transmission via the "normal" HART® protocol is not safe. To this end, the mV value or the Ohm value, and other necessary values such as the reference voltage, temperature at sensor terminal, etc., are measured with a predefined precision and accuracy.

If temperature measurement is used, the temperature value is calculated and then converted to a mA value. This value is then output at the current output.

HART® Transmission with SAF 2

Transmission via the HART® protocol in the SIL mode is subject to the following restrictions:

- Multidrop mode is not possible
- Burst mode is not possible

In the SIL mode, the HART® modem in the transmitter can adopt the following states:

- HART® modem is disabled
- HART® modem is enabled but no HART® communication
- HART® modem is enabled with cyclic, unsafe HART® communication

These different states affect the PFH/PFD/SFF values of the transmitter. The PFH/PFD/SFF values indicated in this manual already factor this in.

Precision and Timing of SAF 1 and SAF 2

NOTE

As a prerequisite for all the information or events listed in the following section, no faults resulting from faulty sensors must have occurred, e.g. bad material properties, cracks etc.

The error when measuring with the transmitter is made up of several parts:

- A/D error or measured error: error when converting the analog signal to a digital signal for processing in the transmitter.
- D/A error or measured error: error when converting the digital measured value in the transmitter to an analog signal at the current output 4 to 20 mA.(1)
- Drift error: error that occurs by the measuring system drifting over time, known as the long-term drift.

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1. The drift error from D/A conversion does not apply as this is part of the long-term drift. It must always be assumed.

Validity of information on the total safety accuracy:

- Total temperature range of the transmitter
- Defined range of the supply voltage
- Limited safety measuring range of the sensor element, which might be smaller than the permitted operating temperature range of the sensor elements.
- The accuracy already contains all the round-off errors in the software due to linearization and calculations.
- Minimum span for each sensor, see the corresponding table
- For every input channel of the transmitter
- The values are 26 values, i.e. 95.4 % of all the measured values have this deviation from the true measured value at maximum.

Total Safety Accuracy Ratings

Table 1. 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 (a)
IEC 60584-1	Type A (W5Re-W20Re) (30)	50 K (90 °F)	0 to +2500 °C (+32 to +4 532 °F)	12 K (21.6 °F)	0.5 % of the span	1.42 °C/year
	Type B (PtRh30-PtRh6) (31)	50 K (90 °F)	+500 to +1820 °C (+932 to +3 308 °F)	5.1 K (9.2 °F)		2.01 °C/year
	Type E (NiCr-CuNi) (34)	50 K (90 °F)	–150 to +1000 °C (–238 to +1 832 °F)	4.9 K (8.8 °F)		0.43 °C/year
	Type J (Fe-CuNi) (35)	50 K (90 °F)	–150 to +1200 °C (–238 to +2 192 °F)	4.9 K (8.8 °F)		0.46 °C/year
	Type K (NiCr-Ni) (36)	50 K (90 °F)	–150 to +1200 °C (–238 to +2 192 °F)	5.1 K (9.2 °F)		0.56 °C/year
	Type N (NiCrSi-NiSi) (37)	50 K (90 °F)	–150 to +1300 °C (–238 to +2 372 °F)	5.5 K (9.9 °F)		0.73 °C/year
	Type R (PtRh13-Pt) (38)	50 K (90 °F)	+50 to +1768 °C (+122 to +3 214 °F)	5.6 K (10.1 °F)		1.58 °C/year
	Type S (PtRh10-Pt) (39)	50 K (90 °F)	+50 to +1768 °C (+122 to +3 214 °F)	5.6 K (10.1 °F)		1.59 °C/year
	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 °C/year
IEC 60584-1; ASTM E988-96	Type C (W5Re-W26Re) (32)	50 K (90 °F)	0 to +2000 °C (+32 to +3 632 °F)	7.6 K (13.7 °F)		0.94 °C/year
ASTM E988-96	Type D (W3Re-W25Re) (33)	50 K (90 °F)	0 to +2000 °C (+32 to +3 632 °F)	7.1 K (12.8 °F)		1.14 °C/year
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 °C/year
	Type U (Cu-CuNi) (42)		–150 to +600 °C (–238 to +1 112 °F)	5.0 K (9 °F)		0.52 °C/year
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 °C/year
Voltage transmitter (mV)		5 mV	–20 to 100 mV	200 mV		27.39 mV/year

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

Table 2. RTD Sensors

Standard	Designation	Min. Span	Limited Safety Measuring Range	Measured Error (+A/D), -40 to +70 °C (-40 to +158 °F)	Mea-sured Error (D/A)	Long-term Drift (a)
IEC 60751:2008	Pt100 (1) Pt200 (2) Pt500 (3) Pt1000 (4)	10 K (18 °F) 10 K (18 °F) 10 K (18 °F) 10 K (18 °F)	–200 to +600 °C (–328 to +1 112 °F) –200 to +600 °C (–328 to +1 112 °F) –200 to +500 °C (–328 to +932 °F) –200 to +250 °C (–328 to +482 °F)	1.1 K (2.0 °F) 1.6 K (2.9 °F) 0.9 K (1.6 °F) 0.6 K (1.1 °F)	0.5 % of the span	0.23 °C/year 0.92 °C/year 0.38 °C/year 0.19 °C/year
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 °C/year
DIN 43760 IPTS-68	Ni100 (6) Ni120 (7)	10 K (18 °F)	–60 to +250 °C (–76 to +482 °F) –60 to +250 °C (–76 to +482 °F)	0.4 K (0.7 °F) 0.3 K (0.54 °F)		0.22 °C/year 0.18 °C/year
GOST 6651-94	Pt50 (8) Pt100 (9)	10 K (18 °F) 10 K (18 °F)	–180 to +600 °C (–292 to +1 112 °F) –200 to +600 °C (–328 to +1 112 °F)	1.3 K (2.34 °F) 1.2 K (2.16 °F)		0.61 °C/year 0.34 °C/year
OIML R84: 2003, GOST 6651-2009	Cu50 (10) Cu100 (11)	10 K (18 °F) 10 K (18 °F)	–180 to +200 °C (–292 to +392 °F) –180 to +200 °C (–292 to +392 °F)	0.7 K (1.26 °F) 0.5 K (0.9 °F)		0.46 °C/year 0.23 °C/year
	Ni100 (12) Ni120 (13)	10 K (18 °F) 10 K (18 °F)	–60 to +180 °C (–76 to +356 °F) –60 to +180 °C (–76 to +356 °F)	0.4 K (0.72 °F) 0.3 K (0.54 °F)		0.21 °C/year 0.18 °C/year
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 °C/year
Resistance transmitter Ω	400 Ω 2 000 Ω	10 Ω 100 Ω	10 to 400 Ω 10 to 2000 Ω	0.5 Ω 2.1 Ω		0.096 Ω/year 0.51 Ω/year

a. 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.

NOTE

A detailed calculation example can be found in the appendix. See "Calculation of the Total Safety Accuracy" on page 60.

Safety-related Signal and Safe State

The safety-related signal is the 4 to 20 mA analog information output at the current output. There are no other safe outputs.

The safe state is defined as follows:

- No current output (= 0 mA) for min. 4 s
- Low error current (≤ 3.6 mA at the output for min. 4 s)

NOTE

The error current ≥ 21 mA (HIGH alarm) is not used in the SIL mode to signal the safe state.

The transmitter leaves the safe state as soon as it is rebooted. When the device is rebooted, all the self-tests are successful if

- the transmitter has been started correctly in the SIL mode, and
- the transmitter outputs a measured value (≠ error current)

NOTE

The safe state is detected by the logical PCS component connected. However this component does not detect whether the transmitter has been 'repaired'. It only detects a measured value after the error current has been applied for at least 4 s.

- Reset the transmitter manually, e.g. disconnect the power to the transmitter by disconnecting the power supply cables (terminals + and -)

4. Restrictions for the Safe Function

NOTE
Follow all the instructions regarding the installation of the temperature transmitter as specified in Operating Instructions. Compliance with the specified ambient conditions is mandatory at all times.

Other obligatory restrictions for use in safety-related applications

- Installation, commissioning, operation and maintenance of the safety measuring system must only be carried out by trained technical personnel. The technical personnel must be authorized to perform the work on the safety-related system by the owner/operator.
- The failure rates are calculated based on the assumption that the device is being operated at an average ambient temperature of 60 °C (140 °F) or 40 °C (104 °F). If the ambient temperatures are higher, the failure rates must be corrected accordingly.
- Before commissioning the transmitter wiring must be checked carefully.
- Compliance with the ambient conditions as per IEC 61326-3-2 is mandatory.
- The permitted voltage range of the SIL device is: 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).
- There should be no strong magnetic fields in the physical vicinity of the transmitter.
- The device must be protected against overvoltage (e.g. lightning) or strong electromagnetic interference.
- The head transmitter may only be operated in the housing and not as a DIN rail replacement with remote sensors.
- Examine the polarity of the terminals carefully.
- Permitted storage temperature for transmitter = –50 to +100 °C (–58 to +212 °F).
- Permitted ambient temperature range –40 to +70 °C (–40 to +158 °F). If these ambient temperature limits are exceeded, it is recommended to mount the transmitter remotely.
- Never use the CDI interface at the same time as a connected current output. Always follow the directions in the Master Instruction Book when using the device in hazardous areas.
- The CDI interface may only be used for system diagnostics by the manufacturer's service department. If the CDI interface is not used, the cover of the CDI interface must be fitted on the head transmitter.

- The mains frequency filter must be set correctly to either 50 Hz or 60 Hz depending on the application. However, this setting is no measure against EMC interferences. To ensure an optimum EMC protective effect the plant must be provided with corresponding measures, e. g. passive measures such as shielding. Thus no mains frequency filter is actually needed. The mains frequency filter has not negative effects on the safety function.
- It is advisable to only use shielded HART® cables (see also the associated Operating Instructions).
- The maximum permitted sensor cable resistance in the event of voltage measurement at sensor input 1 or/and 2 is 1000 Ω.
- The current loop must be monitored at all times.
- Take the DUAL seal (CEC) into consideration (secondary containment).
- Visual inspection of the sensor and thermowell as regards immersion depth, material, integrity etc.
- A thermowell calculation is recommended.
- Avoid differences in potential for grounded thermocouple sensors. Use at least one ungrounded thermocouple.
- If there are fixed specifications for the terminal temperature make sure that the terminal temperature remains constant or that any deviation is factored into the accuracy observations.
- If the polarity is reversed when the thermocouples are wired, this causes an inverse temperature pattern. The process temperature is then in reverse proportion to the measured temperature. Avoid reverse polarity! This makes it possible to monitor the proportional value curve.
- RTD sensors are generally more suitable for SIL operation than thermocouple sensors.

Functional Safety Parameters

The system always uses the same set of self diagnostics, regardless of the measured variable: temperature, voltage or electrical resistance. Therefore the safety-related information and parameters are the same for all three measured variables.

Table 3. Specific Functional Safety Parameters for Single-Channel Device Operation

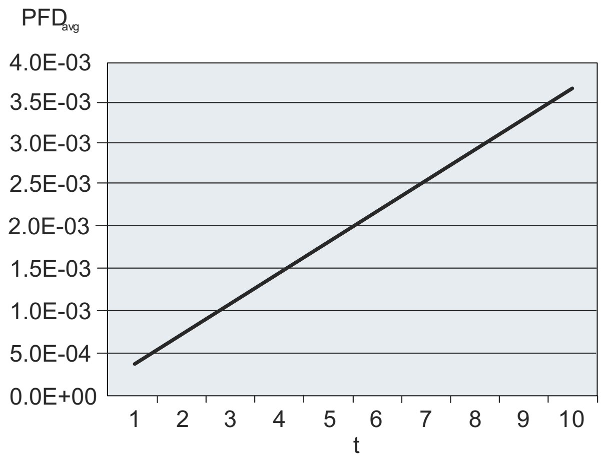
Parameters as per IEC 61508, ed. 20	**Temperature Transmitter**	
Safety function	1: Temperature limit value monitoring (SAF 1) 2: Measurement of the temperature value (SAF 2) 3: Safe parameterization (SAF 3)	
SIL	Hardware: 2 Software: 3 In homogeneous redundancy: 3	
HFT	0	
Device type	B	
Mode of operation	Low demand mode	
MTTR (used to calculate the PFD)	24 h	
t_1 (test interval)	1 year (recommended) (See Figure 6 on page 28).	
Ambient temperature	**60 °C (140 °F)**	**40 °C (104 °F)**
λ_{SD}	7 FIT	4 FIT
λ_{SU}	286 FIT	129 FIT
λ_{DD}	567 FIT	258 FIT
λ_{DU}	84 FIT	40 FIT
λ_{Total} Safety (a)	943 FIT	431 FIT
λ_{Total} Transmitter	1618 FIT	734 FIT
SFF	91.3 %	90.7 %
PFD_{avg} (for t_1 = 1 year) (b)	3.6×10^{-4}	
PFH	8.2×10^{-8}	
MTBF / $MTBF_{DU}$	71 years/1227 years	
Diagnostic test interval (c)	< 32 min with RAM/Flash test < 45 s without RAM/Flash test < 14.7 s without RAM/Flash test and external errors	
Error response time (d)	< 10.7 s	
DC_D (= Diagnostic Coverage Dangerous)	87 %	

a. As per Siemens SN29500 at +60 °C (+140 °F) or +40 °C (+104 °F). MTBF calculated as the reciprocal value of PFH/$λÉ_{Total}$, assuming a constant failure rate.

b. Other (e.g. longer) test intervals can be specified at any time. A suitable interval can be selected with the chart shown.

c. All diagnostic functions are carried out in full at least once during this time.

d. Time between the detection of a failure and the response to the failure. This is the error current.



Test intervals	PFD_{avg}
1 year	3.6E-04
2 years	7.2E-04
3 years	1.1E-03
4 years	1.4E-03
5 years	1.8E-03
6 years	2.2E-03
7 years	2.5E-03
8 years	2.9E-03
9 years	3.3E-03
10 years	3.6E-03

Figure 6. 1oo1D Architecture. PFD_{avg} Depending on the Selected Test Interval (t in Years)

The test interval depends on the PFD_{avg} for a 1oo1D transmitter architecture.

NOTE

- These data do NOT contain ANY PFD_{avg}/SFF values for the external power supply systems or external voltage monitoring systems used.
- A Markov model for a 1oo1D system has been used to calculate the PFD_{avg}.
- The device must be installed, wired and commissioned correctly for it to operate safely.

Dangerous Undetected Failure in this Mode

A dangerous undetected failure is defined as an incorrect measuring signal at the current outputs in the range from 4 to 20 mA, wherein an incorrect measured value is a value that deviates from the real measured value by more than the specified amount. See “Precision and Timing of SAF 1 and SAF 2” on page 20.

Useful Lifetime of Electronic Components

The established failure rates apply for a useful lifetime as per IEC 61508-2 [IEC 61508:2000], section 7.4.7.4 or as per IEC 61508-2 [IEC 61508:2010] section 7.4.9.5 note 3. Other empirical values from earlier use in a similar environment can also be used. It is presumed that a high percentage of early failures are detected during production testing and that a constant failure rate during the useful lifetime can therefore be assumed. In accordance with IEC 61508-2 [IEC 61508:2000] section 7.4.7.4 or as per IEC 61508-2 [IEC 61508:2010] section 7.4.9.5 a useful life should be based on empirical values.

5. Device Behavior During Normal Operation and in the Event of a Fault

Device Behavior During Power-Up

After power-up, internal device diagnostics are performed while a current of 3.58 mA is output. With the SIL startup mode: **Enabled** the safety-related output signal is available after approx. 140 s. With the SIL startup mode: **Disabled** it depends on how quickly the SIL checksum is entered.

Device Behavior In Demand Mode

If an internal error is detected, the device switches to the safe state within the error response time (see "Safety-related Signal and Safe State" on page 22). If the device adopts the active safe state, an **error current** is displayed at the current output and error states are transmitted via the HART® protocol (not safe). If the device adopts the passive safe state, the system stops completely and reboots automatically after 0.5 s at the very latest.

NOTE

Please note that a passive safe state indicates a serious problem in the system.

Device Behavior in the Event of Internal Error Detection

Error current: In the SIL mode the alarm current is always the **low error current** or the **high error current**.

Alarm messages and warning messages are also output on the display in the form of error codes (see Operating Instructions).

Resets: the system is only reset if:

- The system watchdog function is enabled,
- The system detects a power failure,
- The system is physically reset.

6. Installation

Installation, Wiring and Commissioning

NOTE

The procedures for installing, wiring and commissioning the device are described in detail in the Operating Instructions pertaining to the device.

NOTE

Device operation is restricted if the device is mounted outside technical specifications.

- Pay close attention to the information in Chapter 4, “Restrictions for the Safe Function”.

Orientation

Apart from the 'restrictions for the safe function' there are no other requirements regarding the orientation of the device.

7. Operation and Parameterization

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

Standard Parameterization

NOTE

The standard transmitter parameterization is described in detail in Operating Instructions.

Safe Parameterization

NOTE

If safe parameterization is performed it must be documented! The 'Documentation of device parameterization' form is suitable for documenting the safe parameterization. A master copy of this document can be found at the back 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.

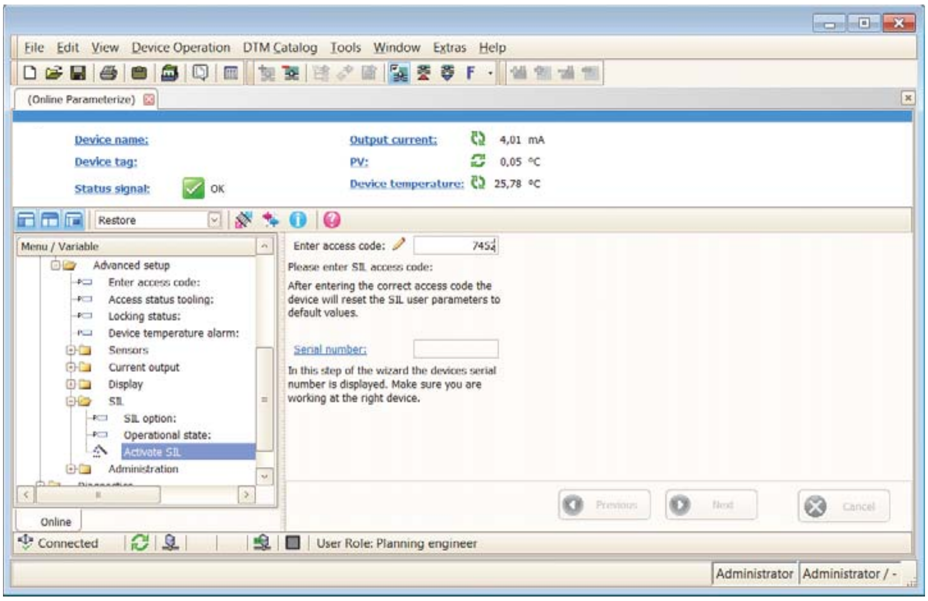
NOTE

All screenshots of the operating menu shown in this chapter are exemplary. Depending on the used operating tool the display may vary.

1. Safe parameterization can only be performed in the online mode. It is not possible in the offline mode. In the submenu **Setup→Extended setup→SIL**, start safe parameterization - **Activate SIL**.

   ↳ The **SIL access code** window opens.

2.



Device name:

Device tag:

Status signal: OK

Output current: 4,01 mA

PV: 0,05 °C

Device temperature: 25,78 °C

Enter access code: 7454

Please enter SIL access code:

After entering the correct access code the device will reset the SIL user parameters to default values.

Serial number:

In this step of the wizard the devices serial number is displayed. Make sure you are working at the right device.

Connected

User Role: Planning engineer

In the **Enter SIL access code** line, enter the code 7452.

↳ Once the correct access code has been entered, the device will reset the safety-related parameters to their default values.

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

NOTE

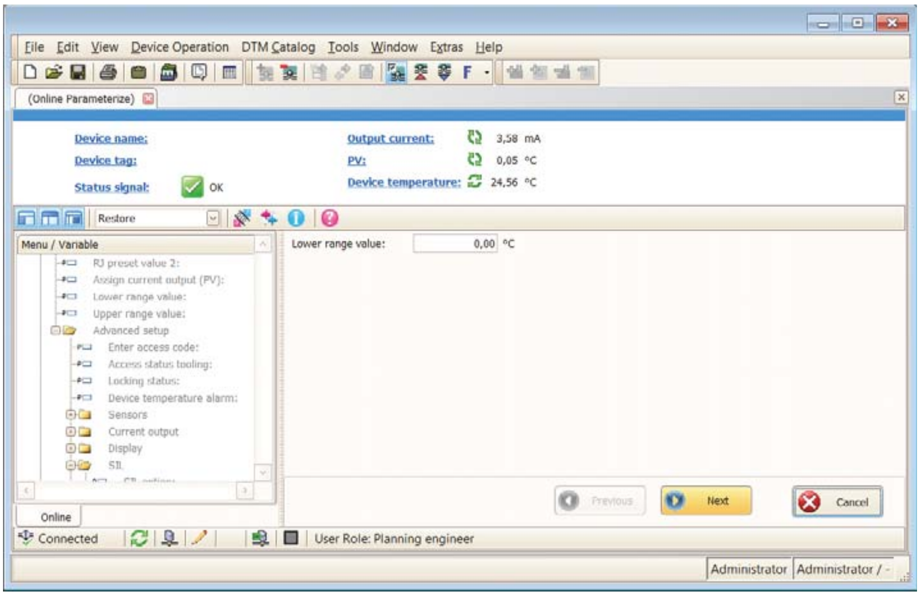
Each parameter, having been transmitted to the device, is read out anew and displayed. Afterwards it is necessary to confirm that the value displayed matches the value entered. The value that is read back also contains the text xxx#END at the end of each value. This ensures that the parameter read out of the device has the correct length. A table containing the assignment of the code number to the set parameter can be found in the appendix to this Safety Manual.

NOTE

If the engineering unit Fahrenheit (°F) or Rankine (°R) is selected, the read out parameter value may deviate from the entered parameter value by 0.01 °F or °R during the parameter verification. This deviation can occur with the following parameters: Lower range value (4 mA), Upper range value (20 mA), Sensor offset, Drift/difference mode, sensor upper limit and sensor lower limit (only for Callendar van Dusen- or polynomial copper/Nickel sensors).

3. Enter all the relevant transmitter parameters in the specified order and confirm each entry by pressing the ENTER key.

4.



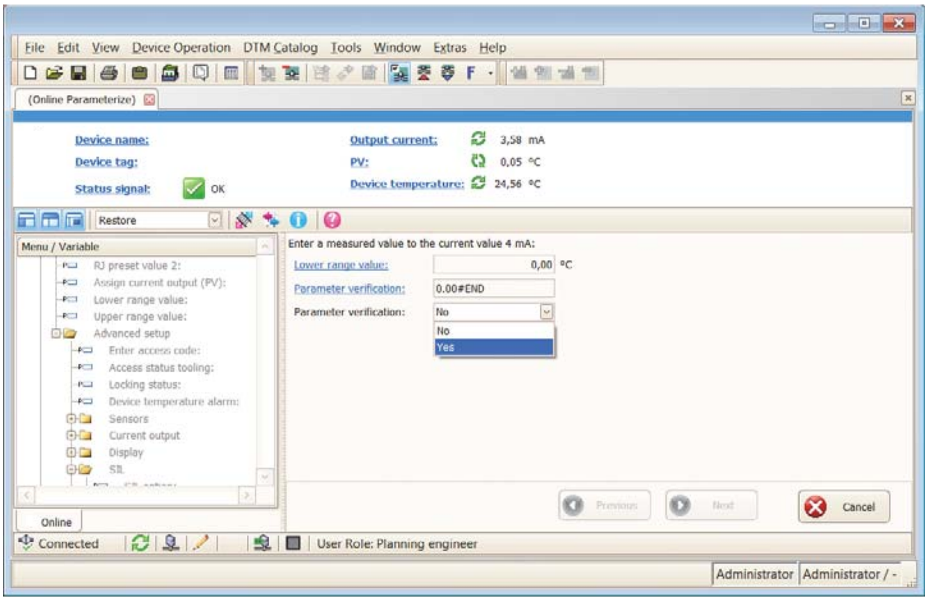
Device name:
Device tag:
Status signal: OK
Output current: 3,58 mA
PV: 0,05 °C
Device temperature: 24,56 °C
Lower range value: 0,00 °C
User Role: Planning engineer

Figure 7. Parameter Entry and Configuration Using the Example of the "Lower Range Value" Parameter

Click 'Next'.

↳ The **Parameter verification** screen now appears.

5.

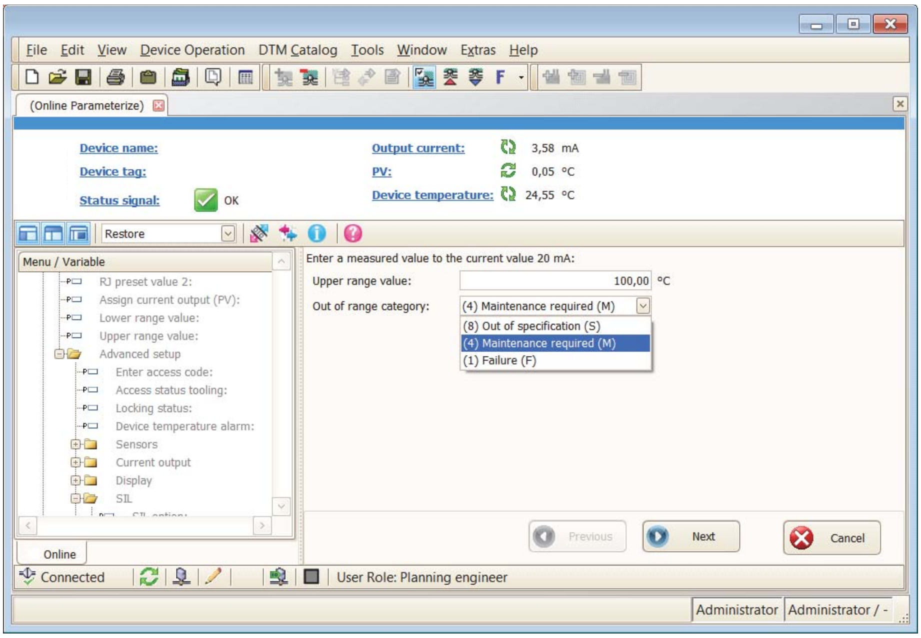


Device name:
Device tag:
Status signal: OK
Output current: 3,58 mA
PV: 0,05 °C
Device temperature: 24,56 °C
Enter a measured value to the current value 4 mA:
Lower range value: 0,00 °C
Parameter verification: 0.00#END
Parameter verification: No
User Role: Planning engineer

Here once again, check the parameters entered. In the options for **Parameter verification**, select YES and then press the ENTER key to confirm. Click 'Next'.

↳ The input window for the next parameter setting appears.

6.



Device name:
Device tag:
Status signal: OK
Output current: 3,58 mA
PV: 0,05 °C
Device temperature: 24,55 °C

Enter a measured value to the current value 20 mA:
Upper range value: 100,00 °C
Out of range category: (4) Maintenance required (M)

(8) Out of specification (S)
(4) Maintenance required (M)
(1) Failure (F)

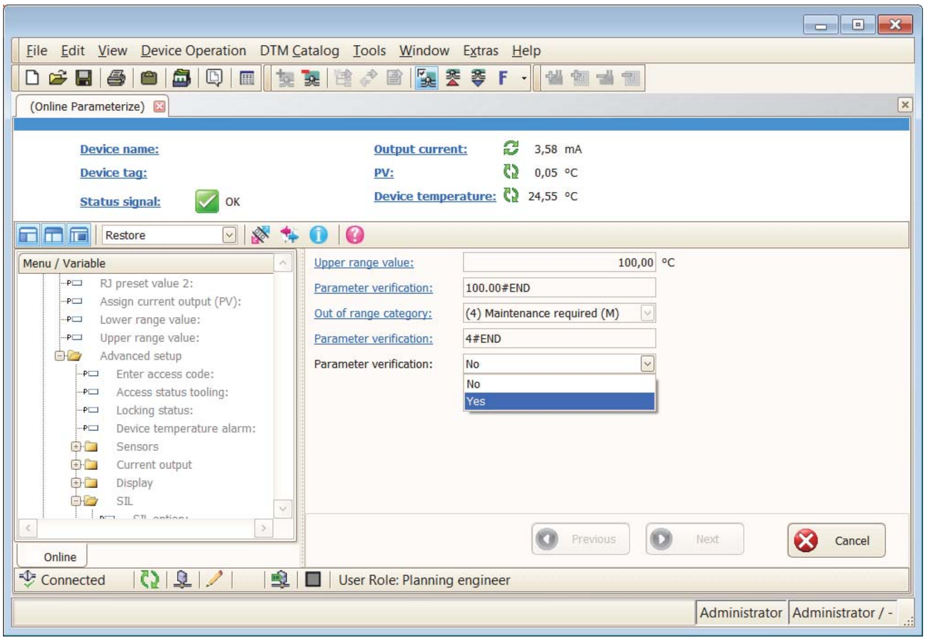
User Role: Planning engineer

Figure 8. Parameter Entry and Confirmation Using the Example of the "Upper Range Value" and "Out of Range"

Enter the value for the upper measuring range, select the out of range category and press ENTER to confirm. Click 'Next'.

↳ The **Parameter verification** screen now appears.

7.



Device name:
Device tag:
Status signal: OK
Output current: 3,58 mA
PV: 0,05 °C
Device temperature: 24,55 °C

Upper range value: 100,00 °C
Parameter verification: 100.00#END
Out of range category: (4) Maintenance required (M)
Parameter verification: 4#END
Parameter verification: No

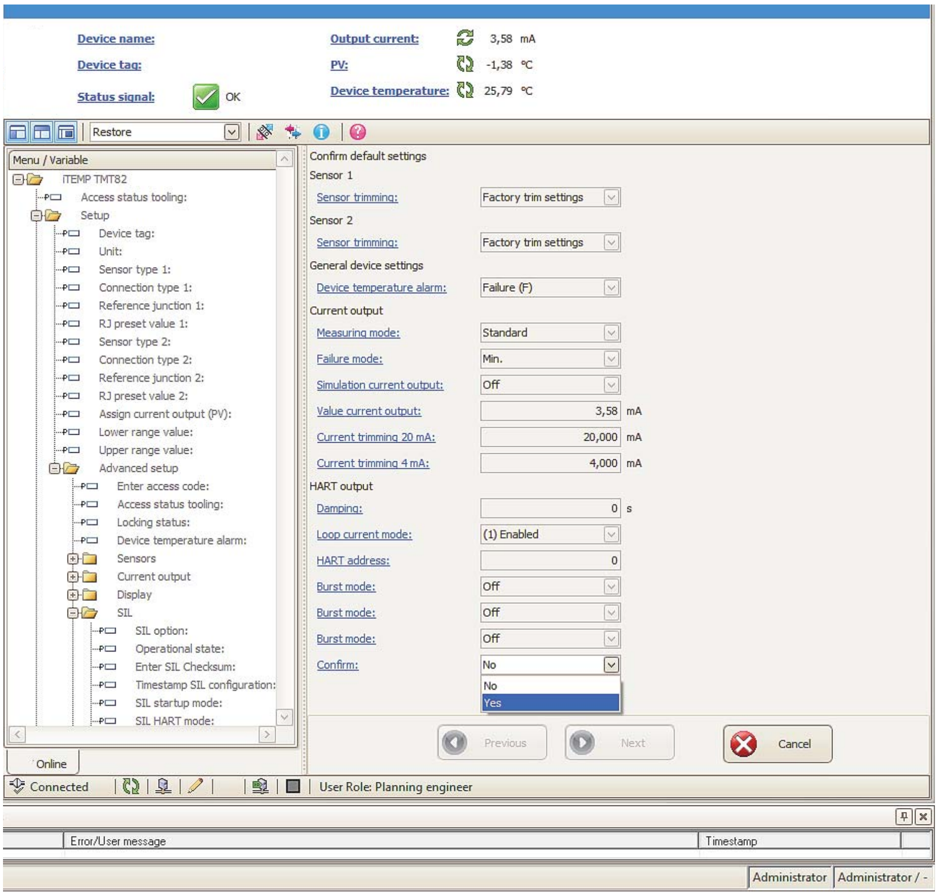
No
Yes

User Role: Planning engineer

Here once again, check the parameters entered. In the options for **Parameter verification**, select YES and then press the ENTER key to confirm. Click 'Next'.

↳ Once all the safety-related parameters have been set in the specified order and confirmed, a complete overview of all the non changeable safety-related parameters then appears on the screen.

8.



Device name:
Device tag:
Status signal: ✓ OK

Output current: 3,58 mA
PV: -1,38 °C
Device temperature: 25,79 °C

Confirm default settings

Sensor 1
Sensor trimming: Factory trim settings

Sensor 2
Sensor trimming: Factory trim settings

General device settings
Device temperature alarm: Failure (F)

Current output
Measuring mode: Standard
Failure mode: Min.
Simulation current output: Off
Value current output: 3,58 mA
Current trimming 20 mA: 20,000 mA
Current trimming 4 mA: 4,000 mA

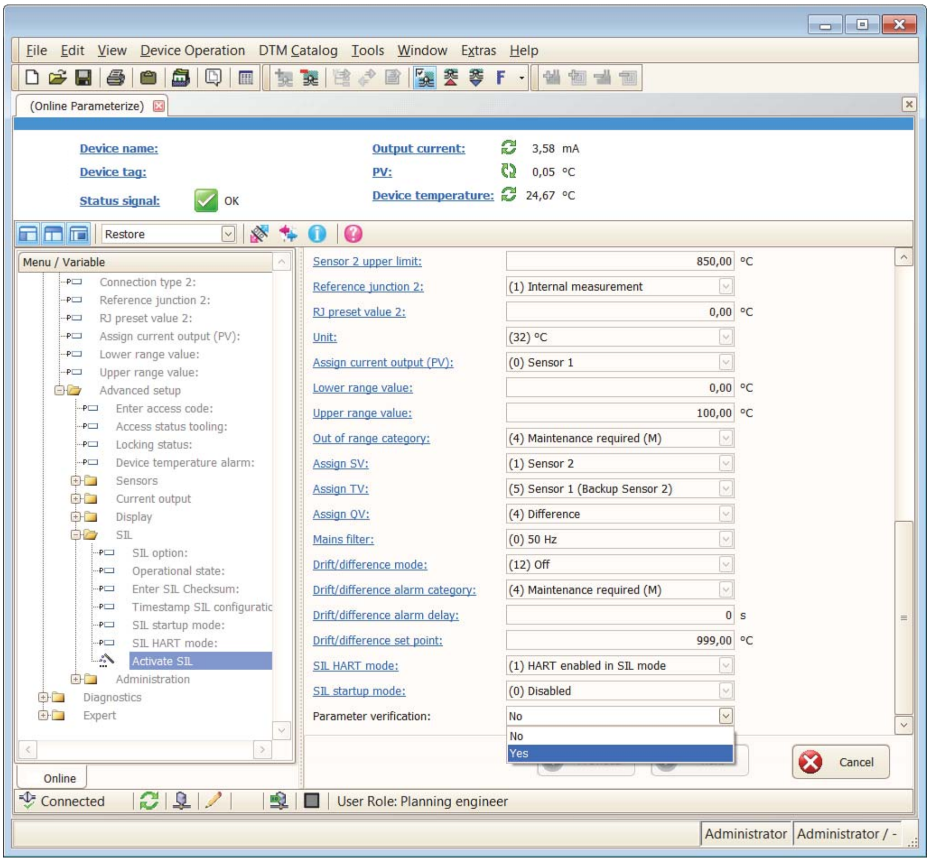
HART output
Damping: 0 s
Loop current mode: (1) Enabled
HART address: 0
Burst mode: Off
Burst mode: Off
Burst mode: Off
Confirm: No
No
Yes

User Role: Planning engineer

All the non changeable safety-related parameters (default settings) will be checked and confirmed one more time. If all the parameter settings are set up correctly, in the option for **Confirm** select YES and then press the ENTER key to confirm. Click 'Next'.

↳ A complete overview of all the changeable safety-related parameters then appears on the screen.

9.



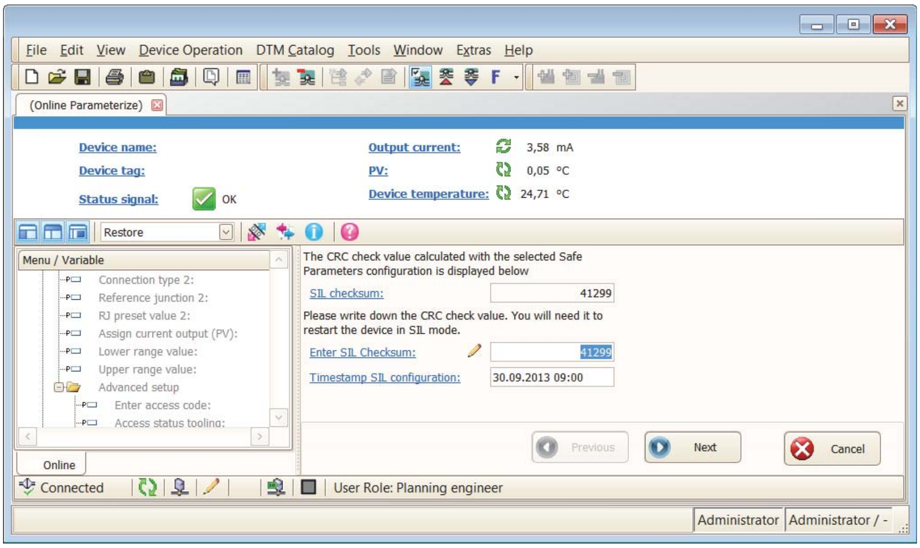
Device name:
Device tag:
Status signal: OK
Output current: 3,58 mA
PV: 0,05 °C
Device temperature: 24,67 °C

Sensor 2 upper limit: 850,00 °C
Reference junction 2: (1) Internal measurement
RJ preset value 2: 0,00 °C
Unit: (32) °C
Assign current output (PV): (0) Sensor 1
Lower range value: 0,00 °C
Upper range value: 100,00 °C
Out of range category: (4) Maintenance required (M)
Assign SV: (1) Sensor 2
Assign TV: (5) Sensor 1 (Backup Sensor 2)
Assign QV: (4) Difference
Mains filter: (0) 50 Hz
Drift/difference mode: (12) Off
Drift/difference alarm category: (4) Maintenance required (M)
Drift/difference alarm delay: 0 s
Drift/difference set point: 999,00 °C
SIL HART mode: (1) HART enabled in SIL mode
SIL startup mode: (0) Disabled
Parameter verification: No
No
Yes

User Role: Planning engineer

All the changeable safety-related parameters will be checked and confirmed one more time. If all the parameter settings have been made correctly, in the option for **Parameter verification** select YES and then press the ENTER key to confirm. Click 'Next'.

10.



Device name:

Device tag:

Status signal: OK

Output current: 3,58 mA

PV: 0,05 °C

Device temperature: 24,71 °C

The CRC check value calculated with the selected Safe Parameters configuration is displayed below

SIL checksum: 41299

Please write down the CRC check value. You will need it to restart the device in SIL mode.

Enter SIL Checksum: 41299

Timestamp SIL configuration: 30.09.2013 09:00

User Role: Planning engineer

Figure 9. The SIL Checksum is Displayed. This has been calculated from the setting for safety-related parameters.

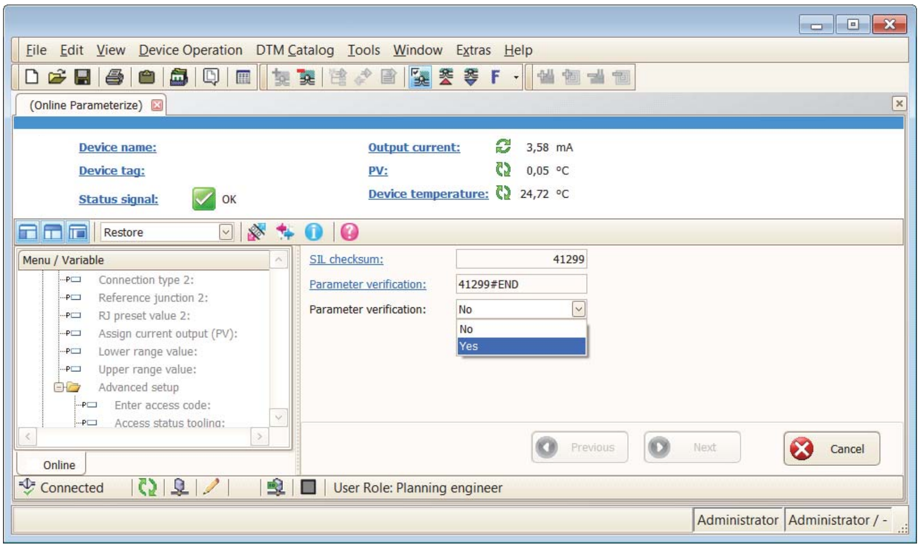
NOTE

Make sure to jot down the value displayed for the SIL checksum in the documentation (logbook, etc.) for this measuring point. This value allows you to document the settings made and start the device in the SIL mode at any time.

Enter the SIL checksum in the **Enter SIL checksum** field and fill in the date and time in the **Timestamp SIL configuration** field. Press the ENTER key to confirm your entries.

↳ The P**arameter verification** screen now appears.

11.



Device name:
Device tag:
Status signal: OK
Output current: 3,58 mA
PV: 0,05 °C
Device temperature: 24,72 °C
SIL checksum: 41299
Parameter verification: 41299#END
Parameter verification: No (No / Yes)

Safe parameterization has only been successful if the **Parameter verification** screen appears and the SIL checksum numbers indicated match. Otherwise the safe parameterization is incorrect and must be repeated!

Here, once again check the SIL checksum entered. In the options for **Parameter verification**, select YES and then press the ENTER key to confirm. Click 'Next'.

↳ In a new window you are prompted to select 'Next' to confirm the safe parameterization and close device operation. This concludes the safe parameterization routine and the device is rebooted.

12. Click 'Next'.

Safe parameterization is completed. The device reboots automatically in the SIL mode. See “Switching to the SIL Mode” on page 45.

NOTE

Check the reboot procedure! Safe parameterization is successful only if the device is rebooted.

Parameters and Default Settings for Safe Parameterization	
Firmware version	Use this function to view the device firmware version installed. A max. 6-digit character string is displayed 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**

Parameters and Default Settings for Safe Parameterization (Continued)	
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)
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**

Parameters and Default Settings for Safe Parameterization (Continued)	
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**
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**

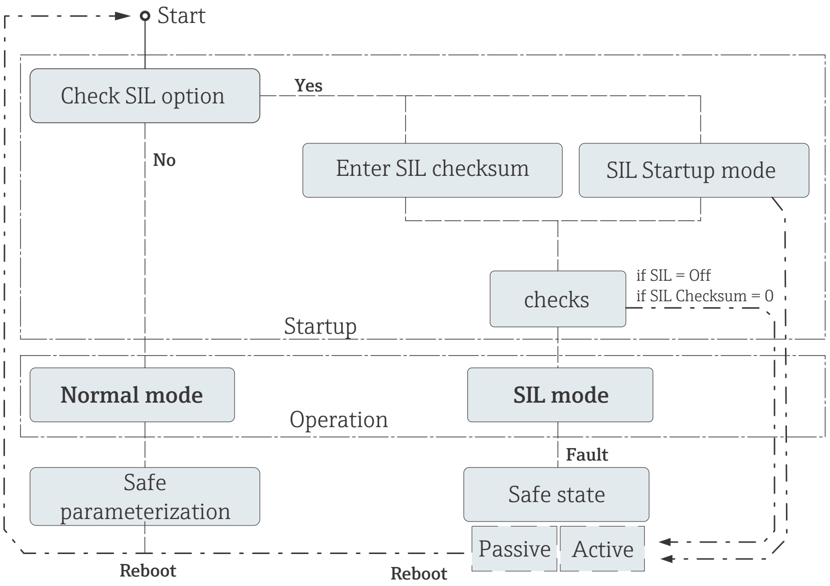
Parameters and Default Settings for Safe Parameterization (Continued)	
Drift/difference alarm delay	Alarm delay for drift detection monitoring. Prerequisite: The **Drift/difference mode** parameter must be activated with the **Out band (drift)** or **In band** option. Factory setting: **0 s** (cannot 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)**
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: **Disabled**
Force safe state	During SIL proof testing 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 (fourth) 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)

The values configured safely in the transmitter can be used for temperature measurement in the SIL mode using SAF 1 and/or SAF 2. The SAF 3 safety function requires the user to perform a number of tests and checks during safe parameterization. Special displays are used for this purpose in order to communicate safely with the user.

System States and Mode of Operation

Working States

The system has two working states: normal mode and SIL mode. All the system self-tests are only enabled in the SIL mode.



Working States	
Normal mode	The normal mode is the standard mode to which the device is set after delivery. This is the unsafe mode of the transmitter. HART® communication is always active.
SIL mode	The SIL mode is the operating mode for safety functions. The entire measuring system can only be considered safe in the SIL mode. It is not possible to switch between the SIL mode and the normal mode on the fly. The device has to be rebooted in order to switch modes. If the SIL mode is started, the measured value is transmitted safely to the PCS. The entire safety diagnostics are executed in the background. If a fault is discovered, e.g. sensor cable interrupted, the system leaves the SIL measuring mode and switches to the safe state.

Safe States

Safe States		
Active safe state	Passive safe state	Panic safe state
Output error current, < 3.6 mA (= LOW alarm)	Output error current, e.g. < 3.6 mA - safe state System reset is triggered automatically.	The system stops immediately. 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 three states depending on the error detected. The active safe state is the only state in which the system continues working without a reset being triggered automatically.

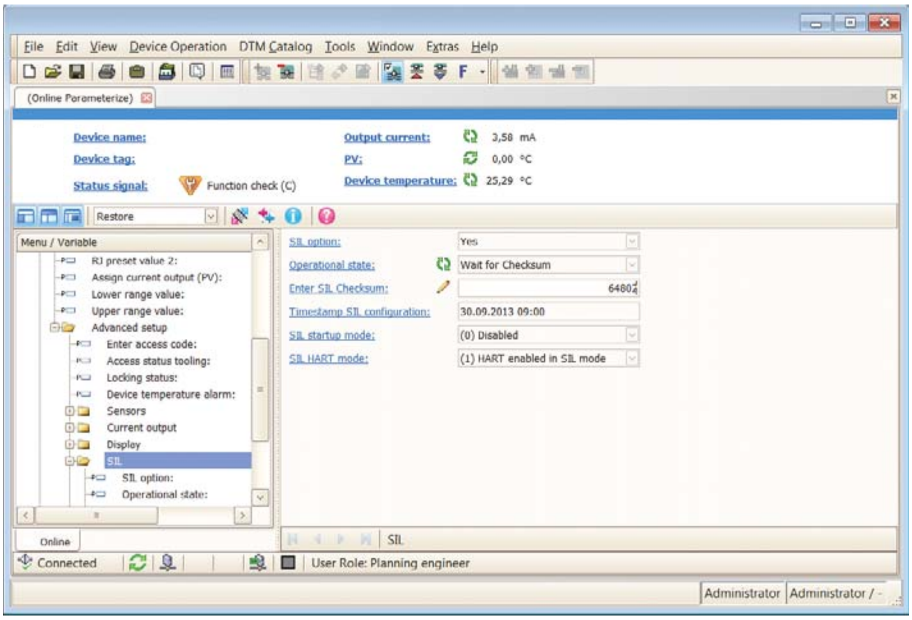
System Mode of Operation

NOTE

During the system startup sequence, HART® communication is active until the system switches to the normal mode or the SIL mode. The configuration of the system dictates whether HART® remains active afterwards.

Switching to the SIL Mode

1. Start the system in the normal mode.
2. Start and perform safe parameterization with subsequent system reboot. See “Safe Parameterization” on page 33.

   ↳ The device waits about 60 seconds before rebooting. Operational state **reboot pending.** During this time, use the operating tool to end all communication with the device so that no communication problems occur.
3. 

Device name:
Device tag:
Status signal: Function check (C)
Output current: 3,58 mA
PV: 0,00 °C
Device temperature: 25,29 °C

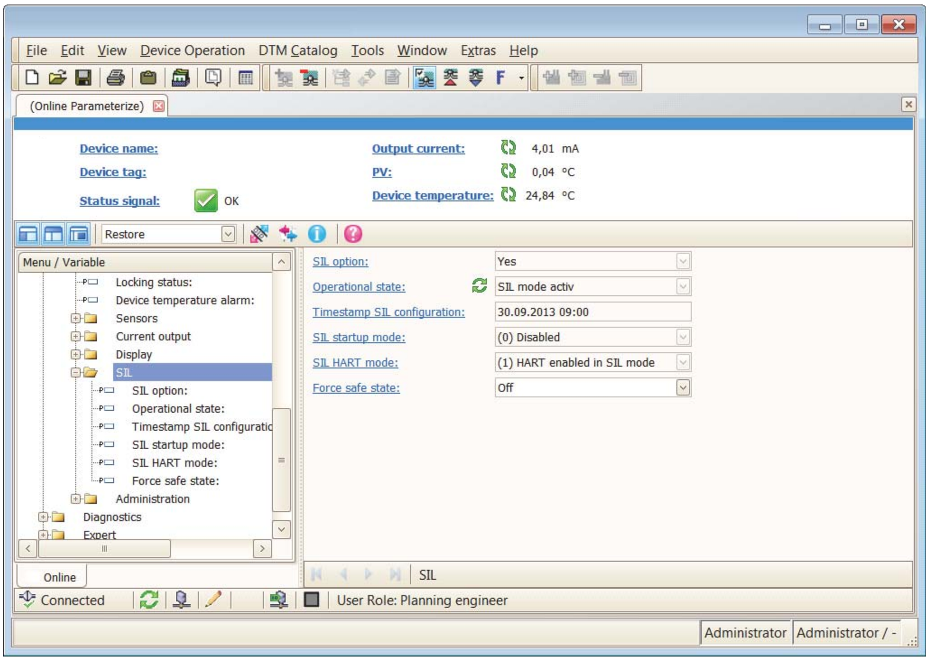
SIL option: Yes
Operational state: Wait for Checksum
Enter SIL Checksum: 6480
Timestamp SIL configuration: 30.09.2013 09:00
SIL startup mode: (0) Disabled
SIL HART mode: (1) HART enabled in SIL mode

Connected
User Role: Planning engineer

Once the device has been rebooted the **Operational state** field displays the state Wait for **checksum**. The device is still in the startup phase.

Enter the SIL checksum from the safe parameterization (“Safe Parameterization” on page 33) in the **Enter SIL checksum** field and press ENTER to confirm.

↳ Once the startup time has elapsed the device switches automatically to the SIL mode. The Operational state displays **SIL mode active**.



Device name:
Device tag:
Status signal: OK

Output current: 4,01 mA
PV: 0,04 °C
Device temperature: 24,84 °C

SIL option: Yes
Operational state: SIL mode activ
Timestamp SIL configuration: 30.09.2013 09:00
SIL startup mode: (0) Disabled
SIL HART mode: (1) HART enabled in SIL mode
Force safe state: Off

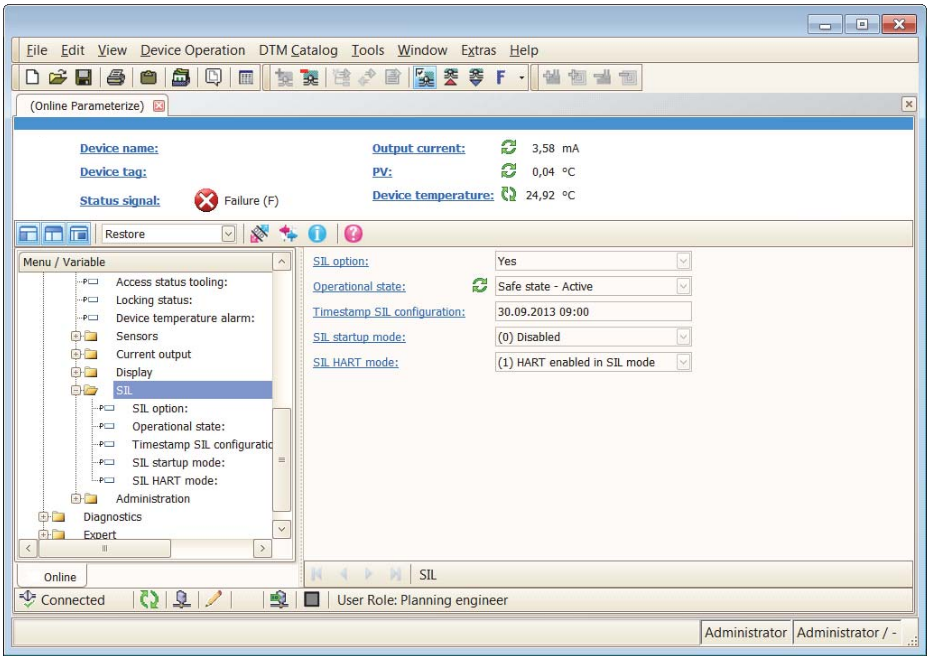
Connected
User Role: Planning engineer
Administrator
Administrator / -

The system is in the SIL mode and can be used within the context of a safety function.

NOTE

If an error occurs in the system during the safe mode (SIL mode) the safe state is activated.

- If the safe state still permits communication via HART®, the **Operational state** field displays the state "**Safe state - active**". The device can therefore be analyzed as regards the error or the configuration.



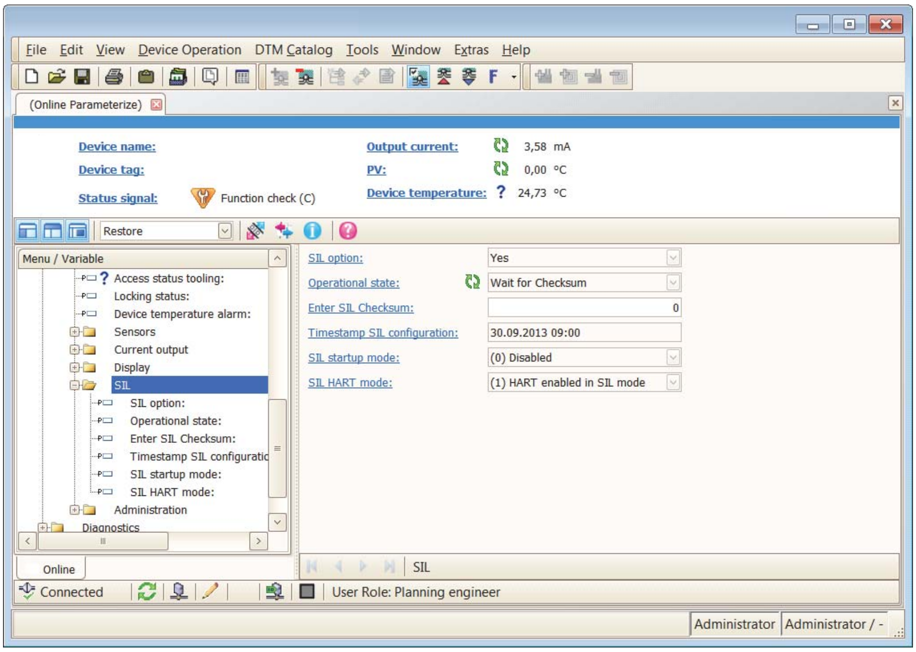
Device name:
Device tag:
Status signal: Failure (F)
Output current: 3,58 mA
PV: 0,04 °C
Device temperature: 24,92 °C

SIL option: Yes
Operational state: Safe state - Active
Timestamp SIL configuration: 30.09.2013 09:00
SIL startup mode: (0) Disabled
SIL HART mode: (1) HART enabled in SIL mode

Important parameters for the startup sequence in the SIL mode.

- **SIL checksum:** The CRC value that uniquely identifies this transmitter with these settings. The system returns this value at the end of the safe parameterization.
- **SIL startup mode:** This parameter can be configured. It defines whether the system starts automatically in the SIL mode after startup if it was being operated in the SIL mode beforehand.
- **Enter SIL checksum:** This parameter can be used to switch the system to the SIL mode or to switch back to the startup for normal mode from the startup for SIL mode. This parameter can be entered via an operating tool.

Switching from SIL Mode to Normal Mode



Device name:
Device tag:
Status signal: Function check (C)
Output current: 3,58 mA
PV: 0,00 °C
Device temperature: ? 24,73 °C

SIL option: Yes
Operational state: Wait for Checksum
Enter SIL Checksum: 0
Timestamp SIL configuration: 30.09.2013 09:00
SIL startup mode: (0) Disabled
SIL HART mode: (1) HART enabled in SIL mode

1. Start the system.
2. Enter the number 0 in the **Enter SIL checksum** field.
3. Press the ENTER key by the way of confirmation, or
4. Start the wizard **Deactivate SIL** in the submenu: **Setup→Extended setup→SIL**.

   ↳ This interrupts the SIL start phase of the system. The device switches to the active safe state and must be rebooted.

After rebooting, the device is in the unsafe mode (normal mode). To switch to the SIL mode, the user must start safe parameterization once again. See “Safe Parameterization” on page 33.

Calibration and Adjustment

The following calibrations/adjustments can be used for the transmitter:

- 1-point adjustment (→ offset)
- Callendar/Van-Dusen (CvD) calibration/sensor-transmitter matching (for Pt-RTD), polynomial calibration for Cu-RTD and Ni-RTD.

NOTE

Both settings can be configured simultaneously. The transmitters are always delivered with a factory calibration of the current output. If two sensors are connected (e.g. as backup) the calibrations/adjustments can be selected and performed per sensor.

Quality of Diagnostics

A **short-circuit** at the sensor connection is detected on RTDs with a diagnostics coverage of 99%. If two thermocouples are connected, the diagnostic measure is only active if drift monitoring is also enabled. The diagnostics coverage rate is also 99% here.

Optional Transmitter Diagnostics in the SIL Mode

The diagnostics described here are **not** necessary for the safe operation of the transmitter itself. However they can be important as part of a safety function in which the transmitter is used.

Corrosion or Cable Open Circuit

The transmitter detects corrosion at sensor input 1 and 2 for RTD and TC sensors.

The following limits for corrosion detection (cable resistance) are defined for the various input ranges:

	Warning as of:	Cable Open Circuit as of (error):
100 mV	14000 Ω	27000 Ω
400 Ω	1740 Ω	6750 Ω
2000 Ω	3000 Ω	11500 Ω

The limits indicated are typical values(1) and apply for ambient temperatures of 25 °C (77 °F). On account of several factors (tolerances, temperature drift etc.) the detection of corrosion or a cable open circuit is triggered at different resistance values for each individual device. In the SIL mode there is no ''Warning" diagnostic message similar to that in the normal mode. The device immediately displays the "Error" diagnostic message. The cable open circuit diagnostic has a diagnostic coverage rate of 99%. In addition drift monitoring diagnostics can also be used. See “Sensor Drift Diagnostic Event” on page 15.

---

1. Generously rounded off on the safe side

8. Proof-testing

General Information

The operativeness of safety functions must be checked at appropriate intervals. The intervals depend on various parameters and must be specified by the operator. The tests must be performed as described in the following section. An interval of 1 year is recommended for proof testing as this makes it possible to perform many self-test shutdown operations that are not possible during operation.

If several devices are used in "MooN" configurations ("M out of N"), then the test described here must be performed separately for each device. In addition, checks must be performed to ensure continued compliance with all the restrictions that apply for operation. See Chapter 4, “Restrictions for the Safe Function”.

Proof Tests to Guarantee Safe Operation

NOTE

Also read the 'Maintenance and cleaning' section. See Chapter 9, “Maintenance and Repair”.

NOTE

Non-compliance with testing criteria and influence of systematic errors on the safety function.

- Cease using the device as part of a safety-related system if one of the test criteria cited is not met.
- The test is used to detect any failures that remain undetected by online tests when the system is running. This test does not cover the influence of systematic errors on the safety function. This must be examined separately. Systematic errors can be caused by factors such as properties of the medium, ambient conditions, corrosion, etc.
- The proof test can be performed in the laboratory or directly in the process.
- The proof test described here is suitable for safe outputting of values at the current output. It applies for all housing versions and is independent of the sensor type used.

A reliable ammeter is required to measure the current at the current output. The accuracy rating must be at least ± 0.1 mA. The proof test is performed as follows:

1. Disconnect the power to the transmitter.
2. Switch on the transmitter.
3. Operate the system in the normal mode, not the SIL mode.
4. Perform a complete safe parameterization of the device. The configuration should correspond to the configuration to be used. The suitable sensors should be connected.

↳ On completion of the safe parameterization the device reboots. This reboot is triggered by the watchdog function, thereby also testing the ability of the watchdog function to switch off the device.

5. Make sure that the system reset is triggered by the transmitter! A reset may not be triggered by the user here. Document this point in the proof test report!
6. Operational system

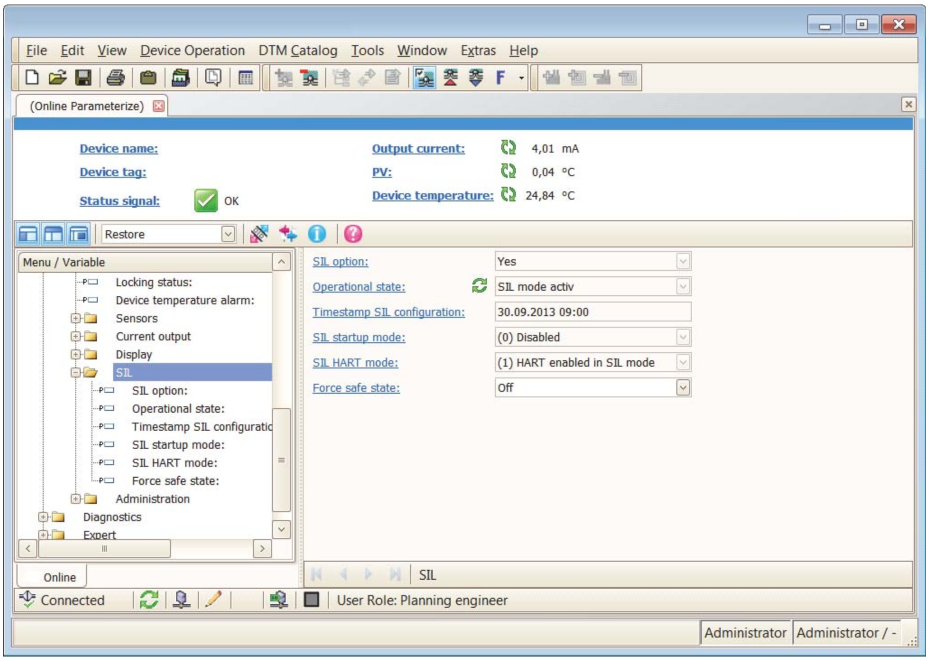
   Switch the system to the SIL mode.

   ↳ Up to this point all the self-tests during the device startup phase have been performed successfully.
7. Recommendation for calibration at two different temperatures: select the temperatures such that they are a maximum of ± 10 to 20 % from the two limit values of the temperature interval to be monitored, i.e. the temperature values presented at 4 mA and/or 20 mA.

   For the calibration, apply a temperature to the sensor and keep it steady, measure the current at the current output and compare it against the result expected. Observe the value at the current output for at least 30 s. Repeat the entire routine for the second temperature value.

   ↳ The current output must have a constant value between 4 to 20 mA. It is important that the measured value remain constant and that no error current be measured.
8. Repeat the sequence for the second temperature value.
9. Connecting two sensors.

   Perform the calibration with both sensors. Optional: If backup has been configured disconnect the first sensor before calibrating the second one.
10.



Device name:
Device tag:
Status signal: OK
Output current: 4,01 mA
PV: 0,04 °C
Device temperature: 24,84 °C

SIL option: Yes
Operational state: SIL mode activ
Timestamp SIL configuration: 30.09.2013 09:00
SIL startup mode: (0) Disabled
SIL HART mode: (1) HART enabled in SIL mode
Force safe state: Off

Connected
User Role: Planning engineer

Force emergency power shutdown causing the system to assume the passive safe state. For this purpose, the Force safe state parameter must be set to On.

↳ The system must respond with the passive safe state after 2 min at the very latest and thereby output an error current. The parameter is automatically reset to Off when the device is rebooted.

11. Disconnect the power to the transmitter.

This completes the proof test.

NOTE
The transmitter can now be used in the safe measuring mode.

The test must be documented with the date, the name of the tester and the exact result (see "Test Report" on page 58). This test detects approx. 90 % (proof test coverage) of all the possible dangerous and safe failures that are undetected by diagnostics in the system.

9. Maintenance and Repair

Maintenance

If necessary and depending on the particular application it is advisable to clean the device occasionally.

Repair

The transmitter must always be repaired by the manufacturer. Send the defective device in to your local manufacturer's service department along with a description of the error (be as accurate as possible) and use a new device.

Call 1-866-746-6477 (inside U.S.) or +1-508-549-2424 (outside U.S.) for an RMA number.

Appendix A.

Notes on Redundant Deployment for SIL 3

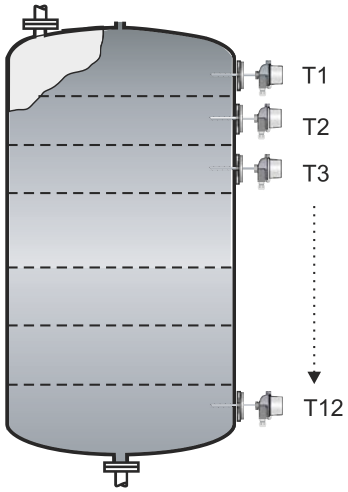
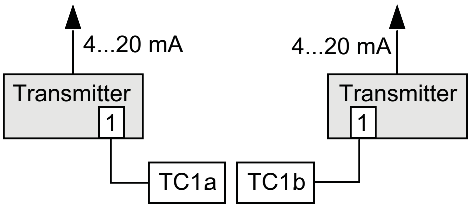


Figure 10. Temperature Measurement with SIL3 Measuring Points: T1, T2, T3 to T12

Application: In a tank 13 m (42.65 ft) in height the temperature is measured at increments of 1 m. Thermocouples (TC) are used as temperature sensors for this purpose. This temperature measurement can be implemented by the following with the transmitter as the SIL 3 measuring point:

Method 1 Complete redundancy, each place of measurement has 2 measuring points (TC1.a and TC1.b) and two transmitters each with one connected input channel (1). 24 transmitters are needed = SIL3 with homogeneous redundancy.	

Test Report

Application-specific Data	To Be Completed by the Tester
Company	
Measuring point	
Facility	
Device type	SIL Temperature Transmitter
Serial number	
Operational restrictions rechecked	☐ YES ☐ NO
System reset automatically after safe parameterization	☐ YES ☐ NO
Any deviations found from the procedure in this manual	☐ YES (if yes please specify) ☐ NO
Calibration temperatures used	
System adopted the passive safe state and a reset was triggered	☐ YES ☐ NO
Test performed with 2 sensors	☐ YES ☐ NO
Sensor(s) used	
PFD_{avg} value before test	
PFD_{avg} value after test	
Date of last test	
Date of next test (estimated)	
Name of tester	
Date	
Signature	

Examples of Calculating the PFD_{avg}

This section contains some examples of how to calculate the PFD_{avg} values of a measuring chain and the PFD_{avg} value after the tests.

NOTE

$PFD_{avg}(T) = 1/T \int_0^T (\lambda_{DU}\, t)\, dt = 1/2\, \lambda_{DU}\, t$. Valid for a 1oo1 system, assuming a constant and low failure rate λ_{DU}. PFD_{avg} is generally given without a parameter "T". This means that this was the value of PFD_{avg} at the time "T" of the obligatory check.

Example of Calculating the PFD_{avg} for Proof Testing

The test is designed to verify that the system does not have any undetected dangerous failures. The proof test coverage indicates the effectiveness of the check. Once the test has been completed successfully, the PFD_{avg} value of the system "improves". It is possible to specify when the next test should be performed. In this example, the temperature transmitter is being used in a 1oo1D environment.

Example 1: The test is performed after one year of operation.

The PFD_{avg} value is $3.6 \cdot 10^{-4}$ directly before the test. Directly after the test it is $3.6 \cdot 10^{-4} * 0.1 = 0.36 \cdot 10^{-4}$ with 90% proof test coverage (PTC). If the device is operated for another year, the PFD_{avg} value increases at the end of the second year to $0.36 \cdot 10^{-4} + 3.6 \cdot 10^{-4} = 3.96 \cdot 10^{-4}$.

↳ If the limit value for the PFD_{avg} value of the transmitter corresponds to $3.8 \cdot 10^{-4}$, for example, on account of the selected safety function of the transmitter, the system may not be operated until the end of the second year. The new proof test must be performed before the end of the two years because the PFD_{avg} value is $3.96 \cdot 10^{-4}$ at the end of the test interval.

Example 2: The test is performed after two years of operation.

The PFD_{avg} value is $2 * 3.6 \cdot 10^{-4} = 7.2 \cdot 10^{-4}$ directly before the test. Directly after the test, with a PTC of 90%, the new value is $7.2 \cdot 10^{-4} + 0.1 * 7.2 \cdot 10^{-4} = 7.92 \cdot 10^{-4}$.

Example of Calculating the PFD_{avg} for a Temperature Measuring Point

NOTE

Measuring point architecture for this calculation example
- Pt100 RTD 4-wire sensor
- SIL temperature transmitter
- Measuring chain is connected to a PCS (e.g. PLC with actuator) that can activate the safe state.

The PFD value of the entire chain (PFD_{avg} mc. mc = measuring chain) can be calculated by adding up the individual PFD values of all the components in the chain:

↳ The PFD_{avg} value of the sensor is $5.0 \cdot 10^{-4}$.

PFD_{avg} mc = PFD_{avg} sensor + PFD_{avg} transmitter + PFD_{avg} protocols (poss. HART® communication)

↳ A safety instrumented system (SIS) comprises:

PFD_{avg} SIS = PFD_{avg} mc + PFD_{avg} PCS + PFD_{avg} actuator

An example of a value for the complete (non-redundant) temperature measuring chain that was described at the start of this section could be as follows:(1)

$$\mathbf{PFD_{avg}\ mc} = 5.0 \cdot 10^{-4} + 3.6 \cdot 10^{-4} + 1.0 \cdot 10^{-4} = 9.6 \cdot 10^{-4}\ ^{(1)\ (2)}$$

In accordance with IEC 61508, ed. 2.0 a maximum PFD_{avg} value of $1 \cdot 10^{-2}$ is required to implement a SIS according to SIL2 specifications. Therefore there is approximately a 10 % match between the calculated value and the SIL2 PFD_{avg}. This means that the remaining 90 % of the SIL2 PFD_{avg} value can be used for the PCS and the actuators.

Calculation of the Total Safety Accuracy

Example: typical temperature measuring chain as RTD 4-wire measurement.

It is assumed that there is no noteworthy EMC interference and that the system (transmitter) is being operated at an ambient temperature of 25 °C (77 °F). Sample calculation for a Pt100 in the temperature range from –200 to +600 °C (–328 to +1 112 °F) in the restricted safety measuring range.

The safety function is using the current output and the TSA is calculated as following: 0.5 % of the span = 0.5 % of 200 K = 1 K, i.e. the TSA = 1.1 K + 1 K + 0.23 K/year = 2.33 K after one year.

Non-negligible EMC Interference

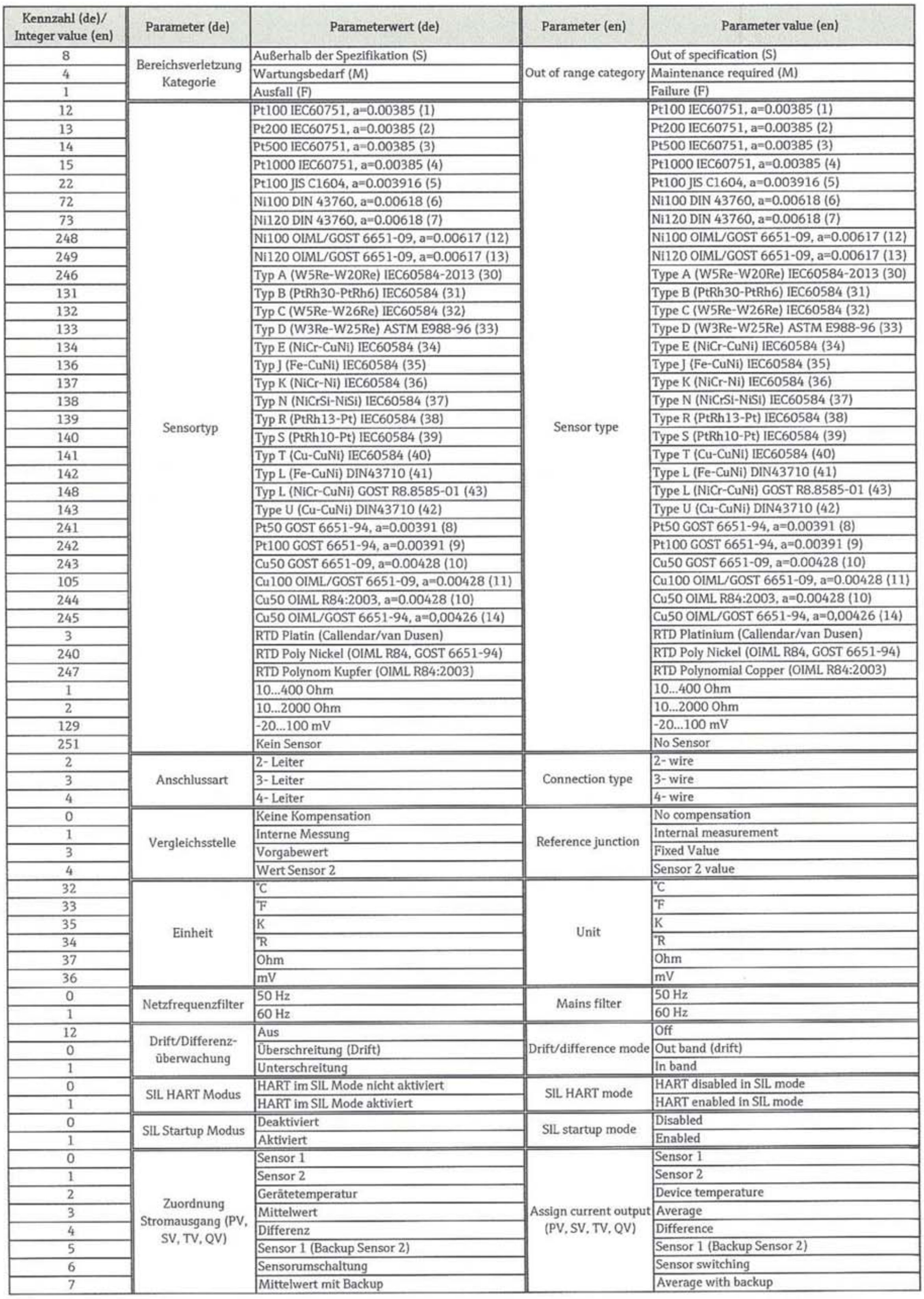
In the case of non-negligible EMC interference an additional deviation of < 0.5 % to the above mentioned value is possible. Deviation = 200 K * 0.5 % = 1 K.

NOTE

If a HART® filter is used, as recommended, the HART® modulation does not contribute to the inaccuracy. Therefore it is not taken into consideration in this example.

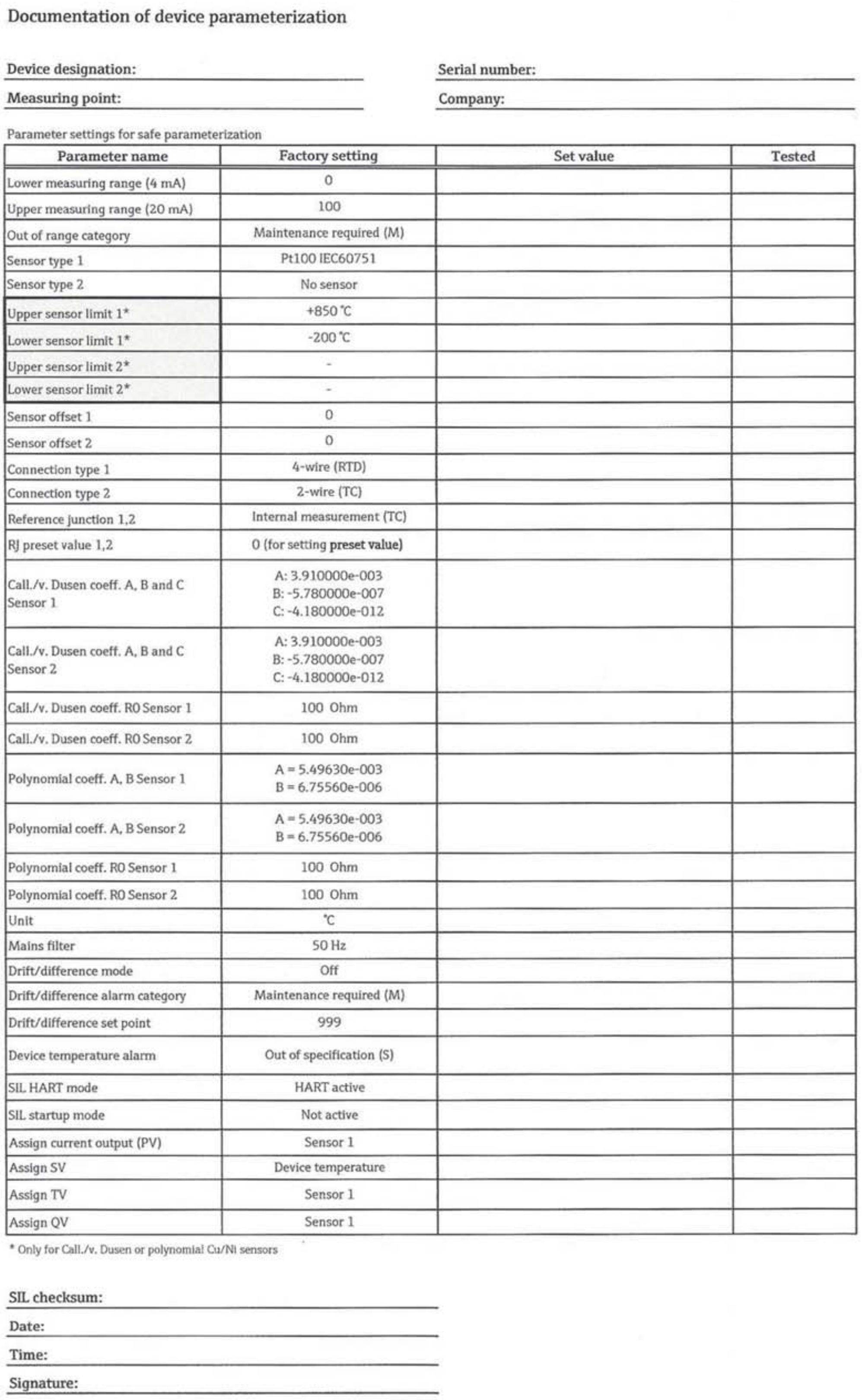
---

1. The HART® protocol has been taken into consideration with 1% of the PFD SIL2 value = 1.0 E-4.
2. Testing interval for all devices: 1 year.



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

Documentation of Device Parameterization



Documentation of device parameterization

Device designation:

Serial number:

Measuring point:

Company:

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*	+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)		
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	A: 3.910000e-003 B: -5.780000e-007 C: -4.180000e-012		
Call./v. Dusen coeff. A, B and C Sensor 2	A: 3.910000e-003 B: -5.780000e-007 C: -4.180000e-012		
Call./v. Dusen coeff. R0 Sensor 1	100 Ohm		
Call./v. Dusen coeff. R0 Sensor 2	100 Ohm		
Polynomial coeff. A, B Sensor 1	A = 5.49630e-003 B = 6.75560e-006		
Polynomial coeff. A, B Sensor 2	A = 5.49630e-003 B = 6.75560e-006		
Polynomial coeff. R0 Sensor 1	100 Ohm		
Polynomial coeff. R0 Sensor 2	100 Ohm		
Unit	°C		
Mains filter	50 Hz		
Drift/difference mode	Off		
Drift/difference alarm category	Maintenance required (M)		
Drift/difference set point	999		
Device temperature alarm	Out of specification (S)		
SIL HART mode	HART active		
SIL startup mode	Not active		
Assign current output (PV)	Sensor 1		
Assign SV	Device temperature		
Assign TV	Sensor 1		
Assign QV	Sensor 1		

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

SIL checksum:

Date:

Time:

Signature:

Declaration of Decontamination

Because of legal regulations and for the safety of our employees and operating equipment, we need the "declaration of decontamination", with your signature, before your order can be handled. Please make absolutely sure to include it with the shipping documents, or - even better - attach it to the outside of the packaging.

Please return your products to your supplier:

Please direct your inquiry to:

Type of instrument/sensor: ______________________ **Serial number:** ______________________

☐ Used as SIL device (Safety Integrity Level) in a Safety Instrument System

Process data: Temperature: ______________ [°C] Pressure: ______________ [bar]

Conductivity: ______________ [S] Viscosity: ______________ [mm²/s]

Medium and warnings:

	Medium/ Concentration	flammable	toxic	corrosive	harmful/ irritant	other*	harmless
Process medium							
Medium for process cleaning							
Returned part cleaned with							

Please tick, should one of the above be applicable, include security sheet and, if necessary, special handling instructions.

*e.g: explosive; oxidising; dangerous for the environment; biological risk; radioactive

Reason for return:

____

____

Company data:

Company: ______________________ Phone number: ______________________

Contact person: ______________________ Fax: ______________________

Address: ______________________ E-Mail: ______________________

______________________ Your order No.: ______________________

„We hereby certify that the returned parts have been carefully cleaned. To the best of our knowledge they are free from any residues in dangerous quantities."

____

Place, date Company stamp and legally binding signature

ISSUE DATES

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Invensys Systems, Inc.
10900 Equity Drive
Houston, TX 77041
United States of America
http://www.invensys.com

Global Customer Support
Inside U.S.: 1-866-746-6477
Outside U.S.: 1-508-549-2424
Website: http://support.ips.invensys.com

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