JUMO dTRANS T07

Two-channel temperature transmitter with HART®/Ex/SIL for installation in terminal head, B form, and for mounting on DIN rails

Safety Manual SIL

70708000T99Z001K000

V5.00/EN/00681611/2022-05-11

Contents

Contents

General

Device designation and admissible versions	JUMO dTRANS T07 B SIL JUMO dTRANS T07 B Ex SIL JUMO dTRANS T07 T SIL JUMO dTRANS T07 T Ex SIL		
Safety-related output signal	4 to 20 mA		
Error current	3.58 mA		
Evaluated measurand/function	Temperature/voltage/resistance		
Safety function(s)	Min., max., range		
Device type according to IEC 61508-2	☐ Type A	☑ Type B	
Operating mode	☑ Low Demand Mode	☑ High Demand	☐ Continuous Mode
Valid hardware version	Head transmitter: DIN rail device:	01.00.07 or higher 01.00.04 or higher	
Valid firmware version	01.01.10 or higher (Dev. Rev.: 2 or higher)		
SIL safety manual	70708000T99Z000K000 (German) 70708000T99Z001K000 (English) 70708000T99Z002K000 (French)		
Type of evaluation	☑	Complete HW/SW evaluation throughout development process, including FMEDA and change process according to IEC IEC 61508-2,3	
	☐	Evaluation regarding verification of HW/SW operational reliability, including FMEDA and change process according to IEC IEC 61508-2,3	
	☐	Evaluation of faulty HW/SW data to verify "earlier use" according to IEC 61511	
	☐	Evaluation by FMEDA according to IEC 61508-2 for devices without software	
Evaluation through certificate number	TÜV Süd Product Service GmbH, Germany, certificate no. Z10 17 05 01028 0001		
Inspection documents	Development documents, test reports, data sheets		

SIL integrity

Systematic safety integrity		☐ SIL 2 compatible	☑ SIL 3 compatible
Hardware safety integrity	Single-channel use (HFT = 0)	☑ SIL 2 compatible	☐ SIL 3 compatible
	Multi-channel use (HFT ≥ 1)	☐ SIL 2 compatible	☑ SIL 3 compatible

1 Safety-relevant parameters

FMEDA

	Head transmitter	**DIN rail device**
Safety function(s)	Min., max., range	Min., max., range
λ_{DU}[ab]	40 FIT	41 FIT
λ_{DD}[ab]	258 FIT	258 FIT
λ_{SU}[ab]	127 FIT	123 FIT
λ_{SD}[ab]	3 FIT	3 FIT
SFF - Safe Failure Fraction	91 %	90 %
PFD_{avg} for T1 = 1 year[b] (single-channel architecture)	1.75×10^{-4}	1.79×10^{-4}
PFD_{avg} for T1 = 5 years[b] (single-channel architecture)	8.76×10^{-4}	8.98×10^{-4}
PFH	$4.0 \times 10^{-8} \times 1/h$	$4.1 \times 10^{-8} \times 1/h$
PTC[c]	96 %	96 %
MTBF[d]	156 years	156 years
Diagnosis test interval[e]	32 min	32 min
Fault response time[f]	< 10.7 s	< 10.7 s
Process safety time[g]	53 h	53 h

a FIT = Failure In Time, number of failures in 10^9 h.

b Valid for average ambient temperatures up to +40 °C. A factor of 2.1 should be taken into account for an average permanent operating temperature approaching +60 °C.

c PTC = Proof Test Coverage (degree of diagnosis coverage for device faults during manual repeat tests).

d This value considers all types of failure in electronic components according to SN29500.

e In this period, all diagnostic functions are executed at least once.

f Maximum time between fault detection and response.

g The process safety time is calculated by multiplying the diagnosis test interval by 100 (calculation according to IEC 61508).

Explanation

Our in-house quality management team is verifying information regarding safety-relevant systematic errors to be announced in future.

1.1 Functional life of electrical components

The underlying failure rates of electrical components apply within their functional life according to IEC 61508-2:2010 Section 7.4.9.5 Item 3.

ZERTIFIKAT ◆ CERTIFICATE ◆ 認證證書 ◆ СЕРТИФИКАТ ◆ CERTIFICADO ◆ CERTIFICAT

Product Service

CERTIFICATE

No. Z10 001028 0002 Rev. 00

Holder of Certificate: **JUMO GmbH & Co. KG**
Moritz-Juchheim-Straße 1
36039 Fulda
GERMANY

Certification Mark:

Product: **Temperature measuring equipment**

Model(s): **Temperature Transmitter**
JUMO dTRANS T07 B SIL
JUMO dTRANS T07 B Ex SIL
JUMO dTRANS T07 T SIL
JUMO dTRANS T07 T Ex SIL

Parameters:

Systematic Capability:	SC3
Structure-SIL:	1oo1 - SIL2
Output:	4 ... 20mA
Error Current:	<=3.6mA or >=21.0mA
Class of Protection:	IP20
Temperature range:	-40°C ... +70°C

The report and the user documentation in the current valid revision are mandatory part of this certificate. The product complies with the following safety requirements only if the specifications documented in the currently valid revision of this report are met.

Tested according to:
IEC 61508-1:2010
IEC 61508-2:2010
IEC 61508-3:2010
IEC 61508-4:2010

The product was tested on a voluntary basis and complies with the essential requirements. The certification mark shown above can be affixed on the product. It is not permitted to alter the certification mark in any way. In addition the certification holder must not transfer the certificate to third parties. This certificate is valid until the listed date, unless it is cancelled earlier. All applicable requirements of the testing and certification regulations of TÜV SÜD Group have to be complied. For details see: www.tuvsud.com/ps-cert

Test report no.: CC-JF96677T
Valid until: 2026-03-31
Date, 2021-04-07

(Christian Dirmeier)

Page 1 of 1
TÜV SÜD Product Service GmbH • Certification Body • Ridlerstraße 65 • 80339 Munich • Germany

2 Certificate

3.1 How this document works

This document forms part of the operating manual and should be used as a reference for application-specific parameters and notes.

The structure of parameters within the "Operation", "Setup" and "Diagnostics" menus is described in detail in the device's operating manual.

NOTE!

General information on functional safety (SIL) is available in our specialist book FAS 630: "Functional Safety – Safety Integrity Level".

3.2 Symbols

3.2.1 Warning symbols

CAUTION!

This symbol in connection with the signal word indicates that **material damage or data loss** will occur if the respective precautionary measures are not taken.

3.2.2 Note symbols

NOTE!

This symbol refers to **important information** about the product, its handling, or additional benefits.

3.2.3 Symbols and descriptions for types of information

REFERENCE!

This symbol refers to **additional information** in other sections, chapters, or other manuals.

3.3 Other applicable device documentation

Document	Content of the document
Data sheet 707080 JUMO dTRANS T07	**Planning aid for the device** The document provides all technical data related to the device and an overview of all accessories that can be ordered for the device.
Operating manual JUMO dTRANS T07	These instructions contain information that is required in the various phases of the device's lifecycle: from product identification, product acceptance and storage to mounting, connection, basic operation, and startup, through to troubleshooting, maintenance and disposal.
Ex safety manual JUMO dTRANS T07	Safety information and technical data for electrical equipment for potentially explosive areas according to Directive 2014/34/EU (ATEX).

This safety manual applies in addition to the operating manual, data sheet and the Ex safety manual. The other applicable documents must be observed during installation, startup, and operation. Any deviating requirements for safety functions are described in this safety manual.

4 Admissible device types

The information in this manual related to functional safety applies to the device types listed below from the specified firmware and hardware versions. Unless specified otherwise, all of the following versions can also be applied to safety functions.

A modification process in line with IEC 61508 is applied in the event of changes to devices. Valid device types for safety-related use:

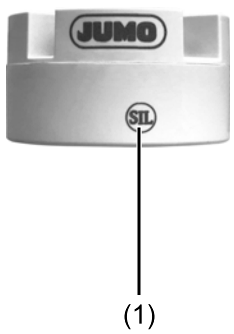
Type	Designation	Description
707081	dTRANS T07 B SIL	For installation in terminal head, form B, with SIL approval
707083	dTRANS T07 T SIL	For mounting on DIN rail, TS 35, with SIL approval
707086	dTRANS T07 B EX SIL	For installation in terminal head, form B, with Ex and SIL approval
707088	dTRANS T07 T Ex SIL	For mounting on DIN rail, TS 35, with Ex and SIL approval

Valid firmware version	From 01.01.10
Valid hardware version (electronics)	From 01.00.07 (head transmitter) From 01.00.04 (DIN rail device)
Valid device drives	DTM from version 1.9.0.396 DD from revision 04

NOTE!

SIL-certified devices are marked with an SIL symbol on their nameplate.

4.1 SIL identification marking on the nameplate

On the head transmitter	On the DIN rail device
	

(1) SIL symbol

4 Admissible device types

5.1 Definition of safety functions

Admissible safety functions in the device are as follows:

- Limit value monitoring, ⇨chapter 5.1.2 "Limit value monitoring", Page 13
- Safe measuring, ⇨chapter 5.1.3 "Safe measuring", Page 14

5.1.1 Safety-related output signal

The device's safety-related signal is the analog 4 to 20 mA output signal according to NAMUR NE43. All safety measures relate exclusively to this signal. Furthermore, the device communicates via HART® for information purposes and contains all HART® attributes with additional device information.

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

- Specified limit value is underrange/overrange
- Faults, e.g. error current (≤ 3.6 mA, ≥ 21 mA, interruption or short-circuit of the signal line)

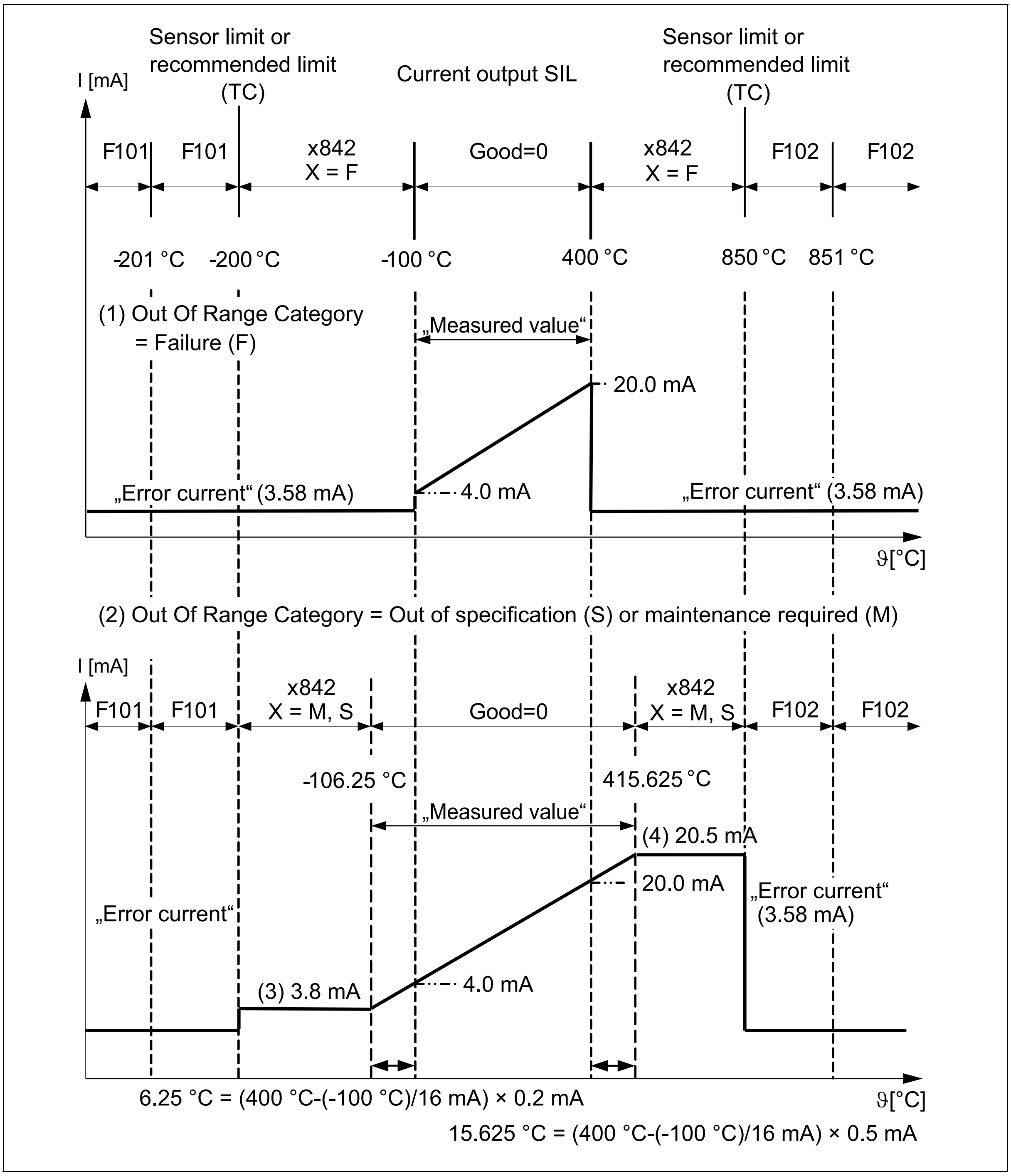
NOTE!

In SIL mode, the current output cannot be configured to an inverse appearance.

5.1.2 Limit value monitoring

The safety function is used to monitor the measured value. In SIL mode, an error or saturation current is emitted for a measurement outside of the measuring range defined by the user (X_{min} to X_{max}) depending on the configuration of the "Out Of Range Category" (F, S, M).

Example in the figure: $I_{4\ mA}$ = -100 °C, $I_{20\ mA}$ = +400 °C



(1) Out of range category curve = Failure status signal (F)

(2) Out of range category curve = Outside of specification (S) or maintenance required (M) status signal

(3) Lower saturation current

(4) Upper saturation current

5.1.3 Safe measuring

The temperature transmitter's safety function consists of emitting a current proportional to the voltage, resistance or temperature value at the output. To be able to use the safety function, the device must be configured using an operating tool and switched to SIL mode, ⇨ chapter 6.2 "Device parameterization for safety-related applications", Page 22

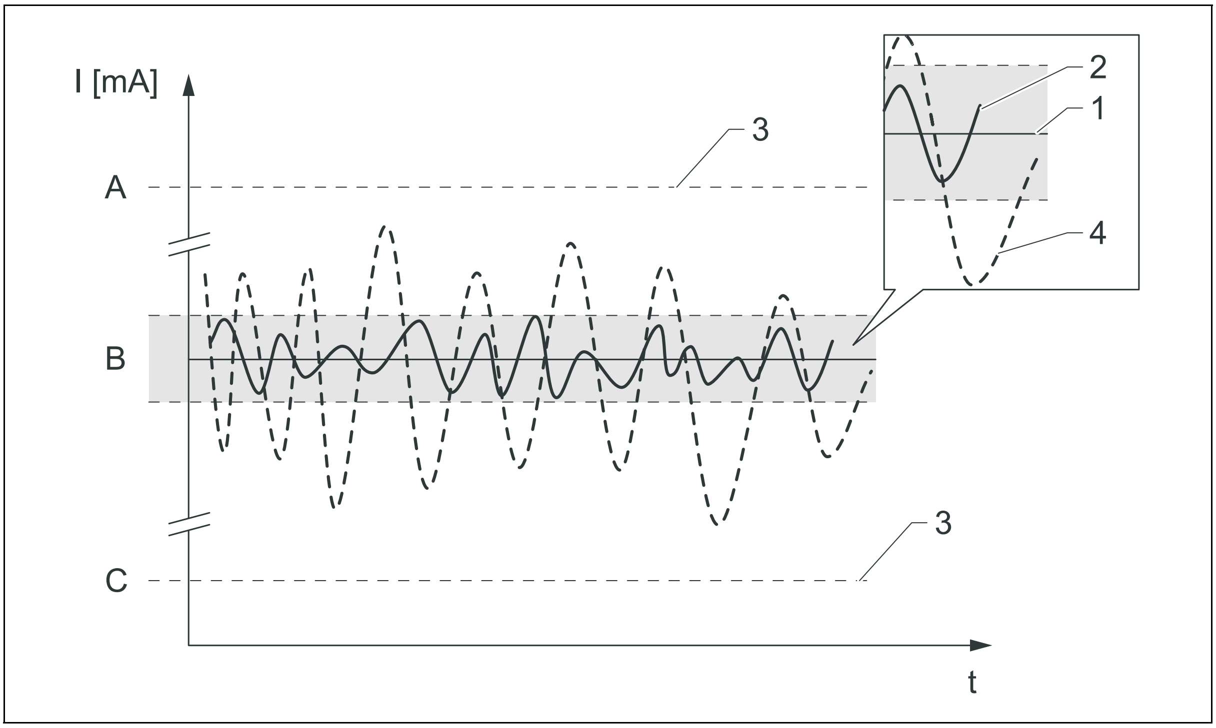
All safety functions can be used with all sensor configurations from chapter 8.1 "Structure of the measuring system", Page 41. When doing so, it is important to note that only the measured value from a sensor or the value for a function (average value/difference between two measured values) can ever be emitted. Limit value monitoring can be set up separately for the two inputs.

5.2 Restrictions for application in safety-related operation

- Make sure the measuring system is used in line with the application, taking into account the medium's properties and environmental influences; observe any notes concerning critical process situations and installation conditions from the operating manuals; comply with any application-specific restrictions
- Specifications regarding the safety-related signal, ⇨chapter 5.1.1 "Safety-related output signal", Page 13
- The specifications from the operating manuals must be observed, ⇨chapter 3.3 "Other applicable device documentation", Page 10
- Environmental influences according to IEC 61326-3-2 Annex B must be observed.
- Head transmitters must not be used as replacements for DIN rails (using the DIN rail clip) with offset sensors
- The FXA291 and TXU10 communications box cannot be used for increased configuration safety mode or expert mode (only with HART® communication)
- Set up the mains voltage frequency filter correctly (50 Hz/60 Hz)
- Maximum admissible sensor line resistance during voltage measurement: 1000 Ω
- During safety-related operation, the measured value "device temperature" must not be emitted as the first device variable (PV)
- The "sensor switchover" and "average value with backup" functions cannot be used for operation in safety-related mode
- Line resistance compensation is not possible for 2-wire measurements
- The following restriction also applies for safety-related operation: Strong, impulse-like EMC faults in the supply line may lead to brief (<1 s) deviations in the output signal (≥ ±1 %). Owing to this, a filter with a time constant of ≥ 1 s should be executed in the downstream logic unit. The tolerance band ⇨chapter 5.3 "Deviations in safety measurements", Page 17) is sensor specific and is defined as a default setting according to FMEDA (Failure Modes, Effects and Diagnostic Analysis). All of the influencing factors described in the Technical Information TI are already covered: non-linearity, non-repeatability, hysteresis, zero-point deviation, temperature drift. Safety-related faults are split into various categories according to IEC/EN 61508 (see table below). The table shows the effects on the safety-related output signal and measurement uncertainty.

Safety-related fault	Explanation	Effect on the safety-related output signal (Position, see figure below)
No device error	Safe: No error	1 Inside the specification
λ_{SD}	Safe detected: Safe and detectable error	3 Device switches to failure signal, ⇨Page 21
λ_{SU}	Safe undetected: Safe but undetectable error	2 Within the specified tolerance band, ⇨Page 17
λ_{DD}	Dangerous detected: Dangerous but detectable error (diagnosis in device)	3 Device switches to failure signal, ⇨Page 21

Safety-related fault	Explanation	Effect on the safety-related output signal (Position, see figure below)
λ_{DU}	Dangerous undetected: Dangerous and undetectable error	4 Potentially outside the specified tolerance band, ⇨Page 17



A High alarm ≥ 21 mA

B Tolerance band, ⇨chapter 5.3 "Deviations in safety measurements", Page 17

C Low alarm ≤ 3.6 mA

NOTE!

HART® communication

Even when it is in SIL mode, the temperature transmitter communicates via HART®. This includes all supported HART® attributes with additional device information. HART® communication is not part of the safety function. Further information ⇨chapter 8.3.2 "Secure HART®", Page 51.

NOTE!

Use shielded supply lines (see applicable operating manual).

5.2.1 Dangerous undetected errors

A "dangerous undetected error" is an incorrect output signal that deviates from the value specified in the manual, whereby the output signal remains in the range from 4 to 20 mA, ⇨chapter 5.2 "Restrictions for application in safety-related operation", Page 15

5.3 Deviations in safety measurements

Thermocouples

Standard	Designation	Min. measuring span	Restricted safety measuring range	Measurement deviation (+A/D), -40 to +70 °C	Measurement deviation (D/A)	Long-term drift in °C/year[a]
IEC 60584-1	Type A (30) (W5Re-W20Re)	50 K	0 to 2500 °C	12 K	0.5 % of the measuring span	1.42
	Type B (31) (PtRh30-PtRh6)		500 to 1820 °C	5.1 K		2.01
	Type E (34) (NiCr-CuNi)		-150 to +1000 °C	4.9 K		0.43
	Type J (35) (Fe-CuNi)		-150 to +1200 °C	4.9 K		0.46
	Type K (36) (NiCr-Ni)		-150 to +1200 °C	5.1 K		0.56
	Type N (37) (NiCrSi-NiSi)		-150 to +1300 °C	5.5 K		0.73
	Type R (38) (PtRh13-Pt)		50 to 1768 °C	5.6 K		1.58
	Type S (39) (PtRh10-Pt)		50 to 1768 °C	5.6 K		1.59
	Type T (40) (Cu-CuNi)		-150 to +400 °C	5.2 K		0.52
IEC 60584-1; ASTM E988-96	Type C (32) (W5Re-W26Re)		0 to 2000 °C	7.6 K		0.94
ASTM E988-96	Type D (33) (W3Re-W25Re)		0 to 2000 °C	7.1 K		1.14
DIN 43710	Type L (41) (Fe-CuNi)		-150 to +900 °C	4.3 K		0.42
	Type U (42) (Cu-CuNi)		-150 to +600 °C	5.0 K		0.52
GOST R8.8585-2001	Type L (43) (NiCr-CuNi)		-200 to +800 °C	8.4 K		0.53

[a] Specified at 25 °C, values must be extrapolated for other temperatures if necessary

Voltage sensor

Standard	Designation	Min. measuring span	Restricted safety measuring range	Measurement deviation (+A/D), -40 to +70 °C	Measurement deviation (D/A)	Long-term drift in µV/year[a]
--		5 mV	-20 to +100 mV	200 µV		27.39

[a] Specified at 25 °C, values must be extrapolated for other temperatures if necessary

Resistance sensors

Standard	Designation	Min. measuring span	Restricted safety measuring range	Measurement deviation (+A/D), -40 to +70 °C	Measurement deviation (D/A)	Long-term drift in °C/year[a]
IEC 60751: 2008	Pt100 (1)	10 K	-200 to +600 °C	1.1 K	0.5 % of the measuring span	0.23
	Pt200 (2)		-200 to +600 °C	1.6 K		0.92
	Pt300 (3)		-200 to +500 °C	0.9 K		0.38
	Pt1000 (4)		-200 to +250 °C	0.6 K		0.19
JIS C1604:1984	Pt100 (5)		-200 to +510 °C	1.0 K		0.32
DIN 43760 IPTS-68	Ni100 (6)		-60 to +250 °C	0.4 K		0.22
	Ni120 (7)		-60 to +250 °C	0.3 K		0.18
GOST 6651-94	Pt50 (8)		-180 to +600 °C	1.3 K		0.61
	Pt100 (9)		-200 to +600 °C	1.2 K		0.34
OIML R84: 2003, GOST 6651-2009	Cu50 (10)		-180 to +200 °C	0.7 K		0.46
	Cu100 (11)		-180 to +200 °C	0.5 K		0.23
	Ni100 (12)		-60 to +180 °C	0.4 K		0.21
	Ni120 (13)		-60 to +180 °C	0.3 K		0.18
OIML R84: 2003, GOST 6651-94	Cu50 (14)		-50 to +200 °C	0.7 K		0.45
Potentiometers Ω	400 Ω	10 Ω	10 to 400 Ω	0.5 Ω		0.096 Ω/a
	2000 Ω	100 Ω	10 to 2000 Ω	2.1 Ω		0.51 Ω/a

[a] Specified at 25 °C, values must be extrapolated for other temperatures if necessary

Potentiometers

Standard	Designation	Min. measuring span	Restricted safety measuring range	Measurement deviation (+A/D), -40 to +70 °C	Measurement deviation (D/A)	Long-term drift in Ω/year[a]
--	400 Ω	10 Ω	10 to 400 Ω	0.5 Ω	0.5 % of the measuring span	0.096
	2000 Ω	100 Ω	10 to 2000 Ω	2.1 Ω		0.51

[a] Specified at 25 °C, values must be extrapolated for other temperatures if necessary

This information does not take any deviations caused by EMC into account. In the event of non-negligible EMC faults, an additional 1 % deviation from the measuring span must be added to the values above.

CAUTION!

Please note the following when using 2-wire resistance measurement – valid from hardware version 01.00.07 (head transmitter) and 01.00.05 (DIN rail device):

- Perform the necessary calibration of the line resistance by correcting the offset.
- Add an additional 5 °C error to the values for the safety measurement deviations.

Sample calculation with Pt100 (9), measuring range 0 to 100 °C, ambient temperature 25 °C, voltage supply 24 V:

Digital measurement deviation = 1.2 K

Measurement deviation D/A = 0.5 % × 100 °C = 0.5 K

Measured value deviation: 1.7 K; assume the worst possible value for safety measurement deviations.

Validity of specifications regarding safety measurement deviation:

- Total admissible temperature range for the transmitter in SIL mode
- Defined voltage supply range
- Restricted safety measuring range for the sensor element
- Accuracy includes all linearization and rounding errors
- Observe minimum measuring span for each sensor
- Housing designs of DIN rail and head transmitters
- Specifications are 2σ values, i.e. 95.4 % of all measured values are within specifications

6.1 Device response during operation

NOTE!

Once the SIL has been locked, further diagnosis functions are active and critical parameters for the safety path are switched to safe values. The device may therefore respond differently depending on whether it is in "SIL locked state" or "SIL not locked state". If a test phase occurs before the plant finally goes live, we recommend running this in SIL locked mode to ensure maximum applicability.

6.1.1 Device response when switching on

After switch-on, the device runs through a diagnostic phase; during this period, the current output is the error current (low alarm).

During the diagnostic phase, the device cannot communicate via the service interface (CDI) or HART®.

Device response when switching on depending on the parameterization

Parameter "SIL HART® mode"	**Parameter "SIL startup mode"**	
	On	Off
On	Approx. 30 s start time - SIL measuring mode	Wait for input of SIL checksum
Off	Approx. 120 s start time - SIL measuring mode	Wait for input of SIL checksum
	During this time, SIL mode can be cancelled by entering an SIL checksum of 0	

6.1.2 Device response when requesting the safety function

The device emits a current value corresponding to the limit value to be monitored; this current value must be monitored and processed in a connected logic unit.

6.1.3 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 automatically initiated
In the active safe state, the transmitter can continue to communicate via HART®, though the current output permanently emits an error current. This state remains in place until the transmitter restarts. All parameters can be read and non-safety-relevant parameters can be amended.	In the passive safe state, the transmitter cannot communicate via HART®. The system stops straight away and restarts again a maximum of 0.5 s. The device does not emit any more error messages. Parameters can no longer be amended.

Depending on the error detected, the system assumes one of the two states. The system only continues to work without triggering an automatic restart in the active safe state.

6.1.4 Device response to alarms and warnings

In the event of an alarm, the output current is ≤ 3.6 mA. In some cases (e.g. short circuit in the feed line), output currents ≥ 21 mA occur, regardless of the defined error current.

To monitor alarms, the downstream logic unit must be able to detect high alarms (≥ 21 mA) and low alarms (≤ 3.6 mA).

6.1.5 Alarms and warnings

The alarms and warnings emitted on the on-site display or operating tool in the form of diagnostic events and corresponding event texts provide additional information.

NOTE!

An overview of diagnostic events is provided in the operating manual for dTRANS T07.

The following diagnostic events (which can be configured in normal mode) lead to the active safe state in SIL mode, causing the error current to be emitted:

- Temperature is above/below the admissible ambient temperature (diagnostic message F925)
- Sensor corrosion (diagnosis F042)

NOTE!

When the device is transferred to SIL mode, additional diagnostic functions are activated (e.g. a comparison of the fed-back output current against the setpoint value). If one of these diagnoses causes an error message (e.g. F041 sensor breakage), an error current is emitted. Once the error has been rectified, the device has to be restarted.

To restart

1. Briefly disconnect the device from the voltage supply or
2. Send a corresponding command via HART® or execute a similar function in the operating tool.

If the device is then restarted, a self-test is carried out and the error message is reset if necessary.

6.2 Device parameterization for safety-related applications

If the devices are used in PLT safety-related systems, the device parameterization must meet two requirements:

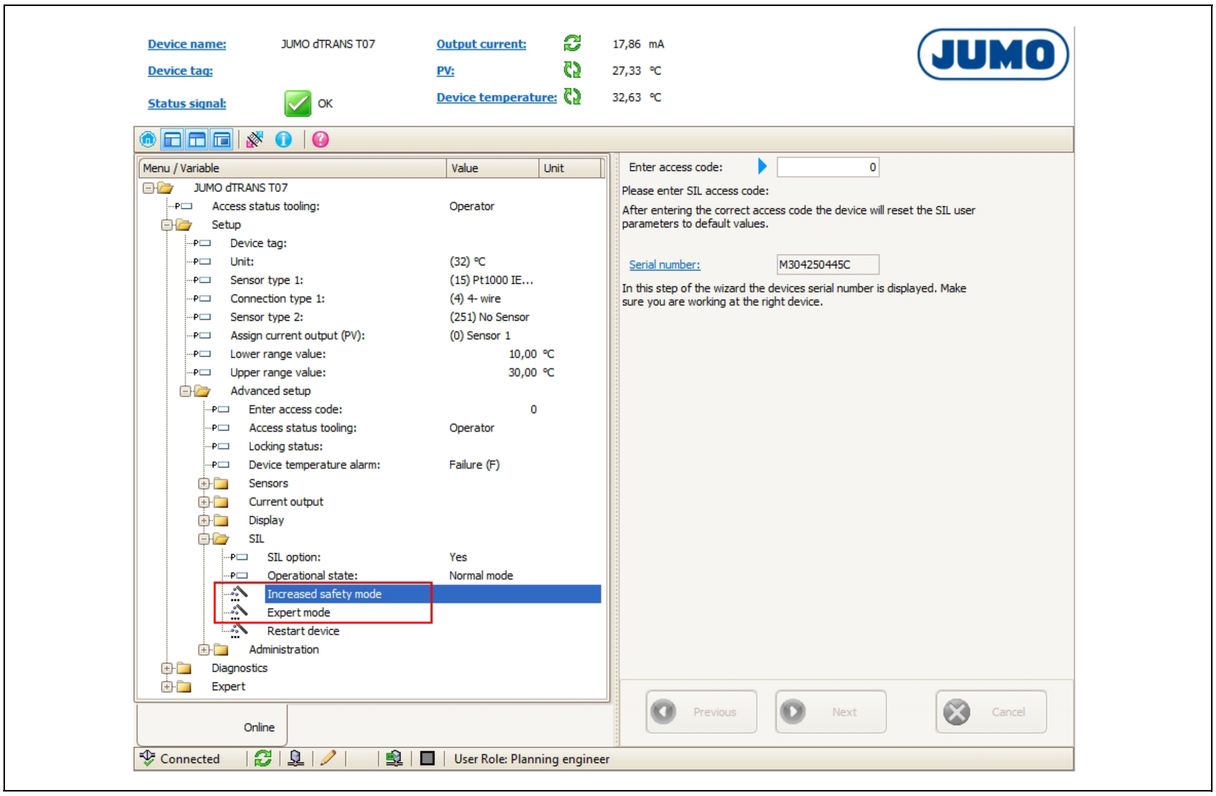
- Confirmation concept:
  Verified, independent inspection of the safety-relevant parameters entered.
- Locking concept:
  Locking of the device after completed parameterization (according to IEC 61511-1 chap. 11.6.4).

To activate SIL mode, an operating sequence must be completed, where operation can take place in the Asset Management Tool (e.g. FieldCare, Pactware, AMS, PDM, Field Communicator 375/475); device driver files (DD or DTM) are available for this tool.

Two methods are available for device parameterization; the main difference between these two methods lies in the confirmation concept:

- **"Increased parameterization safety mode" (safe parameterization = SiPA)**
  When increased parameterization safety mode is launched, all safety-relevant parameters are switched to defined values and the transmitter is configured using guided safe parameterization. A restricted parameter block is available for selection.
- **"Expert mode" (SIL mode activation = SiMA)**
  In this case, the current settings for the transmitter are adopted for SIL mode (restrictions ⇨chapter 8.3.1 "Parameter and default settings for SIL mode", Page 49). This allows defined or preconfigured settings to be used for suitable applications.

Device parameterization mode: Increased parameterization safety mode and expert mode



Both modes are described in detail in the following sections. Increased parameterization safety mode can only be executed in SIL devices (types 707081, 707083, 707086 and 707088) and expert mode can only be executed via HART®. For this reason, only these devices can be used in safety-related systems.

NOTE!

Parameterization of an SIL device must be documented!
The configured parameters must be entered into the "Selected value" column. The date, time and displayed SIL checksum must be noted.

The "Startup or repeat test protocol" is suitable for this purpose, ⇨chapter 8.2 "Startup or repeat test protocol", Page 44

The SIL checksum can be used to verify the selected parameters in multiple devices.

In general, it is important to make sure that burst and multidrop modes are deactivated.

6.2.1 Increased parameterization safety mode, safe parameterization = SiPA

Depending on the operating tool used and the language selected, the user interface may differ from the one shown in the figures. The time stamp entered at the end of safe parameterization can be accessed via the **Timestamp SIL configuration** parameter when SIL mode is active.

Following transfer to the device, each parameter can be extracted again and displayed. You must then confirm that the displayed value matches the entered value. The fed-back value also contains the static text "#END" at the end. A table allocating figures to the parameters can be found in the annex of this safety manual, ⇨ chapter 8.3.6 "Figure allocation for parameters", Page 67.

NOTE!

Termination of safe parameterization
During the safe parameterization process, the transmitter emits an error current ≤ 3.6 mA (low alarm). If an error occurs during safe parameterization or if the result of a parameter check is negative, safe parameterization is not performed successfully and has to be repeated.

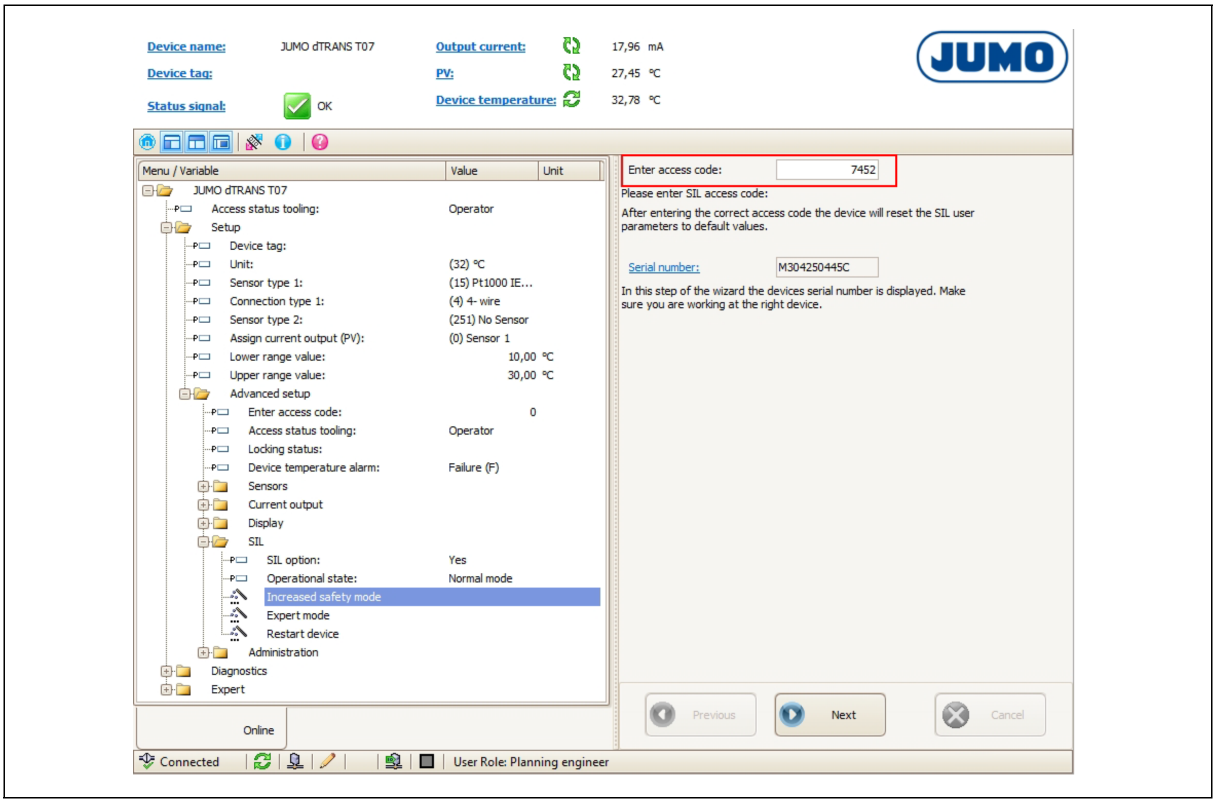
Safe parameterization process

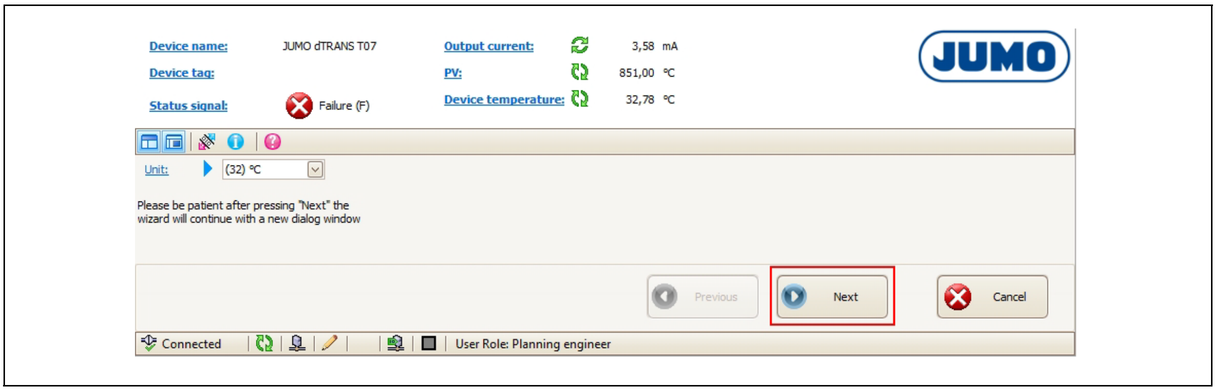
1. Safe parameterization can only be carried out in online mode. Go to the **Setup** → **Advanced setup** → **SIL** sub-menu and start safe parameterization using the **Increased safety mode** wizard.

   *The **access code** window appears.*

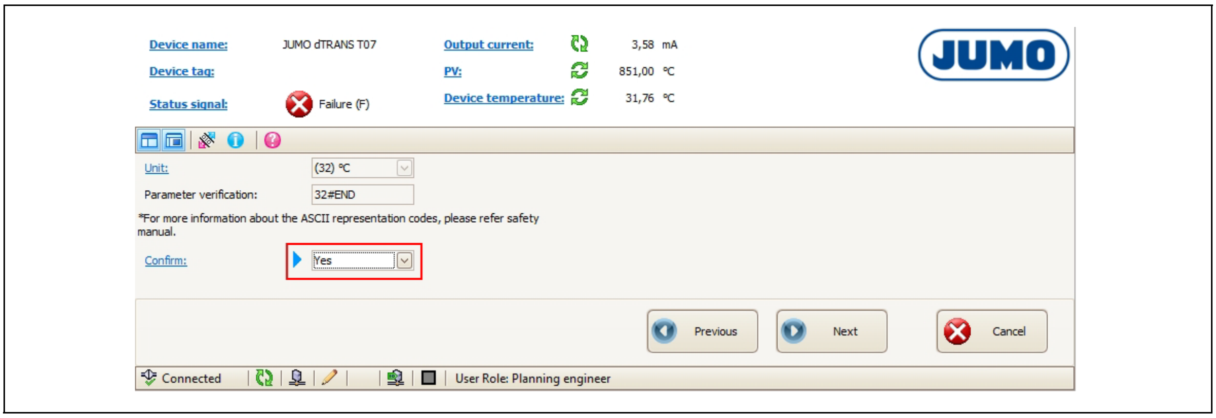
2. In the **Enter access code** input field, enter the code **7452** and confirm with the ENTER key. Continue by pressing the NEXT key.

   The safety-relevant parameters are reset to their default settings, ⇨ chapter 8.3.1 "Parameter and default settings for SIL mode", Page 49.
   The input windows for the device settings then open in the defined order, starting with measurement units.





3. Check the parameters listed in the subsequent windows. If they match, select YES for **Confirm** and confirm with the ENTER key. Continue by pressing the NEXT key.

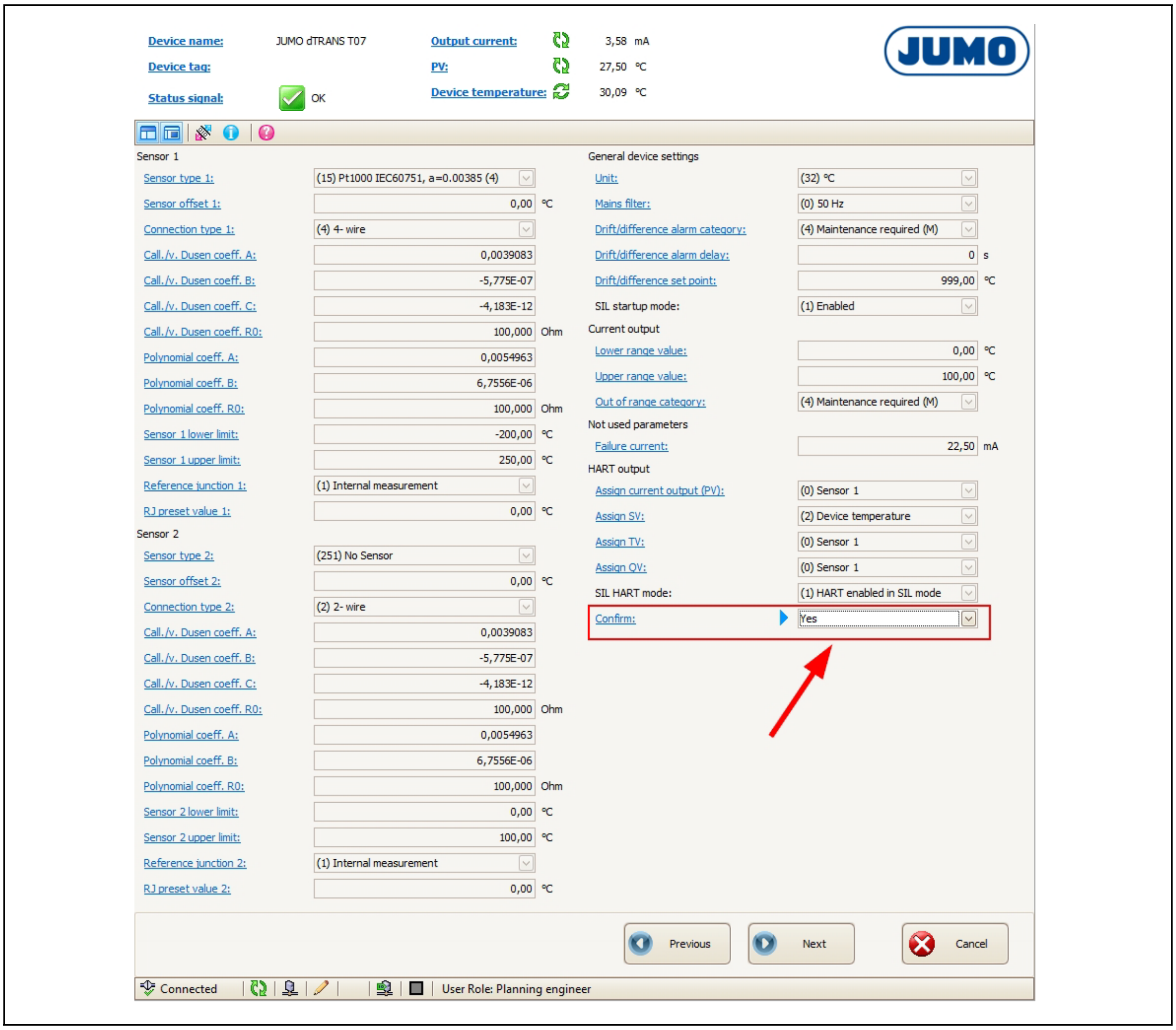


NOTE!

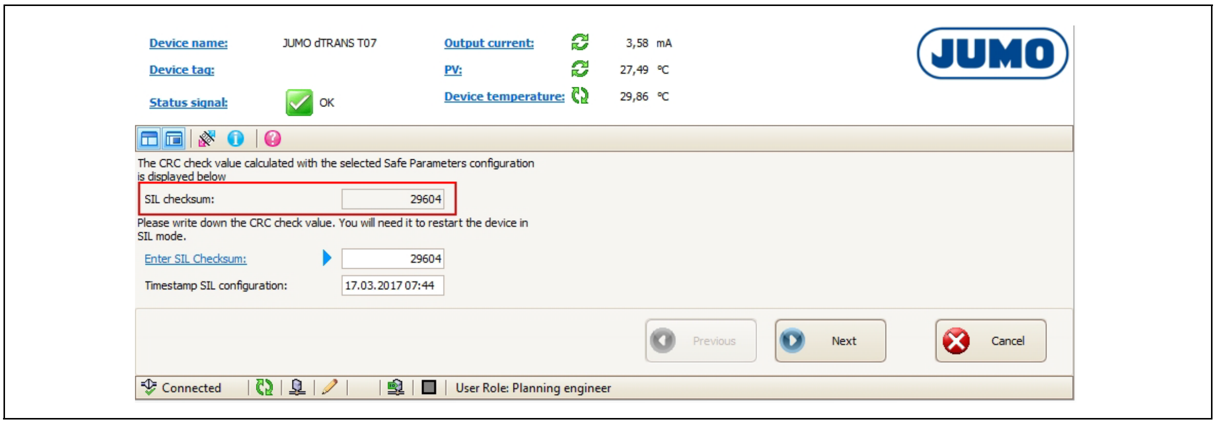
If the unit Fahrenheit (°F) or Rankine (°R) is selected for Callendar-Van Dusen sensors or polynomial copper/nickel sensors, the stored parameter value may deviate from the entered parameter value by 0.01 °F or °R during the parameter check. This deviation may occur for the following parameters: Start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

Once you have entered all safety-relevant parameters, you are given an overview of all default values that cannot be amended. Following confirmation, all of the safety-relevant parameters entered are displayed again for a final check.

4. If all the settings are correct, select YES for **Confirm** and confirm with the ENTER key. Continue by pressing the NEXT key.

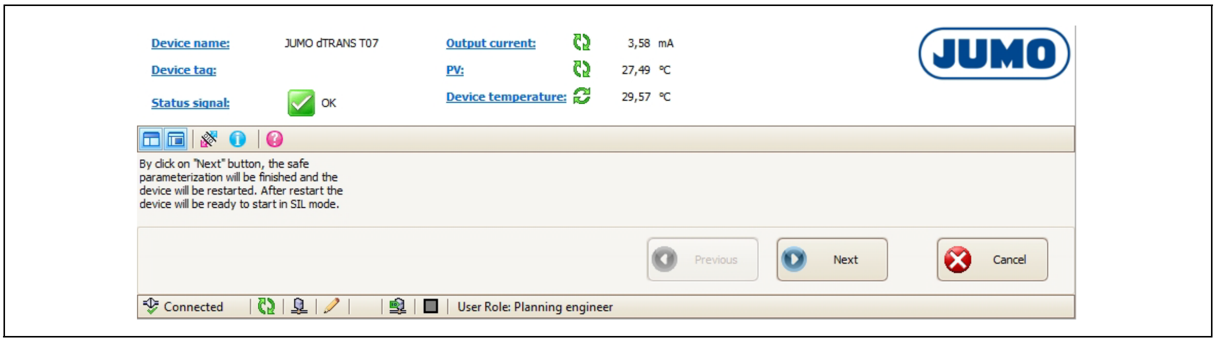


5. Enter the displayed SIL checksum into the **SIL checksum** field and fill out the **Timestamp SIL configuration** field using the current date and time. Confirm your entries with the ENTER key. Continue by pressing the NEXT key.



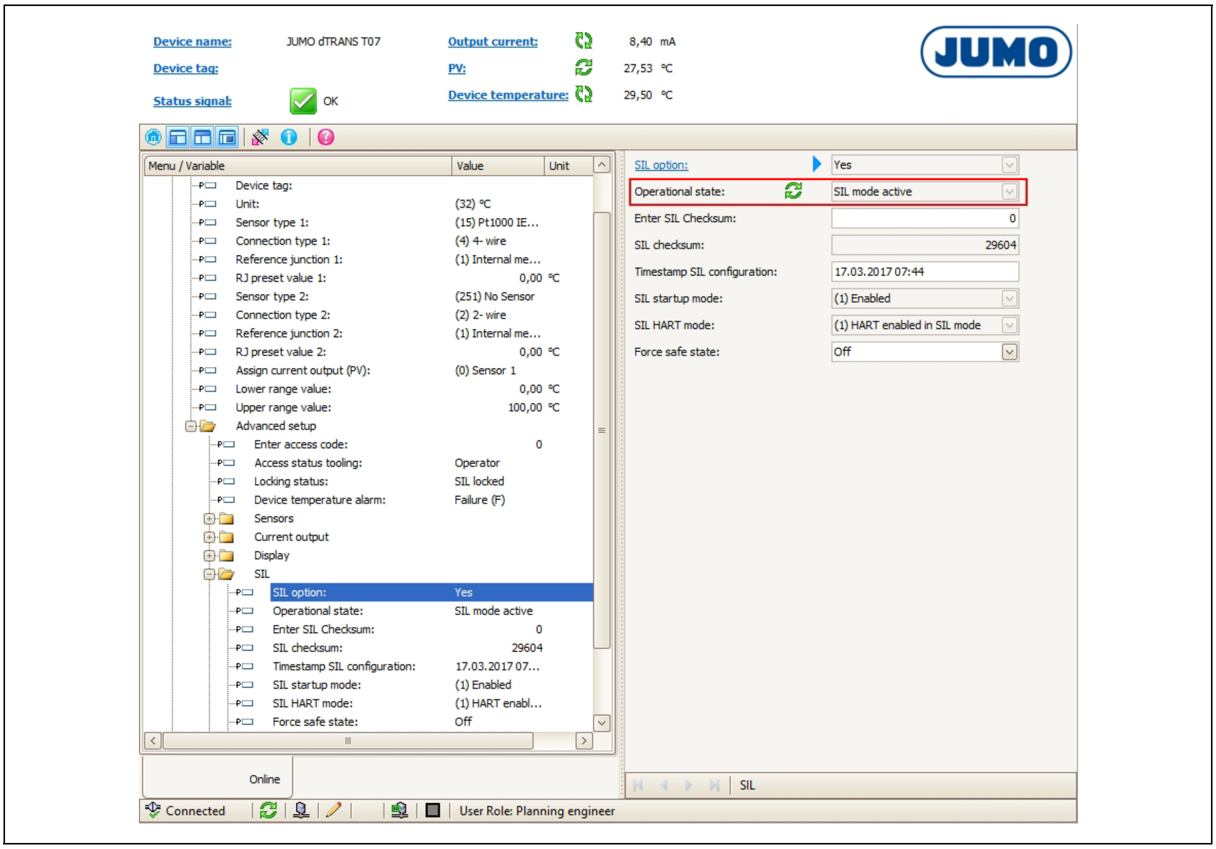
NOTE!

The value in the SIL checksum display is needed to activate SIL mode if the "SIL startup mode" parameter is switched to DEACTIVATED.
Always make sure you make a note of the value in the SIL checksum display in the documentation for this measuring point.



Safe parameterization is complete. Once you have confirmed by pressing the NEXT key, the device automatically restarts in SIL mode, ⇨chapter 6.1 "Device response during operation", Page 21.

6. Checking the operational status



Check the transmitter's operating status (**SIL mode active**) before using it in a safety-related system.

7. Before starting up the transmitter in SIL mode, you must perform a startup check, ⇨chapter 6.3 "Startup and repeat tests", Page 32.

6.2.2 Expert mode, SIL mode activation = SiMA

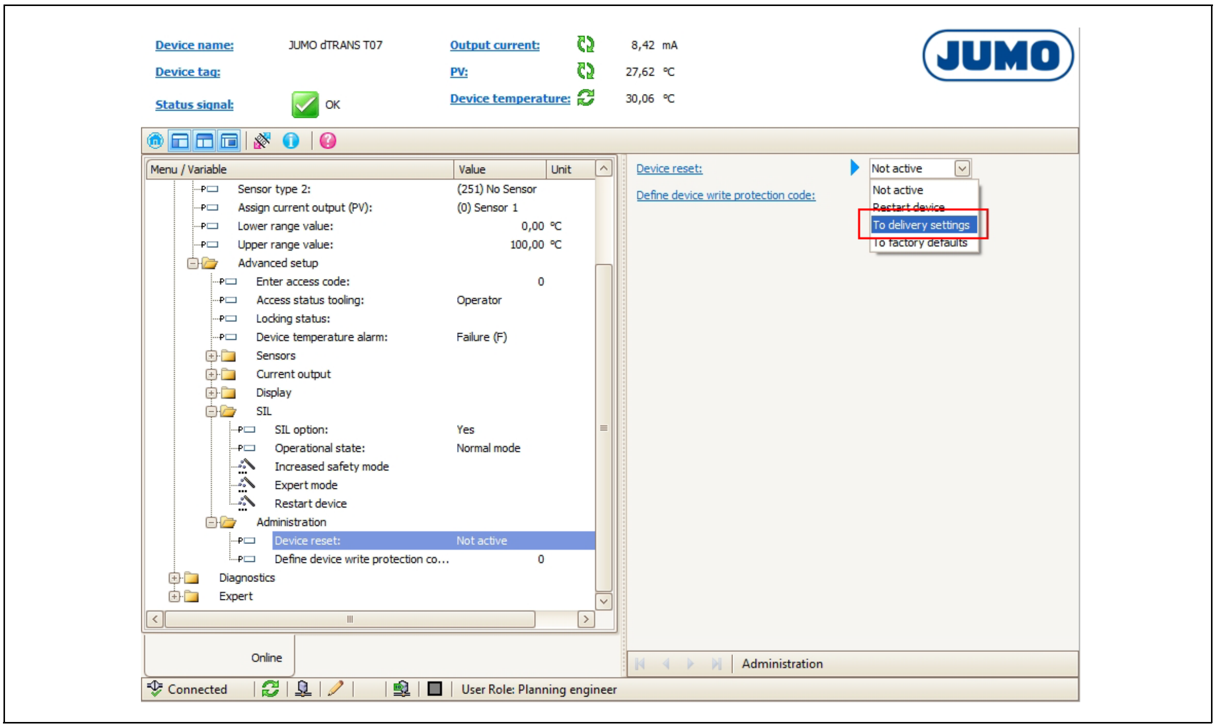
Depending on the operating tool used and the language selected, the user interface may differ from the one shown in the figures.

NOTE!

Termination of SIL mode activation
During the SIL mode activation process in expert mode, the transmitter emits an error current ≤ 3.6 mA (low alarm). If an error occurs during SIL mode activation in expert mode or if the process is terminated, SIL mode activation is not performed successfully and has to be repeated.

SIL mode activation process

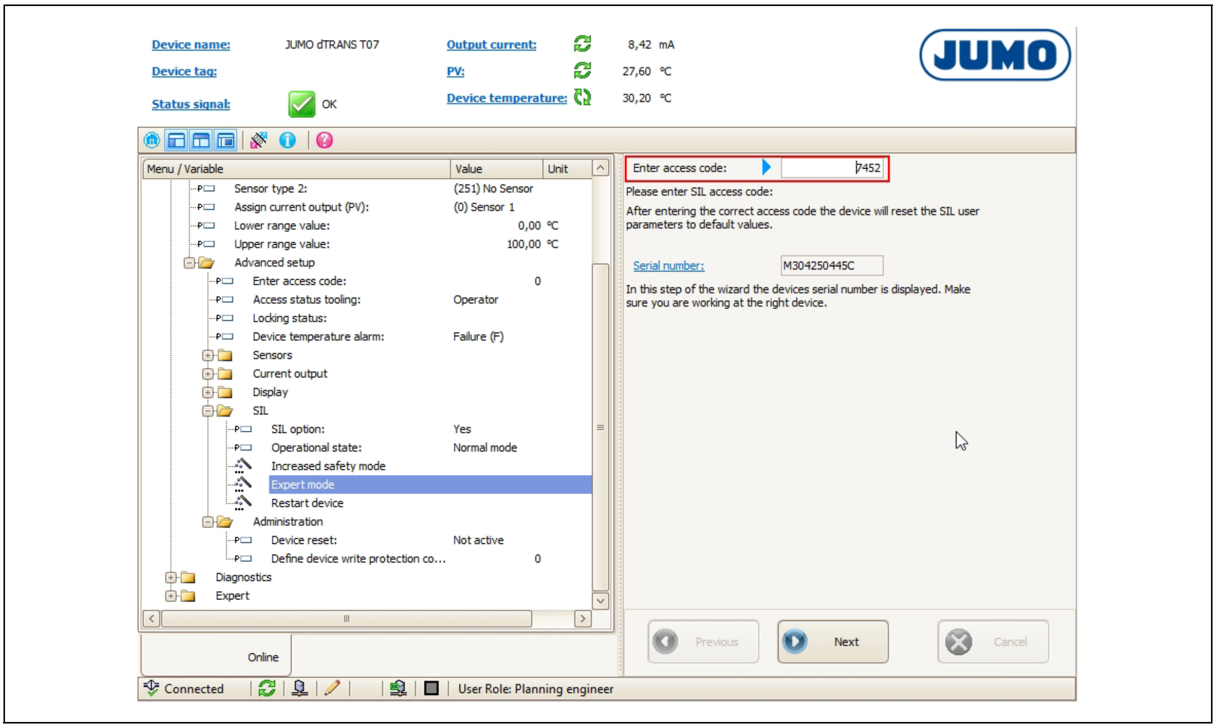
1. If the transmitter is not in its original delivery state, please perform the following steps: Go to the Setup → Advanced Setup → Administration menu and select TO DELIVERY SETTINGS under **Device reset**.



2. Confirm by pressing the ENTER key.
3. Configure the transmitter as required for application in the safety-related system. For this, you can use any of the tools that support the device.

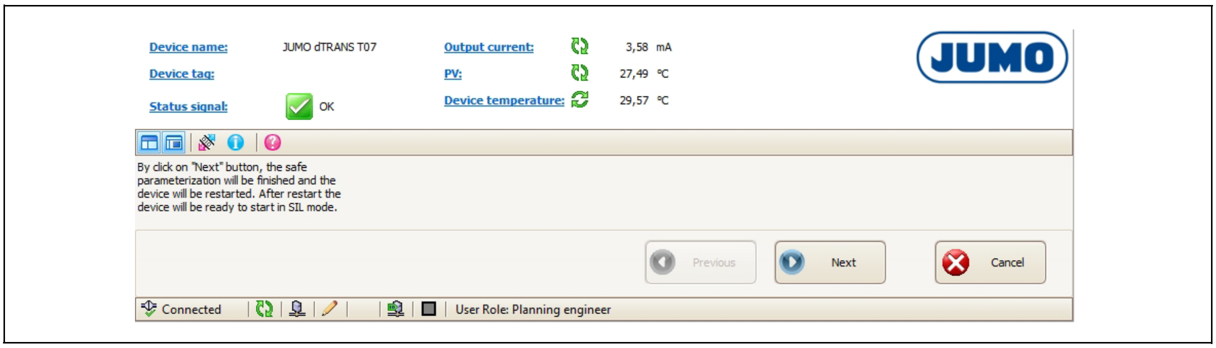
4. SIL mode activation can only be performed in online mode using HART® communication. Go to the Setup → Advanced Setup → SIL menu and start the **Expert mode** wizard.

   *The **Expert mode** wizard opens.*



5. In the **Enter access code** input field, enter the code **7452** and confirm with the ENTER key. Continue by pressing the NEXT key.

   The parameters relevant to device safety that cannot be changed in SIL mode are reset to their default settings, ⇨chapter 8.3.1 "Parameter and default settings for SIL mode", Page 49. All other safety-relevant parameters are adopted by the device and protected against manipulation.



6. Once you have confirmed by pressing the NEXT key, the device automatically restarts in SIL mode.

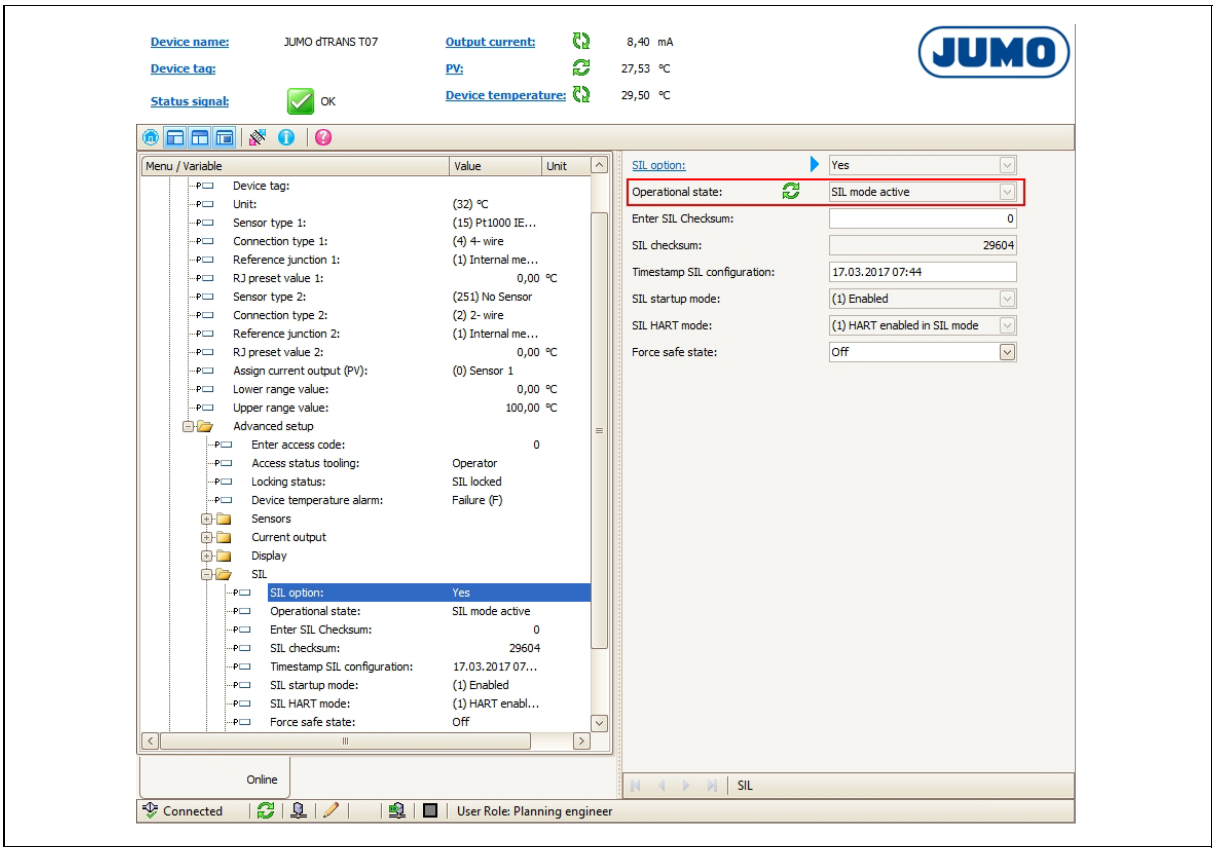
   SIL mode activation in expert mode is complete.

7. The **Timestamp SIL configuration** parameter can be changed to the latest value in SIL mode.

8. Note the **SIL checksum** in the startup protocol. This can be used to verify the settings in multiple devices.

9. Checking the operational status

   Check the transmitter's operating status (**SIL mode active**) before using it in a safety-related system.



10. Before starting up the transmitter in SIL mode, you must perform a startup check, see page 34.

NOTE!

The transmitter's current settings in SIL mode can be checked using handheld controller FC475, for example.

Parameters to be checked	Sequence of function keys on FC475 (HART® 7)
Operating status (SIL mode active)	3 - 3
Start of measuring range (4 mA)	3 - 6 - 3
End of measuring range (20 mA)	3 - 6 - 4
PV	3 - 7 - 3 - 1
Sensor type 1	1 - 3
Sensor type 2	1 - 7
Connection type 1	1 - 4
Connection type 2	1 - 8
Sensor offset 1	3 - 5 - 1 - 5
Sensor offset 2	3 - 5 - 2 - 5
Unit	1 - 2
Mains frequency filter	3 - 4 - 4

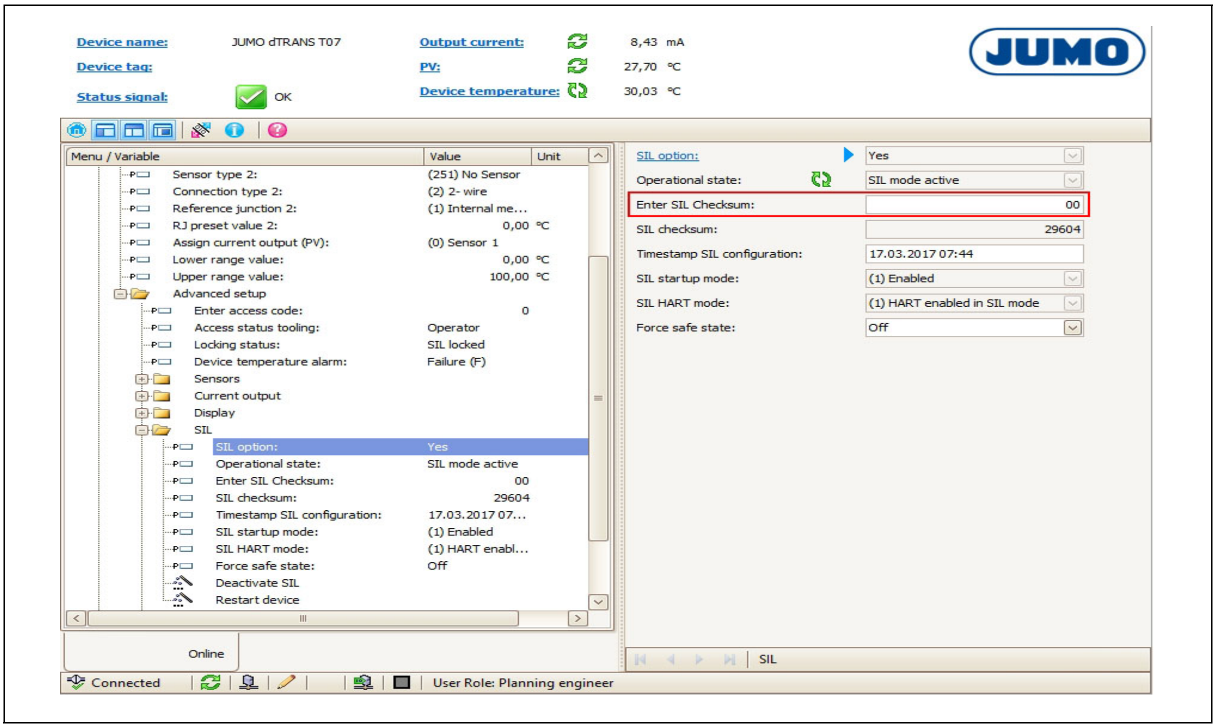
6.2.3 Deactivation of SIL mode

Two options are available (A or B) to deactivate SIL mode. Before doing so, switch off the transmitter's hardware write protection.

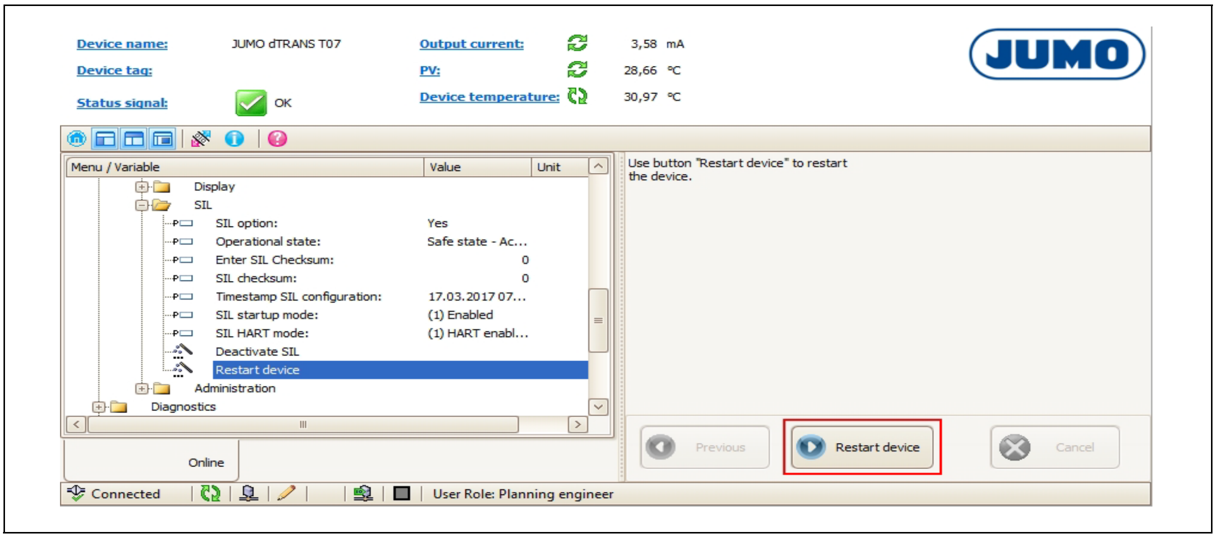
NOTE!

This process is described in the corresponding operating manual.

1. A) Enter the digits 00 into the **SIL checksum field**.

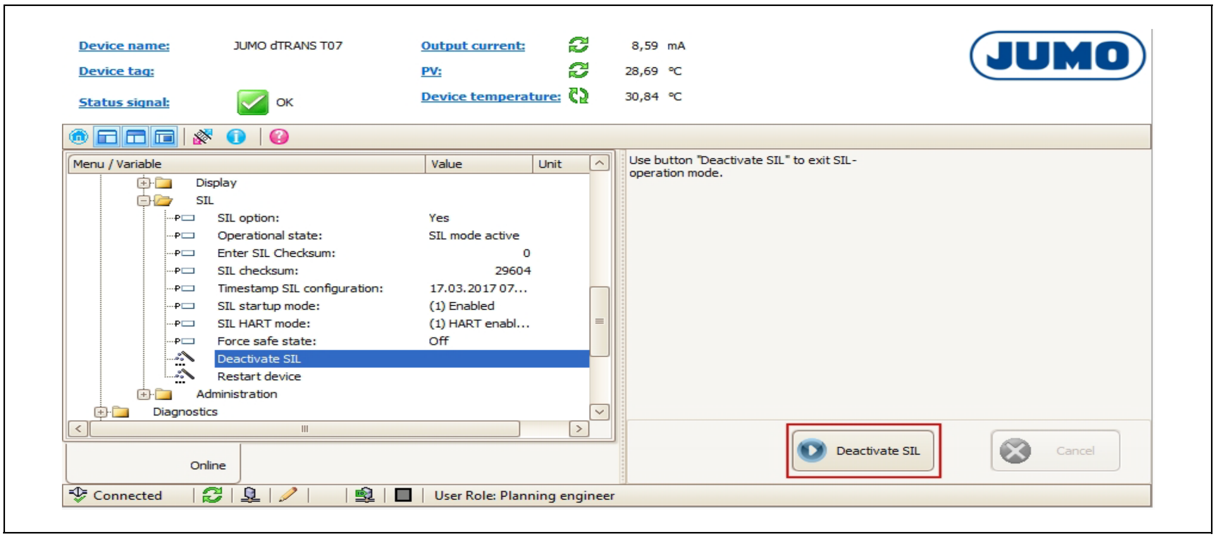


2. Confirm by pressing the ENTER key.
3. Select the **Restart device** wizard (menu Setup → Advanced Setup → SIL → Restart device).
4. Perform a device restart: Click the **Restart device** button. Alternative: disconnect the power supply for the transmitter.

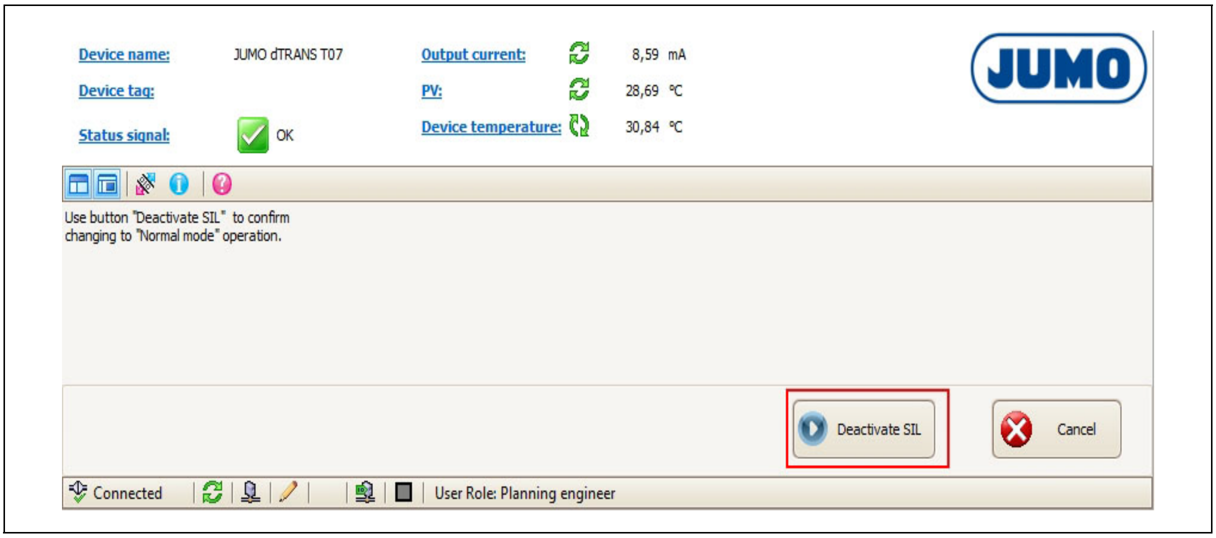


Once restarted, the device is no longer in safe mode (normal mode). To switch back to SIL mode, safe parameterization (SiPA), or SIL mode activation (SiMA) must be restarted at this point, ✍chapter 6.2 "Device parameterization for safety-related applications", Page 22.

5. B) Start the **Deactivate SIL** wizard in the submenu: **Setup - Advanced Setup - SIL.**



6. Press the "Deactivate SIL" key again.



Following an automatic restart, the device is no longer in safe mode (normal mode).

NOTE!

By terminating SIL mode, diagnostic functions are deactivated and the device can no longer run the safety function. For this reason, suitable measures must be used to ensure that no hazards can arise while SIL mode is deactivated.
If HART® communication is switched off in SIL mode (parameter "SIL HART® mode" = deactivated), restart the device. During the transmitter's starting phase, deactivation methods A and B are available for 120 s (HART® is active during this period). To switch back to SIL mode, safe parameterization (SiPA, ✍chapter 6.2.1 "Increased parameterization safety mode, safe parameterization = SiPA", Page 23, or SIL mode activation (SiMA), ✍chapter 6.2.2 "Expert mode, SIL mode activation = SiMA", Page 28, must be performed again.

6.3 Startup and repeat tests

The functionality of the transmitter in SIL mode must be checked upon startup, in the event of changes to safety-relevant parameters following SiMA or SiPA, and at regular intervals.

NOTE!

The safety function is not safeguarded during a startup or repeat test. Suitable measures must be used to guarantee process reliability during the test.
The safety-related output signal 4 to 20 mA must not be used for the safety-related system during the test.
Completed tests must be documented; the form in the annex can be used for this purpose, ⇨chapter 8.2 "Startup or repeat test protocol", Page 44.

6.3.1 Repeat test for the safety function

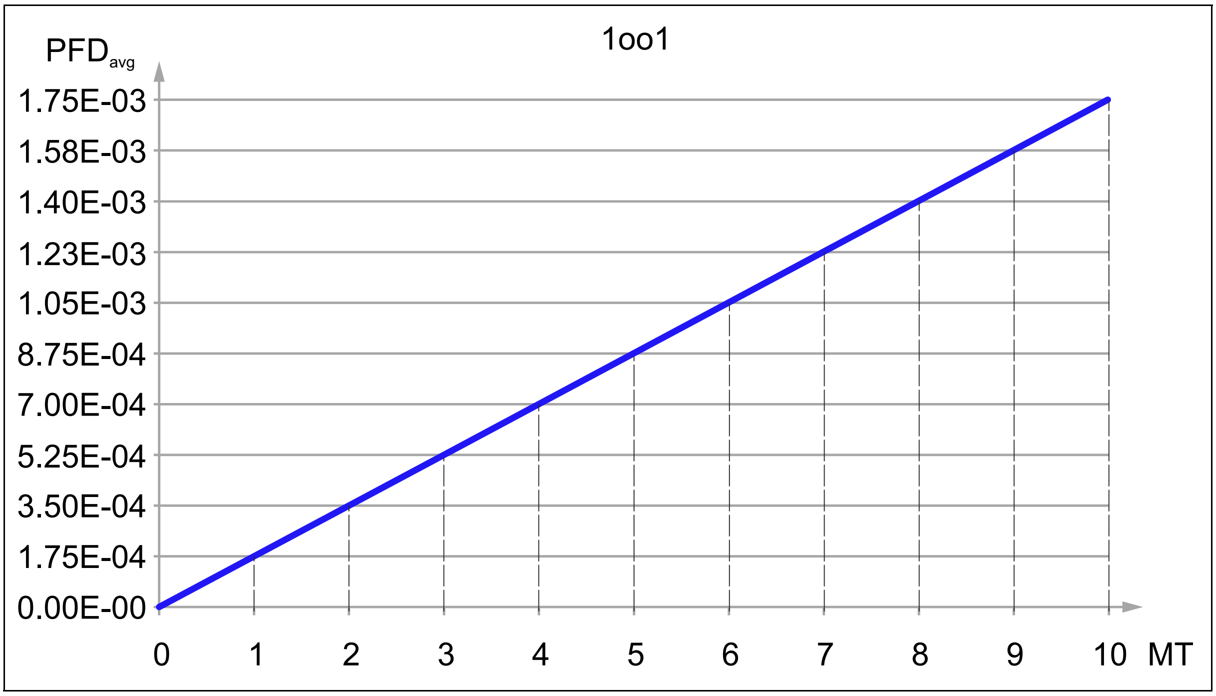
1. Check the safety function for functionality at regular intervals.
2. The operator defines the test interval and this must be taken into account when evaluating the failure probability PFD_{avg} for the sensor system.
   When using single-channel system architecture, the transmitter's average failure probability PFD_{avg} is calculated from the test interval T_i, the failure rate of hazardous, undetectable errors λ_{du}, the proof test coverage PTC, and the assumed lifetime, approximating to:

   $$PFD_{avg} \approx \tfrac{1}{2}\,\lambda_{DU} \times T_i \times PTC + \tfrac{1}{2} \times \lambda_{DU} \times MT \times (1-PTC)$$

3. The operator also defines the process for the repeat test.

NOTE!

According to IEC 61511, a separate repeat test of sub-systems, e.g., the transmitter, is admissible as an alternative to testing the safety function of the overall system. Average failure probability and lifetime PFD_{avg} for a single-channel system (without performing repeat tests).



(1) MT: Lifetime in years

(2) PFD_{avg}: Average probability of a dangerous failure on demand

(3) 1oo1: Single-channel architecture

6.3.2 Startup or repeat tests for the transmitter

If there are no operator-specific requirements regarding repeat tests, the following process can be used as an alternative for testing the transmitter depending on the values used for the safety function. The PTC (= proof test coverage) is specified for the test processes described in the following and can be used for calculation purposes.

The device can be tested as follows:

- Test process A: Complete test with HART® operation
- Test process B: Complete test without HART® operation (with plug-in display BD7)
- Test process C: Simplified test with or without HART® operation

Please note the following for the test processes:

- Test process C is not admissible for a startup test
- The transmitter without a sensor can be tested with a suitable sensor simulator (resistance decade box, reference voltage source, etc.); the sensor error triggered during reconnection causes the transmitter to switch to safe mode and requires it to be restarted
- The accuracy of the measuring device used must satisfy the specifications for the transmitter
- If both of the transmitter's input channels are in use, the test must be repeated accordingly for the second sensor
- When using customer-specific linearization (e.g., with CvD coefficients), three-point calibration also needs to be carried out; furthermore, the **Upper sensor limit** and **Lower sensor limit** must be tested

Please note the following for test processes A and B during a startup test:

If both of the transmitter's input channels are in use, the two-channel functions, like **Sensor drift** or **Backup** (channel allocation at the current output), also need to be tested.

When using thermocouples, the setting selected for **Cold junction** and its reference must be checked. The function for the out of range category must be tested at its limits 3.8 mA or 20.5 mA.

The transmitter's operating status must be tested (SIL mode active).

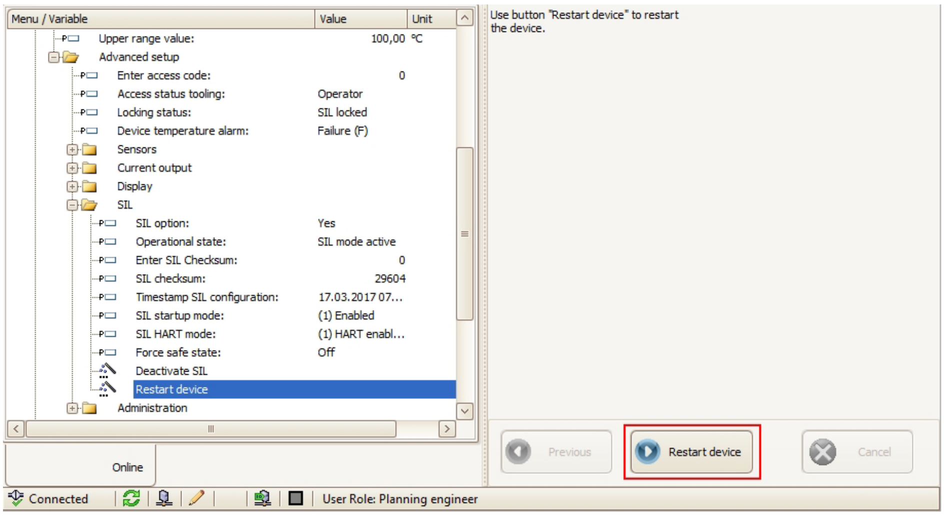
6.3.3 Test process A

1. Two-point calibration
   Test the current output by applying the reference temperature to the sensor or a corresponding reference signal (resistance, voltage) at two points. Select **4 mA to +20 % of the span** for the measuring start and **20 mA to -20 % of the span** for measuring end.

   The measurement results must fall within the specified safety measurement deviation, otherwise the test is deemed to be failed.

2. Safe state test (low alarm)
   Force the transmitter to enter the safe state by triggering a sensor error (e.g., by breaking a wire or short circuiting the sensor lines). Check whether the current emitted at the current output corresponds to the low alarm (≤ 3.6 mA).

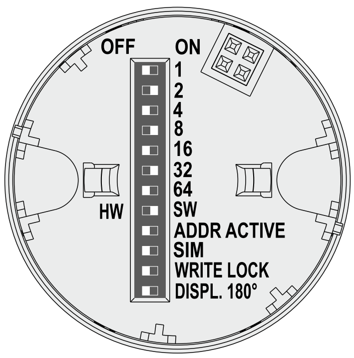
3. Trigger a device restart using the corresponding function on the operating tool in use or HART® command 42.



This test uncovers 96 % of dangerous undetected failures (diagnostic coverage of the repeat test, PTC = 0.96). During the test process, the device's current output typically responds in the same way as the current progress shown in the graph in chapter 6.3.4 "Test process B", Page 35.

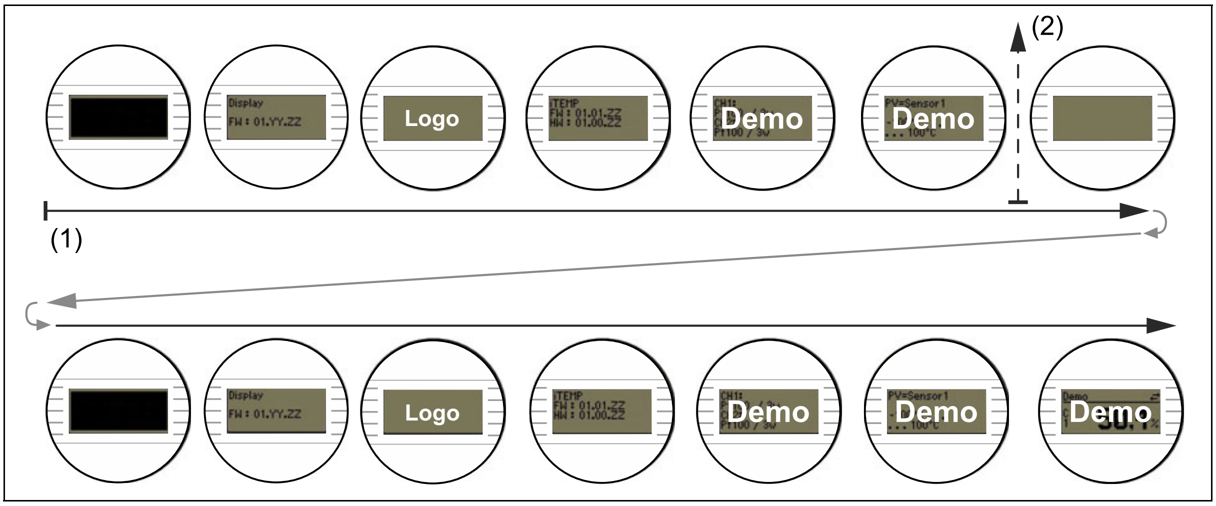
6.3.4 Test process B

1. Two-point calibration
   Test the current output by applying the reference temperature to the sensor or a corresponding reference signal (resistance, voltage) at two points. Select **4 mA to +20 % of the span** for the measuring start and **20 mA to -20 % of the span** for measuring end.
   The measurement results must fall within the specified safety measurement deviation, otherwise the test is deemed to be failed.
2. Safe state test (low alarm)
   Force the transmitter to enter the safe state by triggering a sensor error (e.g., by breaking a wire or short circuiting the sensor lines). Check whether the current emitted at the current output corresponds to the low alarm (≤ 3.6 mA).
3. Trigger a device restart by plugging in a BD7 display with the DIP switch on the back in the corresponding position.



1 = off
2 = on
4 = off
8 = on
16 = off
32 = on
64 = off
SW = on

The starting sequence shown below appears on the BD7 plug-in display when the device restarts.



(1) Start of the sequence
(2) Device restart

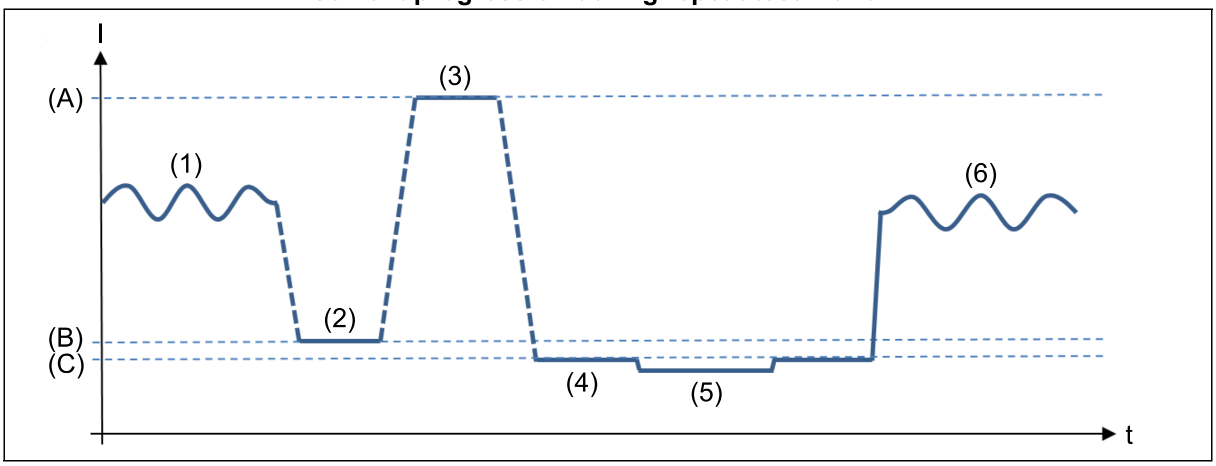
NOTE!

If the BD7 display on the transmitter stays plugged in during subsequent application, the position of the DIP switch must be changed back after the test process

The starting sequence on the BD7 plug-in display indicates whether the restart process has been performed correctly.

This test uncovers 94 % of dangerous undetected failures (diagnostic coverage of the repeat test, PTC = 0.94). During the test process, the device's current output typically responds in the same way as the current progress shown in the graph below.

Current progression during repeat test A and B



(A) 20 mA
(B) 4 mA
(C) ≤ 3.6 mA
(1) Measuring mode
(2) Calibration at start of measurement (two-point calibration)
(3) Calibration at end of measurement (two-point calibration)
(4) Low alarm test
(5) Transmitter restart (via HART® or BD7 plug-in display)

(6) Measuring mode

6.3.5 Test process C

1. Check the plausibility of the current measuring signal. The measured value must be assessed on the basis of empirical values from plant operation; the operator is responsible for this aspect.

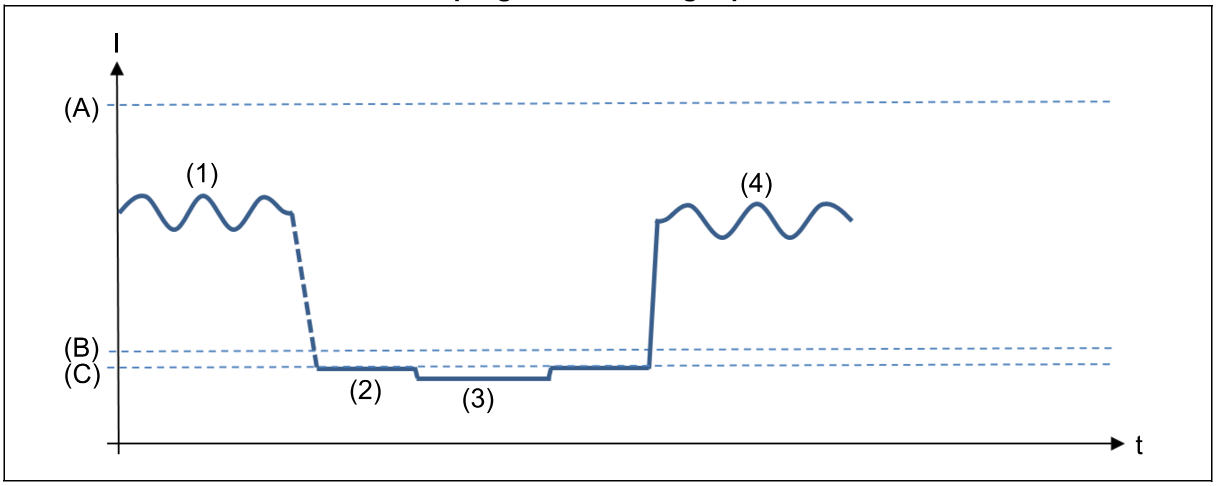
NOTE!

Position of the DIP switch on the BD7 plug-in display: If the display on the transmitter stays plugged in during subsequent application, the position of the DIP switch must be changed back after the test process.

2. Trigger a device restart by plugging in a BD7 plug-in display with the DIP switch on the back in the corresponding position (⇨chapter 6.3.4 "Test process B", Page 35). The sequence on the display indicates whether the restart process has been performed correctly (see test process B, item 3).
   Alternative: Trigger a device restart using the corresponding function on the operating tool in use or HART® command 42.
3. Check whether the current emitted at the current output corresponds to the low alarm (≤ 3.6 mA). See the diagram below.

This test uncovers 58 % of dangerous undetected failures (diagnostic coverage of the repeat test, PTC = 0.58). **Test process C is not admissible for a startup test.**

Current progression during repeat test C



(A) 20 mA
(B) 4 mA
(C) ≤ 3.6 mA
(1) Measuring mode
(2) Transmitter restart (via HART® or BD7 plug-in display)
(3) Low alarm test
(4) Measuring mode

6 Use in safety-related systems

CAUTION!

For test processes A, B, C: The BD7 plug-in display can only be used in conjunction with the head transmitter design type.

The influence of systematic errors on the safety function is not fully covered by the test. Systematic errors can be caused, for example, by measurement medium properties, operating conditions, deposits or corrosion.

- ▶ Take measures to reduce systematic errors.
- ▶ Stop using a transmitter as part of a safety-related system if one of the testing criteria for the described test processes is not met.

7.1 Requirements for personnel

Staff involved in installation, startup, diagnosis, and maintenance must meet the following criteria:

- Qualified personnel: Hold qualifications for their function and area of work
- Have been authorized by the system operator
- Are familiar with local regulations
- Prior to starting work: Have read and understood the instructions in this manual and additional documentation, as well as any certificates (depending on the application)
- Follow instructions and note underlying conditions

Operating staff must meet the following criteria:

- Have been authorized by the system operator and have received instructions in line with the requirements of the task at hand
- Follow the instructions in this manual

7.2 Installation

The instructions for assembling and wiring the device, as well as the admissible installation positions are described in the applicable operating manual, ⇨chapter 3.3 "Other applicable device documentation", Page 10.

7.3 Startup

The process for starting up the device is described in the corresponding operating manual, ⇨chapter 3.3 "Other applicable device documentation", Page 10. A startup test must be carried out prior to operation in a protective device.

7.4 Operation

The process for operating the device is described in the corresponding operating manual, ⇨chapter 3.3 "Other applicable device documentation", Page 10.

7.5 Maintenance

Please refer to the corresponding operating manual for notes on maintenance. During parameterization, the startup test, the repeat test or any maintenance work on the device, alternative measures must be applied and monitored to ensure process reliability, ⇨chapter 3.3 "Other applicable device documentation", Page 10.

7.6 Repairs

If original spare parts are used and the relevant installation instructions are observed, the following components may be replaced by qualified personnel at the customer:

Components	Device testing after repair
BD7 plug-in display	Visual check to make sure all parts are in place and have been mounted correctly, and to make sure the device is in a suitable state.
Case lid	
Sealing sets on case lids	
Housing safety clamps	
Terminal connectors and fixing mechanisms for DIN rail devices	

If the device has been operated in a safety-related system and a device error cannot be ruled out, the replaced components or defective device must be sent to the manufacturer for fault analysis. In this case, the "Declaration on contamination and cleaning" with a note specifying "Used as an SIL device in a safety-related system" must be enclosed when returning the defective device. Note the "Return" chapter in the operating manual for this purpose.

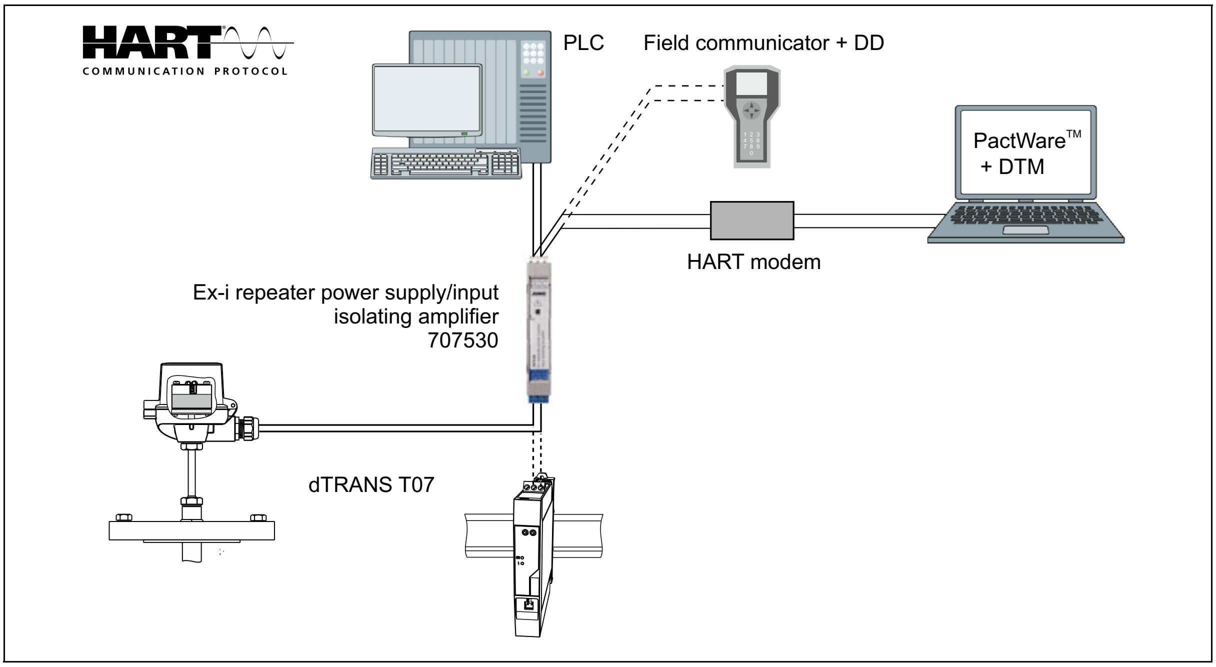
7.7 Modification

NOTE!

Modifications are amendments to SIL devices that have already been delivered and installed.
The user and the manufacturer's service engineers are not permitted to make modifications to SIL devices.

8.1 Structure of the measuring system

The figure below shows an example of the devices in a measuring system.



The transmitter generates an analog signal (64 to 20 mA) proportional to the sensor value in question, which is fed into a downstream logic unit (e.g. PLC, limit signal transducer), where it is monitored to see if it is above or below a specified limit value. For fault monitoring purposes, the logic unit must detect both high alarms (≥ 21.0 mA) and low alarms (≤ 3.6 mA).

NOTE!

The optional BD7 plug-in display is not part of the safety function; neither the display's hardware nor software has been proven to affect the transmitter's defined safety functions. The CDI interface is not safe and therefore is not permitted for use in safety-relevant applications. The interface cannot be used for increased parameterization safety mode or expert mode.

8.1.1 Measuring function

Galvanic isolation

NOTE!

Make sure the sensors are galvanically isolated when connecting two sensors to the transmitter.

Two-channel functions

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

- Two independent measurements:
  In this case, two sensors are connected to the transmitter; the sensors may be different, e.g., TC and 3-wire RTD. Both measuring channels can be used for safety-related functions. To be able to evaluate both sensors' measured values, you must work with the safe proprietary HART® protocol extension, ⇨chapter 8.3.2 "Secure HART®", Page 51.
- **Average value** function:
  The measured values M1, M2 from the two sensors are emitted as an arithmetic mean, i.e., (M1+M2)/2.
- **Difference** function:
  The measured values M1, M2 from the two sensors are emitted as a difference, M1-M2.
- **Backup** function:
  If one of the sensor fails, the system automatically switches to the other measuring channel. For this to happen, both of the sensor types must be identical, e.g. two 3-wire RTD Pt100. The backup function helps to increase availablility and improve diagnostic compatibility. The following sensor types are permitted in SIL mode: 2× thermocouple (TC), 2× RTD, 2-/3-wire
- **Sensor drift** function:
  The use of redundant sensors allows a sensor's long-term drift to be detected, for example. This is a diagnostic measure as the signal from the second sensor is used exclusively for this diagnosis. If identical sensors are used, the **Backup** function can also be used.

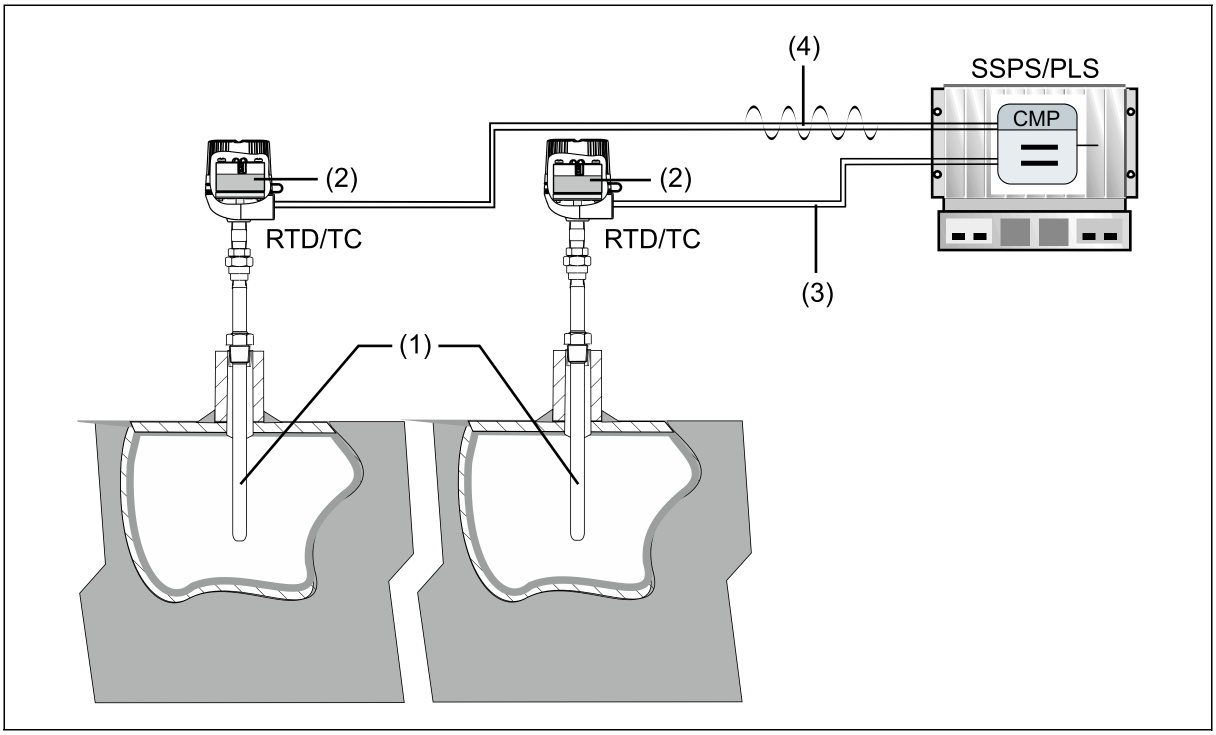
NOTE!

The selected drift-difference limit value should be at least 2 times the value for safety accuracy.

Homogeneous redundant SIL 3 configuration

An SIL 3 measuring point requires two temperature transmitters with one sensor each. The measured values from both transmitters are evaluated in a logic unit with the help of a safe voter, see the diagram below.

The measured values can either be transferred via the 4 to 20 mA signal and/or the secure HART® protocol, ⇨chapter 8.3.2 "Secure HART®", Page 51.



(1) 2 temperature sensors
(2) 2 temperature transmitters (head transmitter design type)
(3) Current output 4 to 20 mA
(4) Current output 4 to 20 mA, with optional secure HART® communication

8.2 Startup or repeat test protocol

8.2.1 Notes on handling the protocol for startup or repeat test

Within the overall safety life cycle of the IEC 61508 standards series, planning of overall operation and maintenance is required.

Among other things, one requirement is that a plan must be drawn up that shows the actions and limitations that will prevent an unsafe condition during a startup or repeat test.

The overall safety life cycle also includes requirements for overall maintenance and overall startup as well as requirements for overall operation and overall repair.

The protocol for the startup and repeat test of the JUMO dTRANS T07 listed here therefore serves as a suggestion as well as a support to the plant manufacturer and plant operator in the documentation of the startup or repeat test with regard to the characteristics of the JUMO dTRANS T07. When using this protocol, the planned definitions must be entered in the protocol by the plant operator. The implementation of the measures must be verified by the respective service provider of the startup or repeat test.

The specific features of the JUMO dTRANS T07 are contained in this safety manual and can be used accordingly for the overall operation.

The validation of the entire plant after startup or repeat testing is the responsibility of the plant operator.

8.2.2 Protocol form

Company/contact person	/
Test performer	

Device information	
Plant	Measuring points/TAG no.
Device type	
Serial number	Firmware version
Access code (if different for each device)	SIL checksum

Verification information
Date/time
Performed by

Result of verification		
Overall result	□ Passed	□ Failed

Comments:

Date

Customer's signature

Test performer's signature

8 Annex

Type of safety function
□ MIN limit value monitoring □ MAX limit value monitoring □ Safe measuring

Startup test
□ Device parameterization via safe parameterization (SiPA) □ Device parameterization via SIL mode activation (SiMA) □ Startup test, test process A □ Startup test, test process B

Repeat test
□ Test process A □ Test process B □ Test process C

Repeat test protocol			
Test phase	Setpoint value	Actual value	Passed
1. Calibration of measurement start, sensor 1			□ Passed □ Failed
2. Calibration of measurement end, sensor 1			□ Passed □ Failed
3. Calibration of measurement start, sensor 2			□ Passed □ Failed □ Not relevant
4. Calibration of measurement end, sensor 2			□ Passed □ Failed □ Not relevant
5. Alarm current			□ Passed □ Failed
6. HART® restart			□ Passed □ Failed □ Not relevant
7. Restart via BD7 plug-in display			□ Passed □ Failed □ Not relevant

Startup test protocol			
Test phase	Setpoint value	Actual value	Passed

Startup test protocol			
1. Calibration of measurement start, sensor 1			□ Passed □ Failed
2. Calibration of measurement end, sensor 1			□ Passed □ Failed
3. Calibration of measurement start, sensor 2			□ Passed □ Failed □ Not relevant
4. Calibration of measurement end, sensor 2			□ Passed □ Failed □ Not relevant
5. Two-channel function, sensor drift			□ Passed □ Failed □ Not relevant
6. Two-channel function, backup			□ Passed □ Failed □ Not relevant
7. Channel allocation at current output			□ Passed □ Failed
8. Out of range category			□ Passed □ Failed
9. Cold junction/reference			□ Passed □ Failed □ Not relevant
10. Alarm current			□ Passed □ Failed
11. HART® restart			□ Passed □ Failed □ Not relevant
12. Restart via BD7 plug-in display			□ Passed □ Failed □ Not relevant

Comments:

8.2.3 Parameter settings for SIL mode

Parameter name	Default setting	Value selected	Checked
Start of measuring range (4 mA)	0		
End of measuring range (20 mA)	100		

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Parameter name	Default setting	Value selected	Checked
Out of range category	Maintenance required (M)		
Sensor type 1	Pt100 IEC60751		
Sensor type 2	No sensor		
Upper sensor limit 1[a]	+850 °C		
Lower sensor limit 1[a]	-200 °C		
Upper sensor limit 2[a]	--		
Lower sensor limit 2[a]	--		
Sensor offset 1	0		
Sensor offset 2	0		
Connection type 1	4-wire (RTD)		
Connection type 2	2-wire (TC)		
Cold junction 1,2	Internal measurement (TC)		
Cold junction reference 1,2	0 (for **Reference junction** setting)		
Call./v. Dusen coeff. A, B and C Sensor 1	A: 3.910000e-003 B: 5.780000e-007 C: 5.780000e-007		
Call./v. Dusen coeff. A, B and C Sensor 2	A: 3.910000e-003 B: 5.780000e-007 C: 5.780000e-007		
Call./v. Dusen coeff. R0 Sensor 1[a]	100 Ω		
Call./v. Dusen coeff. R0 Sensor 2[a]	100 Ω		
Polynomial coeff. A, B Sensor 1[a]	A: 5.49630e-003		
Polynomial coeff. A, B Sensor 2[a]	B: 5.49630e-003		
Polynomial coeff. R0 Sensor 1[a]	100 Ω		
Polynomial coeff. R0 Sensor 2[a]	100 Ω		
Unit	°C		
Mains frequency filter	50 Hz		
Drift/difference monitoring	Off		
Drift/difference alarm category	Maintenance required (M)		
Drift/difference limit value	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		

[a] Only for Call./v. Dusen sensors or polynomial Cu/Ni sensors

8.3 Miscellaneous

8.3.1 Parameter and default settings for SIL mode

Parameter and default settings for increased parameterization safety and expert modes	
Firmware version	Shows the device firmware version installed. Displayed as a sequence of max. 6 digits in the format xx.yy.zz. Check the nameplate or relevant operating manual for the current version of the firmware.
Serial number	Shows the device's serial number. It is also located on the nameplate. It appears as a sequence of max. 11 characters made up of letters and numbers.
Enter access code	Activates the service parameters via the operating tool. Default setting: **0**
Reset device	Resets all device configurations or parts thereof to a defined state. Default setting: **Not active**
Hardware revision	Displays the device's hardware revision.
Current output simulation	Switches the current output simulation on and off. When simulation is active, the display alternates between the measured value and a diagnostic message from the functional control category (C). Default setting: **Off** (default setting for SIL mode, cannot be changed)
Current output value simulation	Selects a current value for the simulation. This can be used to check that the current output has been adjusted correctly and that the downstream evaluation devices are working properly. Default setting: **3.58 mA** (default setting for SIL mode, cannot be changed)
Current trimming 20 mA	Adjusts the correction value for the current output at the measuring range end at 20 mA. Default setting: **20.000 mA** (default setting for SIL mode, cannot be changed)
Current trimming 4 mA	Adjusts the correction value for the current output at the measuring range start at 4 mA. Default setting: **4 mA** (default setting for SIL mode, cannot be changed)
Measuring range start	Allocates a measured value to the current value 4 mA. Default setting: **0**
Measuring range end	Allocates a measured value to the current value 20 mA. Default setting: **100**
Error current	Adjusts the current value that the current output emits in the event of an error. SIL mode: **3.58 mA** (default setting for SIL mode, cannot be changed)
Error behavior	Selects the failure signal level that the current output emits in the event of a fault. Default setting: **Min** (default setting for SIL mode, cannot be changed)
Out of range category	Selects the category (status signal) for how the device responds when the selected measuring range is breached. Default setting: **Maintenance required (M)**
Minimum measuring span	A measuring span is the difference between the temperature at 4 mA and 20 mA. The minimum measuring span is the lowest admissible or logical setting for a sensor type with this difference in the transmitter.
HART® address	Defines the device's HART® address. Default setting: **0** (default setting for SIL mode, cannot be changed)
Device revision	Displays the device revision under which the device is registered at the HART® Communication Foundation. This information is needed to assign the device to the corresponding device description file (DD). Default setting: **2** (fixed value)

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Parameter and default settings for increased parameterization safety and expert modes	
Measurement mode	Selects option to invert the output signal. Options: Standard (4 to 20 mA) or in-verse (20 to 4 mA). Default setting: **Standard** (default setting for SIL mode, cannot be changed).
Sensor type n	Selects the sensor type for sensor input n: • Sensor type 1: Settings for sensor input 1 • Sensor type 2: Settings for sensor input 2 Default setting: • Sensor type 1: **Pt100 IEC751** • Sensor type 2: **No sensor**
Upper sensor limit n	Displays the maximum physical end value for the measuring range. Default setting: • For sensor type 1 = Pt100 IEC751: **+850 °C** • Sensor type 2: **No sensor**
Lower sensor limit n	Displays the minimum physical end value for the measuring range. Default setting: • For sensor type 1 = Pt100 IEC751: **-200 °C** • Sensor type 2: **No sensor**
Sensor offset n	Sets the zero-point correction (offset) for the sensor measured value. The val-ue displayed is added to the measured value. Default setting: **0.0**
Connection type n	Selects the connection type for the sensor. Werkseinstellung: • Sensor 1 (connection type): **4-wire** • Sensor 2 (connection type): **2-wire**
Cold junction n	Selects the cold junction measurement for the temperature compensation of thermocouples (TC). Default setting: **Internal measurement**
Cold junction reference n	Defines the fixed reference for temperature compensation. When cold junction n is selected, the parameter **Reference** must be adjusted. Default setting: **0.00**
Call./v. Dusen coeff. A, B and C	Adjusts the coefficients for sensor linearization according to the Callendar/Van Dusen method. Pre-requisite: The option RTD Platinum (Callendar/Van Dusen) is active under the **Sensor type** parameter. Werkseinstellung: • Coefficient A: **3.910000e-003** • Coefficient B: **-5.780000e-007** • Coefficient C: **-4.180000e-012**
Call./v. Dusen coeff. R0	Adjusts the R0 value for linearization with the Callendar/Van Dusen polynomial .Pre-requisite: The option RTD Platinum (Callendar/Van Dusen) is active under the **Sensor type** parameter. Default setting: **100 Ω¶**
Polynomial coeff. A, B and C	
Polynomial coeff. R0	Adjusts the R0 value for linearization of nickel/copper sensors. Pre-requisite: The option RTD Poly Nickel or RTD Polynomial Cooper is active under the **Sensor type** parameter. Default setting: **100 Ω¶**
Sensor trimming	Selects which linearization method is used for the connected sensor. Default setting: **FactoryTrim** (default setting for SIL mode, cannot be changed)
Unit	Selects the measuring unit for all measured values. Default setting: **°C**

Parameter and default settings for increased parameterization safety and expert modes	
Mains frequency filter	Selects the mains filter for A/D conversion. Default setting: **50 Hz**
Drift/difference monitoring	Selects whether the device responds if the drift/difference limit value is overrange/underrange. Can only be selected for 2-channel operation. Default setting: **Off**
Drift/difference alarm category	Selects the category (status signal) for how the device responds if drift/difference is detected between sensor 1 and sensor 2. Pre-requisite: The parameter **Drift/difference monitoring** must be activated with the option **Overrange (drift)** or **Underrange**. Default setting: **Maintenance required (M)**
Drift/difference limit value	Selects the maximum admissible deviation in measured values between sensor 1 and sensor 2 that leads to a drift/difference being detected. Pre-requisite: The parameter **Drift/difference monitoring** must be activated with the option **Overrange (drift)** or **Underrange**. Default setting: **999.0**
Drift/difference alarm delay	Delays the alarm for drift detection monitoring. Pre-requisite: The parameter **Drift/difference monitoring** must be active with the option **Overrange (Drift)** or **Underrange**. Default setting: **0 s** (default setting for SIL mode, cannot be changed)
Device temperature alarm	Selects the category (status signal) for how the device responds if the temperature of the transmitter's electronics is < -40 °C or > +82 °C Default setting: **Fault (F)** (default setting for SIL mode, cannot be changed)
SIL HART® mode	Adjusts HART® communication during SIL mode. The setting: **HART® not active in SIL mode** deactivates HART® communication in SIL mode (only 4 to 20 mA communication is active). Default setting: **HART® active in SIL mode**
SIL startup mode	Selects an automatic device restart in SIL mode, e.g., after a power cycle. Default setting: **Active**
Force safe state	Tests error detection and the device's safe state during the startup or repeat test. Pre-requisite: The parameter **Operational status** displays **SIL mode active**. Default setting: **Off**
Assign current output (PV)	Assigns a measurand to the first HART® value (PV) Default setting: **Sensor 1**
Assign SV	Assigns a measurand to the second HART® value (SV) Default setting: **Device temperature**
Assign TV	Assigns a measurand to the third HART® value (TV) Default setting: **Sensor 1**
Assign QV	Assigns a measurand to the fourth HART® value (QV) Default setting: **Sensor 1**
Attenuation	Selects the time constant for the attenuation of the current output. Default setting: **0.00 s** (default setting for SIL mode, cannot be changed)
Burst mode	Activates HART® burst mode for burst message X. Message 1 has the highest priority, message 2 second highest, etc. Default setting: **Off** (default setting for SIL mode, cannot be changed)

8.3.2 Secure HART®

The secure HART® protocol is a proprietary extension that is still compatible with the HART® standard. It is used to securely transfer additional information from the transmitter to a connected control via the HART® protocol (up to SIL 3). The HART® protocol itself is considered to be insecure, i.e., the transfer channel is seen as a "gray channel".

A proprietary HART® command is available for secure transfer; to achieve this, information is packed with security data in the HART® command's user data block. The secure HART® protocol is considered to be secure in accordance with the provisions of EN 50159-1. It is assumed that there are no foreign components on the bus. This has to be checked by the user.

8.3.3 Application as a secure measuring system

To create a secure measuring system, the temperature transmitter must be combined with a suitable sensor. The figures needed to set up the system for one year are listed in the table below (it uses a head transmitter as an example).

Single-channel operation

	λ_{du}	λ_{dd}	λ_{su}	λ_{sd}	SFF	PFD_{avg}	Device type
Transmitter	40 FIT	258 FIT	127 FIT	3 FIT	**91%**	**$1.8\cdot10^{-4}$**	B

Sensor elements (thermocouple/RTD temperature probe)

	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
Thermocouple	**94%**	**$2.6\cdot10^{-5}$**	**94%**	**$5.2\cdot10^{-4}$**	**89%**	**$4.8\cdot10^{-4}$**	**89%**	**$9.5\cdot10^{-3}$**	A
RTD 2-/3-wire	**81%**	**$3.9\cdot10^{-5}$**	**81%**	**$7.9\cdot10^{-4}$**	**79%**	**$4.3\cdot10^{-4}$**	**79%**	**$8.7\cdot10^{-3}$**	A
RTD 4-wire	**94%**	**$1.2\cdot10^{-5}$**	**94%**	**$2.5\cdot10^{-4}$**	**94%**	**$1.4\cdot10^{-4}$**	**94%**	**$2.8\cdot10^{-3}$**	A

Sensor combined with transmitter (validation type B)

									Device type
Transmitter + thermocouple	**SIL2**	**$2.0\cdot10^{-4}$**	**SIL2**	**$7.0\cdot10^{-4}$**	**SIL2**	**$6.5\cdot10^{-4}$**	**SIL1**	**$9.7\cdot10^{-3}$**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**$2.1\cdot10^{-4}$**	**SIL2**	**$9.7\cdot10^{-4}$**	**SIL2**	**$6.1\cdot10^{-4}$**	**SIL1**	**$8.8\cdot10^{-3}$**	B
Transmitter + RTD 4-wire	**SIL2**	**$1.9\cdot10^{-4}$**	**SIL2**	**$4.2\cdot10^{-4}$**	**SIL2**	**$3.2\cdot10^{-4}$**	**SIL1**	**$3.0\cdot10^{-3}$**	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) $< 2.5\cdot10^{-3}$
- (yellow) $> 2.5\cdot10^{-3}$
- (red) $> 1\cdot10^{-2}$

Two-channel operation

	λ_{du}	λ_{dd}	λ_{su}	λ_{sd}	SFF	PFD_{avg}	Device type
Transmitter	40 FIT	258 FIT	127 FIT	3 FIT	91%	$1.8\cdot10^{-4}$	B

Sensor elements (thermocouple/RTD temperature probe)

	closed coupled				extention wire					
	low stress		high stress		low stress		high stress			Device type
	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}		
2 × TC	95%	$4.8\cdot10^{-5}$	98%	$3.3\cdot10^{-4}$	91%	$7.6\cdot10^{-4}$	91%	$1.5\cdot10^{-2}$	without diagnostics	A
	95%	$4.4\cdot10^{-5}$	99%	$2.5\cdot10^{-4}$	94%	$5.4\cdot10^{-4}$	94%	$1.1\cdot10^{-2}$	with diagnostics	A
2 × RTD 2-/3-wire	89%	$4.5\cdot10^{-5}$	89%	$9.0\cdot10^{-4}$	88%	$4.9\cdot10^{-4}$	88%	$9.8\cdot10^{-3}$	without diagnostics	A
	98%	$7.2\cdot10^{-6}$	98%	$1.4\cdot10^{-4}$	98%	$7.5\cdot10^{-5}$	98%	$1.5\cdot10^{-3}$	with diagnostics	A
TC + RTD 2-/3-wire	95%	$3.2\cdot10^{-5}$	95%	$6.3\cdot10^{-4}$	92%	$5.4\cdot10^{-4}$	92%	$1.1\cdot10^{-2}$	without diagnostics	A
	96%	$2.7\cdot10^{-5}$	96%	$5.4\cdot10^{-4}$	95%	$3.2\cdot10^{-4}$	95%	$6.3\cdot10^{-3}$	with diagnostics	A

Sensor combined with transmitter (validation type B)

Transmitter + 2 × TC	SIL2	$2.2\cdot10^{-4}$	SIL2	$5.1\cdot10^{-4}$	SIL2	$9.3\cdot10^{-4}$	SIL1	$1.5\cdot10^{-2}$	without diagnostics	B
		$2.2\cdot10^{-4}$		$4.2\cdot10^{-4}$		$7.1\cdot10^{-4}$		$1.1\cdot10^{-2}$	with diagnostics	B
Transmitter + 2 × RTD 2-/3-wire	SIL2	$2.2\cdot10^{-4}$	SIL2	$1.1\cdot10^{-3}$	SIL2	$6.7\cdot10^{-4}$	SIL1	$1.0\cdot10^{-2}$	without diagnostics	B
		$1.8\cdot10^{-4}$		$3.2\cdot10^{-4}$		$2.5\cdot10^{-4}$		$1.7\cdot10^{-3}$	with diagnostics	B
Transmitter + TC + RTD 2-/3-wire	SIL2	$2.1\cdot10^{-4}$	SIL2	$8.1\cdot10^{-4}$	SIL2	$7.1\cdot10^{-4}$	SIL1	$1.1\cdot10^{-2}$	without diagnostics	B
		$2.0\cdot10^{-4}$		$7.2\cdot10^{-4}$		$4.9\cdot10^{-4}$		$6.5\cdot10^{-3}$	with diagnostics	B

NOTE!

- Low stress: <2/3 utilization of the thermometer's maximum admissible acceleration
- High stress: >2/3 utilization of the thermometer's maximum admissible acceleration
- Closed coupled: <30 cm
- Extension wire: >30 cm
- Diagnosis: Sensor drift

8.3.4 Further notes on the applied error models

The calculation examples shown as of page 55 for the application as a safe measuring system are based on the probe error model described below.

Low Stress	< 2/3 utilization of the maximum permissible acceleration of the probes
High Stress	> 2/3 utilization of the maximum permissible acceleration of the probes
Close Coupled	< 30 cm distance between sensor and transmitter or connection of a head transmitter within a protection fitting (head-mounted)
Extension Wire	> 30 cm distance between sensor and transmitter or connection outside the terminal head, e.g. DIN rail device

The calculation according to the JUMO probe error model applies to the connectable RTD temperature probes and thermocouples of the manufacturer JUMO GmbH & Co. KG. It is based on the design and field experience.

8.3.5 Additional indicator tables for the application as a secure measuring system

In this chapter you will find further indicator tables for the application of the device as a safe measuring system in connection with different probe error models. A distinction is also made between the device variants "DIN rail" and "head transmitter".

The following abbreviations are used:

Ti	Proof Test Interval (specification in years)
MT	Mission Time (specification in years)
SFFSFF	Safe Failure Fraction
HFT	Hardware failure tolerance
PFD_{avg}	Probability of Failure on Demand average
λ_{du}	Rate of undetected dangerous failures
λ_{dd}	Rate of detected dangerous failures
λ_{su}	Rate of undetected safe failures
λ_{sd}	Rate of detected safe failures
FIT	Failure in Time (1×10^{-9} pro h)

The following indicator tables include a PTC (diagnostic coverage of the repeat test) of 96 % for the repeat test after test sequence A (⇨chapter 6.3.3 "Test process A", Page 34). The PFD_{avg} is calculated according to the equation given in chapter 6.3.1 "Repeat test for the safety function", Page 33. The λ_{dd} component is not taken into account because it is negligible with an assumed MTTR of 72 h

Single-channel operation

Operating conditions: **Ti (a) = 1** **MT (a) = 5**

	λ_{du} (FIT)	λ_{dd} (FIT)	λ_{su} (FIT)	λ_{sd} (FIT)	SFF (%)	PFD_{avg}	Device type
DIN rail device	41	258	123	3	**90**	**2.1×10^{-4}**	B

Sensor elements (thermocouple/RTD temperature probe)

	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 %**	**3.0×10^{-5}**	**94 %**	**6.0×10^{-4}**	**89 %**	**5.5×10^{-4}**	**89 %**	**1.1×10^{-2}**	A
RTD 2-/3-wire	**81 %**	**4.6×10^{-5}**	**81 %**	**9.2×10^{-4}**	**79 %**	**5.0×10^{-4}**	**79 %**	**1.0×10^{-2}**	A
RTD 4-wire	**94 %**	**1.4×10^{-5}**	**94 %**	**2.9×10^{-4}**	**94 %**	**1.6×10^{-4}**	**94 %**	**3.3×10^{-3}**	A

	SFF	PFD_{avg}			SFF	PFD_{avg}	Device type
Thermocouple	**59 %**	**2.1×10^{-3}**	**or**	Double thermocouple	**≥ 61 %**	**2.1×10^{-3}**	A
RTD 2-/3-wire	**89 %**	**5.5×10^{-4}**					A
RTD 4-wire	**95 %**	**2.5×10^{-4}**					A

Sensor elements (thermocouple/RTD temperature probe) according to JUMO probe error model

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**	**2.4×10^{-4}**	**SIL2**	**8.1×10^{-4}**	**SIL2**	**7.6×10^{-4}**	**SIL1**	**1.1×10^{-2}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**2.5×10^{-4}**	**SIL2**	**1.1×10^{-3}**	**SIL2**	**7.1×10^{-4}**	**SIL1**	**1.0×10^{-2}**	B
Transmitter + RTD 4-wire	**SIL2**	**2.2×10^{-4}**	**SIL2**	**5.0×10^{-4}**	**SIL2**	**3.7×10^{-4}**	**SIL2**	**3.5×10^{-3}**	B

							Device type
Transmitter + thermocouple	**SIL1**	**2.3×10^{-3}**	**or**	Transmitter + double thermocouple	**SIL2**	**2.3×10^{-3}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**7.6×10^{-4}**					B
Transmitter + RTD 4-wire	**SIL2**	**4.6×10^{-4}**					B

Sensor combined with transmitter (validation type B) according to JUMO probe error model

SFF	Typ A			Typ 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
> 90 %	SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

	PFD_{avg}
SIL2	$\leq 3.5\times10^{-3}$
SIL2	$> 3.5\times10^{-3} \leq 1\times10^{-2}$
SIL1	$> 1\times10^{-2} \leq 1\times10^{-1}$
no SIL	$> 1\times10^{-1}$

Single-channel operation

Operating conditions: **Ti (a) = 3** **MT (a) = 5**

	λ_{du} (FIT)	λ_{dd} (FIT)	λ_{su} (FIT)	λ_{sd} (FIT)	SFF (%)	PFD_{avg}	Device type
DIN rail device	41	258	123	3	**90**	**5.5×10^{-4}**	B

Sensor elements (thermocouple/RTD temperature probe)

	low stress closed coupled		high stress closed coupled		low stress extention wire		high stress extention wire		Device type
	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	
Thermocouple	**94 %**	**8.0×10^{-5}**	**94 %**	**1.6×10^{-3}**	**89 %**	**1.5×10^{-3}**	**89 %**	**2.9×10^{-2}**	A
RTD 2-/3-wire	**81 %**	**1.2×10^{-4}**	**81 %**	**2.4×10^{-3}**	**79 %**	**1.3×10^{-3}**	**79 %**	**2.7×10^{-2}**	A
RTD 4-wire	**94 %**	**3.8×10^{-5}**	**94 %**	**7.7×10^{-4}**	**94 %**	**4.4×10^{-4}**	**94 %**	**8.7×10^{-3}**	A

Sensor elements (thermocouple/RTD temperature probe) according to JUMO probe error model

	SFF	PFD_{avg}	Device type
Thermocouple	**59 %**	**5.5×10^{-3}**	A
RTD 2-/3-wire	**89 %**	**1.5×10^{-3}**	A
RTD 4-wire	**95 %**	**6.6×10^{-4}**	A

Sensor combined with transmitter (validation type B)

	low stress closed coupled		high stress closed coupled		low stress extention wire		high stress extention wire		Device type
Transmitter + thermocouple	**SIL2**	**6.3×10^{-4}**	**SIL2**	**2.2×10^{-3}**	**SIL2**	**2.0×10^{-3}**	**SIL1**	**3.0×10^{-2}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**6.7×10^{-4}**	**SIL2**	**3.0×10^{-3}**	**SIL2**	**1.9×10^{-3}**	**SIL1**	**2.7×10^{-2}**	B
Transmitter + RTD 4-wire	**SIL2**	**5.9×10^{-4}**	**SIL2**	**1.3×10^{-3}**	**SIL2**	**9.9×10^{-4}**	**SIL1**	**9.3×10^{-3}**	B

Sensor combined with transmitter (validation type B) according to JUMO probe error model

	SIL	PFD_{avg}	Device type
Transmitter + thermocouple	**SIL1**	**6.0×10^{-3}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**2.0×10^{-3}**	B
Transmitter + RTD 4-wire	**SIL2**	**1.2×10^{-3}**	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
> 90 %		SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

PFD_{avg}	
SIL2	$\leq 3.5\times10^{-3}$
SIL2	$> 3.5\times10^{-3} \leq 1\times10^{-2}$
SIL1	$> 1\times10^{-2} \leq 1\times10^{-1}$
no SIL	$> 1\times10^{-1}$

Single-channel operation

Operating conditions: **Ti (a) = 5** **MT (a) = 5**

	λ_{du} (FIT)	λ_{dd} (FIT)	λ_{su} (FIT)	λ_{sd} (FIT)	SFF (%)	PFD_{avg}	Device type
DIN rail device	41	258	123	3	**90**	**9.0×10^{-4}**	B

Sensor elements (thermocouple/RTD temperature probe)

	low stress		high stress		low stress		high stress		
	closed coupled				extention wire				
	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	Device type
Thermocouple	**94 %**	**1.3×10^{-4}**	**94 %**	**2.6×10^{-3}**	**89 %**	**2.4×10^{-3}**	**89 %**	**4.8×10^{-2}**	A
RTD 2-/3-wire	**81 %**	**2.0×10^{-4}**	**81 %**	**4.0×10^{-3}**	**79 %**	**2.2×10^{-3}**	**79 %**	**4.3×10^{-2}**	A
RTD 4-wire	**94 %**	**6.2×10^{-5}**	**94 %**	**1.2×10^{-3}**	**94 %**	**7.1×10^{-4}**	**94 %**	**1.4×10^{-2}**	A

Sensor elements (thermocouple/RTD temperature probe) according to JUMO probe error model

	SFF	PFD_{avg}	Device type
Thermocouple	**59 %**	**8.9×10^{-3}**	A
RTD 2-/3-wire	**89 %**	**2.4×10^{-3}**	A
RTD 4-wire	**95 %**	**1.1×10^{-3}**	A

Sensor combined with transmitter (validation type B)

	low stress		high stress		low stress		high stress		
	closed coupled				extention wire				
	SIL	PFD_{avg}	SIL	PFD_{avg}	SIL	PFD_{avg}	SIL	PFD_{avg}	Device type
Transmitter + thermocouple	**SIL2**	**1.0×10^{-3}**	**SIL1**	**3.5×10^{-3}**	**SIL2**	**3.3×10^{-3}**	**SIL1**	**4.9×10^{-2}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**1.1×10^{-3}**	**SIL1**	**4.9×10^{-3}**	**SIL2**	**3.1×10^{-3}**	**SIL1**	**4.4×10^{-2}**	B
Transmitter + RTD 4-wire	**SIL2**	**9.6×10^{-4}**	**SIL2**	**2.1×10^{-3}**	**SIL2**	**1.6×10^{-3}**	**SIL1**	**1.5×10^{-2}**	B

Sensor combined with transmitter (validation type B) according to JUMO probe error model

	SIL	PFD_{avg}	Device type
Transmitter + thermocouple	**SIL1**	**9.8×10^{-3}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**3.3×10^{-3}**	B
Transmitter + RTD 4-wire	**SIL2**	**2.0×10^{-3}**	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
> 90 %		SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

	PFD_{avg}
SIL2	$\leq 3.5\times10^{-3}$
SIL2	$> 3.5\times10^{-3} \leq 1\times10^{-2}$
SIL1	$> 1\times10^{-2} \leq 1\times10^{-1}$
no SIL	$> 1\times10^{-1}$

Single-channel operation

Operating conditions: **Ti (a) = 1** **MT (a) = 10**

	λ_{du} (FIT)	λ_{dd} (FIT)	λ_{su} (FIT)	λ_{sd} (FIT)	SFF (%)	PFD_{avg}	Device type
DIN rail device	41	258	123	3	**90**	**2.4×10^{-4}**	B

Sensor elements (thermocouple/RTD temperature probe)

	closed coupled				extention wire				
	low stress		high stress		low stress		high stress		
	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	
Thermocouple	**94 %**	**3.5×10^{-5}**	**94 %**	**7.1×10^{-4}**	**89 %**	**6.5×10^{-4}**	**89 %**	**1.3×10^{-2}**	A
RTD 2-/3-wire	**81 %**	**5.4×10^{-5}**	**81 %**	**1.1×10^{-3}**	**79 %**	**5.9×10^{-4}**	**79 %**	**1.2×10^{-2}**	A
RTD 4-wire	**94 %**	**1.7×10^{-5}**	**94 %**	**3.4×10^{-4}**	**94 %**	**1.9×10^{-4}**	**94 %**	**3.8×10^{-3}**	A

	SFF	PFD_{avg}			SFF	PFD_{avg}	
Thermocouple	**59 %**	**2.4×10^{-3}**	**or**	Double thermocouple	**≥ 61 %**	**2.4×10^{-3}**	A
RTD 2-/3-wire	**89 %**	**6.5×10^{-4}**					A
RTD 4-wire	**95 %**	**2.9×10^{-4}**					A

Sensor elements (thermocouple/RTD temperature probe) according to JUMO probe error model

Sensor combined with transmitter (validation type B)

Transmitter + thermocouple	**SIL2**	**2.8×10^{-4}**	**SIL2**	**9.5×10^{-4}**	**SIL2**	**8.9×10^{-4}**	**SIL1**	**1.3×10^{-2}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**3.0×10^{-4}**	**SIL2**	**1.3×10^{-3}**	**SIL2**	**8.3×10^{-4}**	**SIL1**	**1.2×10^{-2}**	B
Transmitter + RTD 4-wire	**SIL2**	**2.6×10^{-4}**	**SIL2**	**5.8×10^{-4}**	**SIL2**	**4.4×10^{-4}**	**SIL1**	**4.1×10^{-3}**	B

Transmitter + thermocouple	**SIL1**	**2.7×10^{-3}**	**or**	Transmitter + double thermocouple	**SIL2**	**2.7×10^{-3}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**8.9×10^{-4}**					B
Transmitter + RTD 4-wire	**SIL2**	**5.4×10^{-4}**					B

Sensor combined with transmitter (validation type B) according to JUMO probe error model

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
> 90 %		SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

PFD_{avg}	
SIL2	$\leq 3.5\times10^{-3}$
SIL2	$> 3.5\times10^{-3} \leq 1\times10^{-2}$
SIL1	$> 1\times10^{-2} \leq 1\times10^{-1}$
no SIL	$> 1\times10^{-1}$

Single-channel operation

Operating conditions: **Ti (a) = 3** **MT (a) = 10**

	λ_{du} (FIT)	λ_{dd} (FIT)	λ_{su} (FIT)	λ_{sd} (FIT)	SFF (%)	PFD_{avg}	Device type
DIN rail device	41	258	123	3	**90**	**5.9×10^{-4}**	B

Sensor elements (thermocouple/RTD temperature probe)

	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 %**	**8.5×10^{-5}**	**94 %**	**1.7×10^{-3}**	**89 %**	**1.6×10^{-3}**	**89 %**	**3.1×10^{-2}**	A
RTD 2-/3-wire	**81 %**	**1.3×10^{-4}**	**81 %**	**2.6×10^{-3}**	**79 %**	**1.4×10^{-3}**	**79 %**	**2.8×10^{-2}**	A
RTD 4-wire	**94 %**	**4.1×10^{-5}**	**94 %**	**8.2×10^{-4}**	**94 %**	**4.6×10^{-4}**	**94 %**	**9.3×10^{-3}**	A

Sensor elements (thermocouple/RTD temperature probe) according to JUMO probe error model

	SFF	PFD_{avg}	Device type
Thermocouple	**59 %**	**5.8×10^{-3}**	A
RTD 2-/3-wire	**89 %**	**1.6×10^{-3}**	A
RTD 4-wire	**95 %**	**7.0×10^{-4}**	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**	**6.7×10^{-4}**	**SIL2**	**2.3×10^{-3}**	**SIL2**	**2.2×10^{-3}**	**SIL1**	**3.2×10^{-2}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**7.2×10^{-4}**	**SIL2**	**3.2×10^{-3}**	**SIL2**	**2.0×10^{-3}**	**SIL1**	**2.9×10^{-2}**	B
Transmitter + RTD 4-wire	**SIL2**	**6.3×10^{-4}**	**SIL2**	**1.4×10^{-3}**	**SIL2**	**1.1×10^{-3}**	**SIL1**	**9.9×10^{-3}**	B

Sensor combined with transmitter (validation type B) according to JUMO probe error model

	SIL	PFD_{avg}	Device type
Transmitter + thermocouple	**SIL1**	**6.4×10^{-3}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**2.2×10^{-3}**	B
Transmitter + RTD 4-wire	**SIL2**	**1.3×10^{-3}**	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
> 90 %		SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

PFD_{avg}	
SIL2	$\leq 3.5\times10^{-3}$
SIL2	$> 3.5\times10^{-3} \leq 1\times10^{-2}$
SIL1	$> 1\times10^{-2} \leq 1\times10^{-1}$
no SIL	$> 1\times10^{-1}$

8 Annex

Single-channel operation

Operating conditions: **Ti (a) = 5** **MT (a) = 10**

	λ_{du} (FIT)	λ_{dd} (FIT)	λ_{su} (FIT)	λ_{sd} (FIT)	SFF (%)	PFD_{avg}	Device type
DIN rail device	41	258	123	3	**90**	**9.3×10^{-4}**	B

Sensor elements (thermocouple/RTD temperature probe)

	low stress		high stress		low stress		high stress		
	closed coupled				extention wire				
	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	Device type
Thermocouple	**94 %**	**1.4×10^{-4}**	**94 %**	**2.7×10^{-3}**	**89 %**	**2.5×10^{-3}**	**89 %**	**5.0×10^{-2}**	A
RTD 2-/3-wire	**81 %**	**2.1×10^{-4}**	**81 %**	**4.1×10^{-3}**	**79 %**	**2.3×10^{-3}**	**79 %**	**4.5×10^{-2}**	A
RTD 4-wire	**94 %**	**6.5×10^{-5}**	**94 %**	**1.3×10^{-3}**	**94 %**	**7.4×10^{-4}**	**94 %**	**1.5×10^{-2}**	A

Sensor elements (thermocouple/RTD temperature probe) according to JUMO probe error model

	SFF	PFD_{avg}	Device type
Thermocouple	**59 %**	**9.2×10^{-3}**	A
RTD 2-/3-wire	**89 %**	**2.5×10^{-3}**	A
RTD 4-wire	**95 %**	**1.1×10^{-3}**	A

Sensor combined with transmitter (validation type B)

									Device type
Transmitter + thermocouple	**SIL2**	**1.1×10^{-3}**	**SIL1**	**3.6×10^{-3}**	**SIL2**	**3.4×10^{-3}**	**SIL1**	**5.1×10^{-2}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**1.1×10^{-3}**	**SIL1**	**5.0×10^{-3}**	**SIL2**	**3.2×10^{-3}**	**SIL1**	**4.6×10^{-2}**	B
Transmitter + RTD 4-wire	**SIL2**	**1.0×10^{-3}**	**SIL2**	**2.2×10^{-3}**	**SIL2**	**1.7×10^{-3}**	**SIL1**	**1.6×10^{-2}**	B

Sensor combined with transmitter (validation type B) according to JUMO probe error model

			Device type
Transmitter + thermocouple	**SIL1**	**1.0×10^{-2}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**3.4×10^{-3}**	B
Transmitter + RTD 4-wire	**SIL2**	**2.0×10^{-3}**	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
> 90 %		SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

PFD_{avg}	
SIL2	$\leq 3.5\times10^{-3}$
SIL2	$> 3.5\times10^{-3} \leq 1\times10^{-2}$
SIL1	$> 1\times10^{-2} \leq 1\times10^{-1}$
no SIL	$> 1\times10^{-1}$

Single-channel operation

Operating conditions: **Ti (a) = 1** **MT (a) = 5**

	λ_{du} (FIT)	λ_{dd} (FIT)	λ_{su} (FIT)	λ_{sd} (FIT)	SFF (%)	PFD_{avg}	Device type
Head transmitter	40	258	127	3	91	2.0×10^{-4}	B

Sensor elements (thermocouple/RTD temperature probe)

	closed coupled				extention wire				
	low stress		high stress		low stress		high stress		Device type
	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	
Thermocouple	94 %	3.0×10^{-5}	94 %	6.0×10^{-4}	89 %	5.5×10^{-4}	89 %	1.1×10^{-2}	A
RTD 2-/3-wire	81 %	4.6×10^{-5}	81 %	9.2×10^{-4}	79 %	5.0×10^{-4}	79 %	1.0×10^{-2}	A
RTD 4-wire	94 %	1.4×10^{-5}	94 %	2.9×10^{-4}	94 %	1.6×10^{-4}	94 %	3.3×10^{-3}	A

	SFF	PFD_{avg}			SFF	PFD_{avg}	Device type
Thermocouple	59 %	2.1×10^{-3}	or	Double thermocouple	≥ 61 %	2.1×10^{-3}	A
RTD 2-/3-wire	89 %	5.5×10^{-4}					A
RTD 4-wire	95 %	2.5×10^{-4}					A

Sensor elements (thermocouple/RTD temperature probe) according to JUMO probe error model

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	2.3×10^{-4}	SIL2	8.1×10^{-4}	SIL2	7.6×10^{-4}	SIL1	1.1×10^{-2}	B
Transmitter + RTD 2-/3-wire	SIL2	2.5×10^{-4}	SIL2	1.1×10^{-3}	SIL2	7.1×10^{-4}	SIL1	1.0×10^{-2}	B
Transmitter + RTD 4-wire	SIL2	2.2×10^{-4}	SIL2	4.9×10^{-4}	SIL2	3.7×10^{-4}	SIL2	3.5×10^{-3}	B

							Device type
Transmitter + thermocouple	SIL1	2.3×10^{-3}	or	Transmitter + double thermocouple	SIL2	2.3×10^{-3}	B
Transmitter + RTD 2-/3-wire	SIL2	7.6×10^{-4}					B
Transmitter + RTD 4-wire	SIL2	4.6×10^{-4}					B

Sensor combined with transmitter (validation type B) according to JUMO probe error model

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
> 90 %	SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

PFD_{avg}	
SIL2	≤ 3.5×10^{-3}
SIL2	> 3.5×10^{-3} ≤ 1×10^{-2}
SIL1	> 1×10^{-2} ≤ 1×10^{-1}
no SIL	> 1×10^{-1}

8 Annex

Single-channel operation

Operating conditions: **Ti (a) = 3** **MT (a) = 5**

	λ_{du} (FIT)	λ_{dd} (FIT)	λ_{su} (FIT)	λ_{sd} (FIT)	SFF (%)	PFD_{avg}	Device type
Head transmitter	40	258	127	3	**91**	**5.4×10^{-4}**	B

Sensor elements (thermocouple/RTD temperature probe)

	closed coupled, low stress		closed coupled, high stress		extention wire, low stress		extention wire, high stress		
	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	Device type
Thermocouple	**94 %**	**8.0×10^{-5}**	**94 %**	**1.6×10^{-3}**	**89 %**	**1.5×10^{-3}**	**89 %**	**2.9×10^{-2}**	A
RTD 2-/3-wire	**81 %**	**1.2×10^{-4}**	**81 %**	**2.4×10^{-3}**	**79 %**	**1.3×10^{-3}**	**79 %**	**2.7×10^{-2}**	A
RTD 4-wire	**94 %**	**3.8×10^{-5}**	**94 %**	**7.7×10^{-4}**	**94 %**	**4.4×10^{-4}**	**94 %**	**8.7×10^{-3}**	A

Sensor elements (thermocouple/RTD temperature probe) according to JUMO probe error model

	SFF	PFD_{avg}	Device type
Thermocouple	**59 %**	**5.5×10^{-3}**	A
RTD 2-/3-wire	**89 %**	**1.5×10^{-3}**	A
RTD 4-wire	**95 %**	**6.6×10^{-4}**	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**	**6.2×10^{-4}**	**SIL2**	**2.1×10^{-3}**	**SIL2**	**2.0×10^{-3}**	**SIL1**	**3.0×10^{-2}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**6.6×10^{-4}**	**SIL2**	**3.0×10^{-3}**	**SIL2**	**1.9×10^{-3}**	**SIL1**	**2.7×10^{-2}**	B
Transmitter + RTD 4-wire	**SIL2**	**5.8×10^{-4}**	**SIL2**	**1.3×10^{-3}**	**SIL2**	**9.8×10^{-4}**	**SIL1**	**9.3×10^{-3}**	B

Sensor combined with transmitter (validation type B) according to JUMO probe error model

	SIL	PFD_{avg}	Device type
Transmitter + thermocouple	**SIL1**	**6.0×10^{-3}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**2.0×10^{-3}**	B
Transmitter + RTD 4-wire	**SIL2**	**1.2×10^{-3}**	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
> 90 %		SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

PFD_{avg}	
SIL2	$\leq 3.5\times10^{-3}$
SIL2	$> 3.5\times10^{-3} \leq 1\times10^{-2}$
SIL1	$> 1\times10^{-2} \leq 1\times10^{-1}$
no SIL	$> 1\times10^{-1}$

Single-channel operation

Operating conditions: **Ti (a) = 5** **MT (a) = 5**

	λ_{du} (FIT)	λ_{dd} (FIT)	λ_{su} (FIT)	λ_{sd} (FIT)	SFF (%)	PFD_{avg}	Device type
Head transmitter	40	258	127	3	**91**	**8.8×10^{-4}**	B

Sensor elements (thermocouple/RTD temperature probe)

	closed coupled				extention wire				Device type
	low stress		high stress		low stress		high stress		
	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	
Thermocouple	**94 %**	**1.3×10^{-4}**	**94 %**	**2.6×10^{-3}**	**89 %**	**2.4×10^{-3}**	**89 %**	**4.8×10^{-2}**	A
RTD 2-/3-wire	**81 %**	**2.0×10^{-4}**	**81 %**	**4.0×10^{-3}**	**79 %**	**2.2×10^{-3}**	**79 %**	**4.3×10^{-2}**	A
RTD 4-wire	**94 %**	**6.2×10^{-5}**	**94 %**	**1.2×10^{-3}**	**94 %**	**7.1×10^{-4}**	**94 %**	**1.4×10^{-2}**	A

Sensor elements (thermocouple/RTD temperature probe) according to JUMO probe error model

	SFF	PFD_{avg}	Device type
Thermocouple	**59 %**	**8.9×10^{-3}**	A
RTD 2-/3-wire	**89 %**	**2.4×10^{-3}**	A
RTD 4-wire	**95 %**	**1.1×10^{-3}**	A

Sensor combined with transmitter (validation type B)

	closed coupled				extention wire				Device type
	low stress		high stress		low stress		high stress		
Transmitter + thermocouple	**SIL2**	**1.0×10^{-3}**	**SIL2**	**3.5×10^{-3}**	**SIL2**	**3.3×10^{-3}**	**SIL1**	**4.9×10^{-2}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**1.1×10^{-3}**	**SIL1**	**4.8×10^{-3}**	**SIL2**	**3.0×10^{-3}**	**SIL1**	**4.4×10^{-2}**	B
Transmitter + RTD 4-wire	**SIL2**	**9.4×10^{-4}**	**SIL2**	**2.1×10^{-3}**	**SIL2**	**1.6×10^{-3}**	**SIL1**	**1.5×10^{-2}**	B

Sensor combined with transmitter (validation type B) according to JUMO probe error model

	SIL	PFD_{avg}	Device type
Transmitter + thermocouple	**SIL1**	**9.8×10^{-3}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**3.3×10^{-3}**	B
Transmitter + RTD 4-wire	**SIL2**	**1.9×10^{-3}**	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
> 90 %		SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

PFD_{avg}	
SIL2	$\leq 3.5\times10^{-3}$
SIL2	$> 3.5\times10^{-3} \leq 1\times10^{-2}$
SIL1	$> 1\times10^{-2} \leq 1\times10^{-1}$
no SIL	$> 1\times10^{-1}$

Single-channel operation

Operating conditions: Ti (a) = **1** MT (a) = **10**

	λ_{du} (FIT)	λ_{dd} (FIT)	λ_{su} (FIT)	λ_{sd} (FIT)	SFF (%)	PFD_{avg}	Device type
Head transmitter	40	258	127	3	**91**	**2.4×10^{-4}**	B

Sensor elements (thermocouple/RTD temperature probe)

	low stress closed coupled		high stress closed coupled		low stress extention wire		high stress extention wire		
	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	Device type
Thermocouple	**94 %**	**3.5×10^{-5}**	**94 %**	**7.1×10^{-4}**	**89 %**	**6.5×10^{-4}**	**89 %**	**1.3×10^{-2}**	A
RTD 2-/3-wire	**81 %**	**5.4×10^{-5}**	**81 %**	**1.1×10^{-3}**	**79 %**	**5.9×10^{-4}**	**79 %**	**1.2×10^{-2}**	A
RTD 4-wire	**94 %**	**1.7×10^{-5}**	**94 %**	**3.4×10^{-4}**	**94 %**	**1.9×10^{-4}**	**94 %**	**3.8×10^{-3}**	A

	SFF	PFD_{avg}			SFF	PFD_{avg}	Device type
Thermocouple	**59 %**	**2.4×10^{-3}**	or	Double thermocouple	**≥ 61 %**	**2.4×10^{-3}**	A
RTD 2-/3-wire	**89 %**	**6.5×10^{-4}**					A
RTD 4-wire	**95 %**	**2.9×10^{-4}**					A

Sensor elements (thermocouple/RTD temperature probe) according to JUMO probe error model

Sensor combined with transmitter (validation type B)

	low stress closed coupled		high stress closed coupled		low stress extention wire		high stress extention wire		Device type
Transmitter + thermocouple	**SIL2**	**2.7×10^{-4}**	**SIL2**	**9.5×10^{-4}**	**SIL2**	**8.9×10^{-4}**	**SIL1**	**1.3×10^{-2}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**2.9×10^{-4}**	**SIL2**	**1.3×10^{-3}**	**SIL2**	**8.3×10^{-4}**	**SIL1**	**1.2×10^{-2}**	B
Transmitter + RTD 4-wire	**SIL2**	**2.6×10^{-4}**	**SIL2**	**5.8×10^{-4}**	**SIL2**	**4.3×10^{-4}**	**SIL1**	**4.1×10^{-3}**	B

							Device type
Transmitter + thermocouple	**SIL1**	**2.7×10^{-3}**	or	Transmitter + double thermocouple	**SIL2**	**2.7×10^{-3}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**8.9×10^{-4}**					B
Transmitter + RTD 4-wire	**SIL2**	**5.3×10^{-4}**					B

Sensor combined with transmitter (validation type B) according to JUMO probe error model

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
> 90 %		SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

	PFD_{avg}
SIL2	$\leq 3.5\times10^{-3}$
SIL2	$> 3.5\times10^{-3} \leq 1\times10^{-2}$
SIL1	$> 1\times10^{-2} \leq 1\times10^{-1}$
no SIL	$> 1\times10^{-1}$

Single-channel operation

Operating conditions: **Ti (a) = 3** **MT (a) = 10**

	λ_{du} (FIT)	λ_{dd} (FIT)	λ_{su} (FIT)	λ_{sd} (FIT)	SFF (%)	PFD_{avg}	Device type
Head transmitter	40	258	127	3	**91**	**5.7×10^{-4}**	B

Sensor elements (thermocouple/RTD temperature probe)

	low stress		high stress		low stress		high stress		Device type
	closed coupled				extention wire				
	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	SFF	PFD_{avg}	
Thermocouple	**94 %**	**8.5×10^{-5}**	**94 %**	**1.7×10^{-3}**	**89 %**	**1.6×10^{-3}**	**89 %**	**3.1×10^{-2}**	A
RTD 2-/3-wire	**81 %**	**1.3×10^{-4}**	**81 %**	**2.6×10^{-3}**	**79 %**	**1.4×10^{-3}**	**79 %**	**2.8×10^{-2}**	A
RTD 4-wire	**94 %**	**4.1×10^{-5}**	**94 %**	**8.2×10^{-4}**	**94 %**	**4.6×10^{-4}**	**94 %**	**9.3×10^{-3}**	A

Sensor elements (thermocouple/RTD temperature probe) according to JUMO probe error model

	SFF	PFD_{avg}	Device type
Thermocouple	**59 %**	**5.8×10^{-3}**	A
RTD 2-/3-wire	**89 %**	**1.6×10^{-3}**	A
RTD 4-wire	**95 %**	**7.0×10^{-4}**	A

Sensor combined with transmitter (validation type B)

	low stress		high stress		low stress		high stress		Device type
	closed coupled				extention wire				
Transmitter + thermocouple	**SIL2**	**6.6×10^{-4}**	**SIL2**	**2.3×10^{-3}**	**SIL2**	**2.1×10^{-3}**	**SIL1**	**3.2×10^{-2}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**7.0×10^{-4}**	**SIL2**	**3.2×10^{-3}**	**SIL2**	**2.0×10^{-3}**	**SIL1**	**2.9×10^{-2}**	B
Transmitter + RTD 4-wire	**SIL2**	**6.2×10^{-4}**	**SIL2**	**1.4×10^{-3}**	**SIL2**	**1.0×10^{-3}**	**SIL1**	**9.9×10^{-3}**	B

Sensor combined with transmitter (validation type B) according to JUMO probe error model

	SIL	PFD_{avg}	Device type
Transmitter + thermocouple	**SIL1**	**6.4×10^{-3}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**2.1×10^{-3}**	B
Transmitter + RTD 4-wire	**SIL2**	**1.3×10^{-3}**	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
> 90 %		SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

PFD_{avg}	
SIL2	$\leq 3.5\times10^{-3}$
SIL2	$> 3.5\times10^{-3} \leq 1\times10^{-2}$
SIL1	$> 1\times10^{-2} \leq 1\times10^{-1}$
no SIL	$> 1\times10^{-1}$

8 Annex

Single-channel operation

Operating conditions: **Ti (a) = 5** **MT (a) = 10**

	λ_{du} (FIT)	λ_{dd} (FIT)	λ_{su} (FIT)	λ_{sd} (FIT)	SFF (%)	PFD_{avg}	Device type
Head transmitter	40	258	127	3	**91**	**9.1×10^{-4}**	B

Sensor elements (thermocouple/RTD temperature probe)

	closed coupled, low stress SFF	closed coupled, low stress PFD_{avg}	closed coupled, high stress SFF	closed coupled, high stress PFD_{avg}	extention wire, low stress SFF	extention wire, low stress PFD_{avg}	extention wire, high stress SFF	extention wire, high stress PFD_{avg}	Device type
Thermocouple	**94 %**	**1.4×10^{-4}**	**94 %**	**2.7×10^{-3}**	**89 %**	**2.5×10^{-3}**	**89 %**	**5.0×10^{-2}**	A
RTD 2-/3-wire	**81 %**	**2.1×10^{-4}**	**81 %**	**4.1×10^{-3}**	**79 %**	**2.3×10^{-3}**	**79 %**	**4.5×10^{-2}**	A
RTD 4-wire	**94 %**	**6.5×10^{-5}**	**94 %**	**1.3×10^{-3}**	**94 %**	**7.4×10^{-4}**	**94 %**	**1.5×10^{-2}**	A

Sensor elements (thermocouple/RTD temperature probe) according to JUMO probe error model

	SFF	PFD_{avg}	Device type
Thermocouple	**59 %**	**9.2×10^{-3}**	A
RTD 2-/3-wire	**89 %**	**2.5×10^{-3}**	A
RTD 4-wire	**95 %**	**1.1×10^{-3}**	A

Sensor combined with transmitter (validation type B)

	closed coupled, low stress SIL	closed coupled, low stress PFD_{avg}	closed coupled, high stress SIL	closed coupled, high stress PFD_{avg}	extention wire, low stress SIL	extention wire, low stress PFD_{avg}	extention wire, high stress SIL	extention wire, high stress PFD_{avg}	Device type
Transmitter + thermocouple	**SIL2**	**1.0×10^{-3}**	**SIL1**	**3.6×10^{-3}**	**SIL2**	**3.4×10^{-3}**	**SIL1**	**5.1×10^{-2}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**1.1×10^{-3}**	**SIL1**	**5.0×10^{-3}**	**SIL2**	**3.2×10^{-3}**	**SIL1**	**4.6×10^{-2}**	B
Transmitter + RTD 4-wire	**SIL2**	**9.8×10^{-4}**	**SIL2**	**2.2×10^{-3}**	**SIL2**	**1.6×10^{-3}**	**SIL1**	**1.6×10^{-2}**	B

Sensor combined with transmitter (validation type B) according to JUMO probe error model

	SIL	PFD_{avg}	Device type
Transmitter + thermocouple	**SIL1**	**1.0×10^{-2}**	B
Transmitter + RTD 2-/3-wire	**SIL2**	**3.4×10^{-3}**	B
Transmitter + RTD 4-wire	**SIL2**	**2.0×10^{-3}**	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
> 90 %		SIL3	SIL4	SIL4	SIL3	SIL4	SIL4

PFD_{avg}	
SIL2	$\leq 3.5\times10^{-3}$
SIL2	$> 3.5\times10^{-3} \leq 1\times10^{-2}$
SIL1	$> 1\times10^{-2} \leq 1\times10^{-1}$
no SIL	$> 1\times10^{-1}$

8.3.6 Figure allocation for 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

8.4 Further information

NOTE!

General information on functional safety (SIL) is available in our specialist book FAS 630: "Functional Safety – Safety Integrity Level".

8.5 Version history

Version	Changes	Valid as of firm ware version
70708000T99Z001K000 V1.00	First version	10.01.01
70708000T99Z001K000 V2.00	Correction of the measurement deviation for thermocouple DIN 43710 Type L	10.01.01
70708000T99Z001K000 V3.00	Additional notes on handling the protocol for startup or repeat test Addition of indicator tables and notes in the chapter "Application as a secure measuring system" General error corrections	10.01.01
70708000T99Z001K000 V4.00	Exchange of the SIL certificate with a new version, valid until March 31, 2026 General error corrections	01.01.10
70708000T99Z001K000 V5.00	Addition of figures for the use of double thermocouples General error corrections	01.01.10

JUMO GmbH & Co. KG

Street address:
Moritz-Juchheim-Straße 1
36039 Fulda, Germany

Delivery address:
Mackenrodtstraße 14
36039 Fulda, Germany

Postal address:
36035 Fulda, Germany

Phone: +49 661 6003-0
Fax: +49 661 6003-607
Email: mail@jumo.net
Internet: www.jumo.net

JUMO Instrument Co. Ltd.

JUMO House
Temple Bank, Riverway
Harlow, Essex, CM20 2DY, UK

Phone: +44 1279 63 55 33
Fax: +44 1279 62 50 29
Email: sales@jumo.co.uk
Internet: www.jumo.co.uk

JUMO Process Control, Inc.

6724 Joy Road
East Syracuse, NY 13057, USA

Phone: +1 315 437 5866
Fax: +1 315 437 5860
Email: info.us@jumo.net
Internet: www.jumousa.com