SIL-Safety Instructions

SM/TTX200/TTX300/SIL-EN

Temperature Transmitter
TTH200, TTR200, TTH300, TTF300, TTF350

Information about functional safety

Temperature Transmitter
TTH200, TTR200, TTH300, TTF300, TTF350

SIL-Safety Instructions

SM/TTX200/TTX300/SIL-EN

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1 Field of Application

Temperature monitoring of solids, fluids and gases of all types in containers and pipes according to the special safety engineering requirements of IEC 61508.

The operating limits are defined in the data sheets and operating instructions for the separate models. In case of questions, please contact your ABB partner.

2 Acronyms and abbreviations

Acronym/ Abbrevia-tion	English	Description
HFT	Hardware Fault Tolerance	Hardware error tolerance of the unit. Ability of a functional unit (hardware) to continue to perform a required function when faults or errors are prevailing.
MTBF	Mean Time Between Failures	Mean Time Between Failures
MTTR	Mean Time To Repair	Mean time between the occurrence of an error in a unit or system and its repair.
PFD	Probability of Failure on Demand	Probability of hazardous failures for a safety function on demand
PFD_{AVG}	Average Probability of Failure on Demand	Average probability of hazardous failures for a safety function on demand
λ_D	Dangerous	Rate of hazardous failures (per hour) affecting a channel of a subsystem, corresponds to 0.5 λ (assuming 50% hazardous failures and 50% non-hazardous failures)
λ_{DD}	Dangerous Detected	Rate of detected hazardous failures (per hour) affecting a channel of a subsystem. (This is the total rate of hazardous failures within one channel of a subsystem.)
λ_{DU}	Dangerous Undetected	Rate of undetected hazardous failures (per hour) affecting a channel of a subsystem. (This is the total rate of undetected hazardous failures within a subsystem.)
λ_{SD}	Safe Detected	Rate of detected non-hazardous failures (per hour) affecting a channel of a subsystem. (This is the total rate of detected non-hazardous failures within one channel of a subsystem.)
λ_{SU}	Safe Undetected	Rate of undetected non-hazardous failures (per hour) affecting a channel of a subsystem. (This is the total rate of undetected non-hazardous failures within one channel of a subsystem.)

Acronym/ Abbreviation	English	Description
SIL	Safety Integrity Level	The international standard IEC 61508 defines four discrete Safety Integrity Levels (SIL 1 to SIL 4). Each level corresponds to a range of probability for the failure of a safety function. The higher the Safety Integrity Level of the safety-related systems, the lower the probability that they will not perform the required safety function.
SFF	Safe Failure Fraction	Proportion of non-hazardous failures; in other words, the proportion of failures without the potential to put the safety-related system in a hazardous or impermissible state.
Low Demand Mode	Low Demand Mode of operation	Measurement type with low request rate. Measurement type for which the request rate for the safety-related system is not more than once a year and not greater than twice the frequency of the retest.
DCS	Distributed Control System	Control system used in industrial applications to monitor and control decentralized units.
HMI	Human Machine Interface	In this case, the HMI is a combined module consisting of an LCD display with or without a local keyboard.
DTM	Device Type Manager	A DTM is a software module that supports specific functions for accessing device parameters, the setup and the operation of devices, and diagnostics. The DTM is not executable software. It requires an FDT container program in order to be activated.
LRV	Lower Range Value	Lower measuring range limit
URV	Upper Range Value	Upper measuring range limit
Multidrop	Multidrop-Modus	In multidrop mode, up to 15 field devices are connected in parallel to a single wire pair. The analog current signal simply serves to supply power to the devices in two-wire technology with a fixed current of ≤ 4 mA.

Acronym/ Abbrevia-tion	English	Description
	closed coupled	Short connecting lead to the temperature sensor, less than 1 m (39.37 inches) in length and connecting lead laid with mechanical protection.
	extension wire	Long connecting lead to the temperature sensor, more than 1 m (39.37 inches) in length or connecting lead laid without mechanical protection.
	low stress	Low to medium load according to data sheet specification (sensor exposed to temperature and mechanical load)
	high stress	High load according to data sheet specification (sensor exposed to temperature and mechanical load)
	Single Configuration	Single configuration, i.e. use of one transmitter per measuring point. This results in an HFT = 0 (1oo1 architecture) for corresponding SIL2.
	Dual Configuration	Dual configuration, i.e. use of two transmitters per measuring point. In this configuration the two current signals 4 … 20 mA have to be evaluated accordingly by the downstream logics unit (a DCS, for example). This results in an HFT = 1 (1oo2 architecture) for corresponding SIL3.

3 Relevant standards

Standard	Designation
IEC 61508, Part 1 to 7	Functional safety of electrical/electronic/programmable electronic safety-related systems

4 Other applicable documents and papers

Please comply with the following documents in addition to observing the SIL safety instructions:

Product designation	Document name	Document type
TTH200	DS/TTH200	Data sheet
TTH200	OI/TTH200	Operating instructions
TTH200	CI/TTH200	Commissioning instructions
TTR200	DS/TTR200	Data sheet
TTR200	OI/TTR200	Operating instructions
TTR200	CI/TTR200	Commissioning instructions
TTH300	DS/TTH300	Data sheet
TTH300	OI/TTH300	Operating instructions
TTH300	CI/TTH300	Commissioning instructions
TTF300	DS/TTF300	Data sheet
TTF300	OI/TTF300	Operating instructions
TTF300	CI/TTF300	Commissioning instructions
TTF350	DS/TTF350	Data sheet
TTF350	OI/TTF350	Operating instructions
TTF350	CI/TTF350	Commissioning instructions

The documents can be downloaded in the available languages from the ABB website at "www.abb.com/temperature".

In addition, the user of this device is responsible for ensuring compliance with applicable legal regulations and standards.

5 Terms and definitions

Terms	Definitions
Dangerous failure	A failure that has the potential to place the safety-related system in a dangerous state or render the system inoperative.
Safety-related system	A safety-related system carries out the safety functions that are required to achieve or maintain a safe state, e.g., for a system. Example: A pressure meter, a logics unit (e.g., limit transmitter) and a valve constitute a safety-related system.
Safety-related functions	A specified function that is carried out by a safety-related system with the goal, under consideration of a defined dangerous incident, of achieving or maintaining a safe state for the system. Example: limit temperature monitoring.

6 Safety function

TTH200-.H, TTR200-.H, TTH300-.H, TTF300-.H, and TTF350-.H transmitters generate a linear temperature unit signal of 4 ... 20 mA. All safety functions refer strictly to the analog output signal.

The entire valid range for the output signal must be configured between min. 3.8 mA and max. 20.5 mA (factory setting).

WARNING!

In safety mode, HART communication occurs only when write protection is activated. The HART master must comply with the safety requirements of the customer application.

Alarm behavior and current output

When a critical error is detected, the configured alarm current is generated and fed to a downstream logics unit (a DCS, for example), which checks for overshoots of a defined maximum value. There are two selectable modes for this alarm current:

- HIGH ALARM (high alarm, maximum alarm current); this is the factory setting
- LOW ALARM (low alarm, minimum alarm current)

The low alarm current can be configured in a range from 3.5 … 4.0 mA. The factory setting is 3.6 mA.

The high alarm current can be configured in a range from 20.0 … 23.6 mA. The factory setting is 22 mA.

In the following cases, a detected error is displayed independently of the configured alarm current within the low alarm range:

- Runtime errors
- Memory error (non-volatile data, RAM, ROM)

After switching on or restarting the transmitter electronics unit, the minimum low alarm time (LOW alarm, startup time) is 10 to 15 seconds.

WARNING!

To ensure accurate error monitoring, the following conditions must be fulfilled:

- The low alarm must be configured to a value ≤ 3.6 mA.
- The high alarm must be configured to a value ≥ 21 mA.
- The DCS must identify the configured high and low alarms as malfunctions, and the alarm must be configured accordingly.

WARNING!

To ensure reliable functioning of the current output, the terminal voltage at the device must be between 11 V and 42 V DC (non-hazardous-area design) and 11 V and 30 V DC (hazardous area design).

The DCS power supply for the transmitter must be capable of providing the required voltage level even when the current output is running with the configured high alarm.

The device does not meet safety requirements under the following conditions:

- During configuration
- When write protection is deactivated
- When HART multidrop mode is activated
- During a simulation
- When the safety function is being checked

WARNING!

The device's safety function includes the basic device TTH200-.H, TTR200-.H, TTH300-.H, TTF300-.H, and TTF350-.H with connected sensor, inclusive of the housing and the process connections used. The information in the corresponding documentation must be taken into consideration.

Overall safety accuracy

The value defined for the overall accuracy of the safety function for this device is ± 2% of the measuring range.

The basic accuracy depends on the sensor model and is specified in the corresponding data sheets.

Switch-on time and safety operating mode

After switching on the device, all safety-relevant errors are detected after 2 minutes in low demand mode.

6.1 Measuring point for SIL 2 – Single configuration

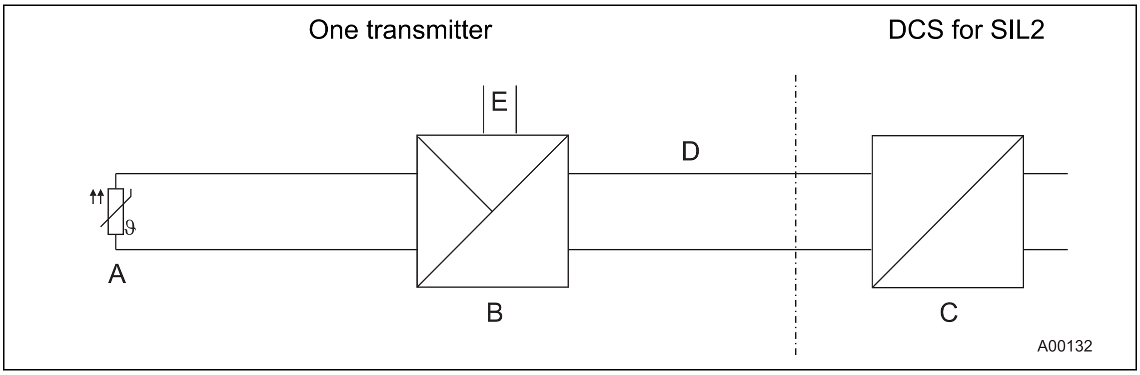

Fig. 1

A Sensor
B Transmitter
C DCS
D 4 ... 20 mA measurement circuit
E Interface for LCD indicator

6.2 Measuring point for SIL 3 – Dual configuration

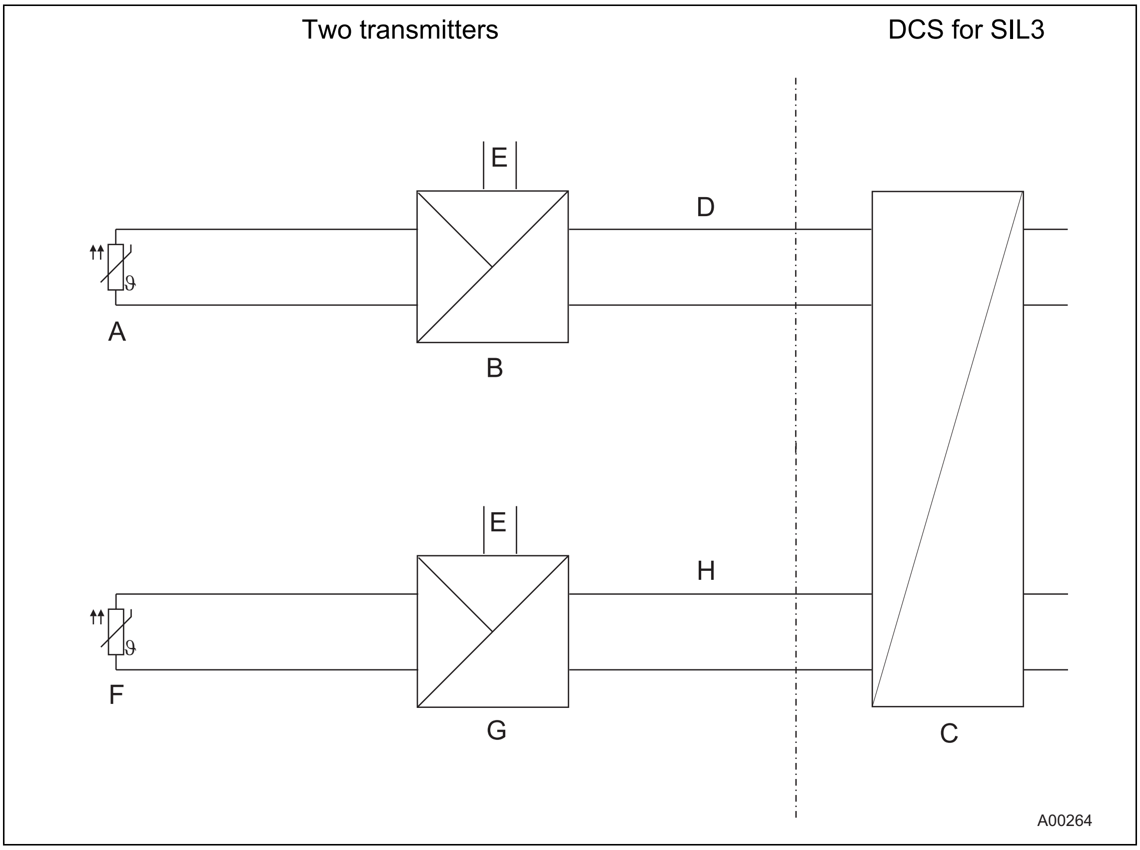

Fig. 2

A Sensor 1
B Transmitter 1
C DCS
D Measuring circuit 1
E Interface for LCD indicator
F Sensor 2
G Transmitter 2
H Measuring circuit 2

Important (Note)

The safety-relevant technical parameters are specified in chapter 11 „Management summary FMEDA – Failure modes, effects, and diagnostic analysis“, page 17.

7 Periodic checks

Safety inspections

The safety function for the entire safety loop must be checked regularly in accordance with IEC 61508. The inspection intervals are defined when calculating the individual safety loops for a system.

Users are responsible for selecting the type of check and the intervals within the specified period. The PFD_{AV} value depends on the selected inspection interval. For the PFD_{AV} values in the SIL declaration of conformity, the inspection interval T[Proof] for checking the safety function is 1 year. For other inspection intervals with corresponding PFDAV values, refer to the section titled "Management summary FMEDA".

Inspections must be conducted in a manner that enables users to verify the proper function of the safety equipment in combination with all components.

One possible procedure for recurring tests to detect hazardous and unidentified device errors is described in the following section. This test is able to detect 99 % of the "Du" errors affecting the transmitter.

Checking the safety function

To check the safety function of the device, proceed as follows:

1. Bridge the safety DCS or take other appropriate measures to ensure the alarm is not triggered unintentionally.
2. Deactivate write protection (refer to the relevant operating instructions).
3. Use the EDD / DTM simulation command (Diagnostics / Simulation / Current Output) to set the transmitter's current output to a high alarm value.
4. Check whether the current output signal reaches this value.
5. Use the EDD / DTM simulation command to set the transmitter's current output to a low alarm value.
6. Check whether the current output signal reaches this value.
7. Activate write protection (refer to the relevant operating instructions) and wait at least 20 seconds.
8. Shut down and restart the device.
9. Check the current output with reference temperature; use 2-point calibration for the LRV value (lower measuring range limit 4 mA) and the URV value (upper measuring range limit 20 mA).
10. Remove the bridge from the safety DCS or use another method to restore normal operating conditions.
11. After performing the test, the events must be documented and archived accordingly.

An appropriate simulator (Pt100 simulator, reference voltage sources) can also be used to check the transmitter without sensor. The sensor has to be tested in accordance with the SIL requirements of the customer application. SensyTemp TSP temperature sensors can be tested in accordance with the OI/TSP by means of a quick check.

8 Configuration

The device has been configured and tested according to customer order.

However, it can be configured via the LCD indicator with a local keyboard or via DTM / EDD through the HART interface. Other configuration tools such as mobile handheld terminals are not described in these instructions.

Reliable operation of the device is not assured during configuration.

WARNING!

Checks:

Before commissioning the device, check whether the device setup assures the system's safety function.

Make sure that the correct device has been installed at the correct measuring point.

Whenever the device is updated (if the device's mounting position is changed or the setup is modified, for example), the safety function of the device must be checked again.

Once the safety function has been checked, the device must be write-protected to prevent changes to the setup, since any change to the measurement system or parameters will impair the safety function.

To ensure safe operation, the device must be write-protected.

To implement this, proceed as follows:

Activating / Deactivating write protection

1. TTH300-.H, TTF300-.H, and TTF350-.H via the LCD display with local keyboard

   Go to "Device Setup", "Write Protection" and enter a password other than "0110" to activate write protection. Enter the password "0110" to disable write protection (see the operating instructions).

2. TTH200-.H, TTR200-.H, TTH300-.H, TTF300-.H, and TTF350-.H via DTM/EDD

   Go to "Device" and select "Write Protection" to activate the function.

   If the device is locked (write-protected), it cannot be configured. Write protection is applied for the entire device. Enter the password “0110” to disable write protection.

3. TTR200-.H, TTH300-.H, TTF300-.H, and TTF350-.H, HW write protection via DIP switches

   Configuration on/off (see the operating instructions)

WARNING!

Checks:

Write protection must be checked as follows:

1. TTH300-.H, TTF300-.H, and TTF350-.H locking via the LCD display with local keyboard
   - Check whether the lock icon is displayed on the LCD display.
   - Select the "Fault Signaling" menu and make sure the edit icon is not showing on the LCD display.
   - Press the Edit button and check that there is no response on the LCD display.
2. TTH200-.H, TTR200-.H, TTH300-.H, TTF300-.H, and TTF350-.H protection via DTM / EDD:
   - LCD display and local keyboard available: Check as described under Point 1.
   - No LCD display and local keyboard available (checking write protection):

     Go to <Device>,<Parameterize> Current Output/Damping and change the damping value, for example. Then select "Save Device Data in Device" and check whether the message "Device is write-protected" is displayed.

WARNING!

The software write protection does not lock again automatically. It remains unlocked until it is specifically reset.

Diagnostics setup

The device's diagnostics setup meets safety requirements and includes the following error detections:

- Sensor board communication error
- Sensor board error
- Sensor board A/D converter error
- Measuring error device temperature
- Sensor limit value alarm upper and lower
- TTH300-.H, TTF300-.H, and TTF350-.H, sensor error ch. 1. and ch. 2.
  - Sensor configuration resistance thermometer, R in two-, three-, and four-wire circuit with wire break and short circuit
  - Sensor configuration thermocouple, mV with wire break
  - Redundancy mode ch. 1 and ch. 2 with drift monitoring activated

Configuration parameters affecting the safety function

All configuration parameters that are changed via the LCD display with keyboard, DTM / EDD or HART communication when write protection is disabled affect the safety function of the device. The parameters are described in the operating instructions. The safety function is checked in accordance with the SIL safety instructions.

For redundancy mode with drift monitoring, the following parameters must be set in DTM, EDD on the TTH300-.H TTF300-.H, and TTF350-.H:

Redundancy mode on the TTH300-.H, TTF300-.H, and TTF350-.H

- Pulse output Active
- Pulse time 60 s, continuous pulse
- Drift value Configured acc. to customer application
- Drift duration Maximum 120 s

Sensor type freestyle characteristic and Callendar-Van Dusen on the TTH300-.H, TTF300-.H, and TTF350-.H

When using these two configurations, it is necessary to check at least 3 reference points to verify the configured characteristic. For complex curves, check more reference points according to complexity.

9 SIL 2 TÜV-Certificate

TÜV NORD

Certificate

SLA 0187/09-01, Ver. 1.0

TÜV NORD SysTec GmbH & Co. KG hereby certifies

ABB Automation Products GmbH

Borsigstr. 2
63755 Alzenau / Germany

that the
Temperature Transmitters

TTH200-.H / TTR200-.H / TTH300-.H
TTR300-.H / TTF300-.H / TTF350-.H

are capable for safety related applications up to SIL 2, SIL 3 pending on the architecture and meets the requirements listed in the following standard.

IEC 61508: 2000;
Functional safety of electrical/electronic/programmable electronic safety-related systems
SIL 2 capability for single transmitter use
SIL 3 capability for dual transmitter use

The certification is based on the report SLA-0187/2009TTR-01 in the valid version. This certificate entitles the holder to use the pictured Safety Approved mark.

Expiry date: 2015-12-22
Reference No.: G.SCC.DL.06.045.01.SLA

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Branch Manager

Augsburg, 2010-12-21

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10 Namur NE 93

TTH200-.H, TTR200-.H, TTH300-.H, TTF300-.H, and TTF350-.H transmitters meet requirements according to Namur NE 93.

11 Management summary FMEDA – Failure modes, effects, and diagnostic analysis

Management summary for TT*200-*H and TT*3*0-*H, 4..20 mA output

This report summarizes the results of the hardware assessment according to IEC 61508 carried out on the temperature transmitters TT*200-*H and TT*3*0-*H with 4..20 mA output.

The temperature transmitter TT*200-*H is a configurable single sensor channel (1 x RTD 2/3/4 wire, 1 x TE, 1 x mV) analog 4..20mA device.

The temperature transmitter TT*3*0-*H is a configurable single or dual sensor channel (1 or 2 x RTD 2/3/4 wire, 2 x TE, 2 x mV, 1 x RTD 2/3 and 1 x TE / mV) analog 4..20mA device output.

Table 1 gives an overview of the different types that belong to the considered temperature transmitters including hardware and software version

The hardware assessment consists of a Failure Modes, Effects and Diagnostics Analysis (FMEDA). A FMEDA is one of the steps taken to achieve functional safety assessment of a device per IEC 61508. From the FMEDA, failure rates are determined and consequently the Safe Failure Fraction (SFF) is calculated for the device. For full assessment purposes all requirements of IEC 61508 must be considered.

Table 1: Version overview

Type	Description	HW Version	SW Version
TTH200-*H	Head mounted temperature transmitter	1.06	1.00.06
TTR200-*H	Rail mounted temperature transmitter	1.01	1.00.06
TTH300-*H	Head mounted temperature transmitter	1.06	1.01.07
TTR300-*H	Rail mounted temperature transmitter	1.01	1.01.07
TTF300-*H	Field mounted temperature transmitter	1.06	1.01.07
TTF350-*H	Field mounted temperature transmitter	1.06	1.01.07

For safety applications only the 4..20 mA output was considered. All other possible output variants or electronics are not covered by this report.

The failure rates of the electronic components used in this analysis are the basic failure rates from the Siemens standard SN 29500.

According to table 2 of IEC 61508-1 the average PFD for systems operating in low demand mode has to be ≥ 1,00E-03 to < 1,00E-02 for SIL 2 safety functions. A generally accepted distribution of PFD_{AVG} values of a SIF over the sensor part, logic solver part, and final element part assumes that 35% of the total SIF PFD_{AVG} value is caused by the sensor part.

For a SIL 2 application operating in low demand mode the total PFD_{AVG} value of the SIF should be smaller than 1,00E-02, hence the maximum allowable PFD_{AVG} value for the sensor part would then be 3,50E-03.

The temperature transmitters TT*200-*H and TT*3*0-*H with 4..20 mA output are considered to be Type B[1] subsystems with a hardware fault tolerance of 0.

The failure rates do not include failures resulting from incorrect use of the temperature transmitters TT*200-*H and TT*3*0-*H with 4..20 mA output, in particular humidity entering through incompletely closed housings or inadequate cable feeding through the inlets.

[1] Type B subsystem: "Complex" subsystem (using micro controllers or programmable logic); for details see 7.4.3.1.3 of IEC 61508-2.

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The listed failure rates are valid for operating stress conditions typical of an industrial field environment similar to IEC 60654-1 class C (sheltered location) with an average temperature over a long period of time of 40ºC. For a higher average temperature of 60°C, the failure rates should be multiplied with an experience based factor of 2,5. A similar multiplier should be used if frequent temperature fluctuation must be assumed.

It is assumed that the connected logic solver is configured per the NAMUR NE43 signal ranges, i.e. the temperature transmitters TT*200-*H and TT*3*0-*H with 4..20 mA output communicate detected faults by an alarm output current ≤ 3,6mA or ≥ 21mA. Assuming that the application program in the safety logic solver does not automatically trip on these failures, these failures have been classified as dangerous detected failures. The following tables show how the above stated requirements are fulfilled.

Table 2: Failure rates [2]

Failure category	Failure rates (in FIT)
Fail Dangerous Detected	**327**
Fail dangerous detected (internal diagnostics or indirectly[3])	227
Fail high (detected by the logic solver)	23
Fail low (detected by the logic solver)	77
Annunciation detected	0
Fail Dangerous Undetected	**41**
Fail dangerous undetected	39
Annunciation undetected	2
No Effect	**110**
Not part	**91**

Table 3: IEC 61508 failure rates

λ_{SD}	λ_{SU} [4]	λ_{DD}	λ_{DU}	SFF [5]	DC_S [6]	DC_D [8]
0 FIT	110 FIT	327 FIT	41 FIT	91%	0%	88%

Table 4: PFD_{AVG} values

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years
PFD_{AVG} = 1,79E-04	PFD_{AVG} = 8,95E-04	PFD_{AVG} = 1,79E-03

[2] It is assumed that practical fault insertion tests can demonstrate the correctness of the failure effects assumed during the FMEDAs.

[3] "indirectly" means that these failure are not necessarily detected by diagnostics but lead to either fail low or fail high failures depending on the transmitter setting and are therefore detectable.

[4] Note that the SU category includes failures that do not cause a spurious trip

[5] Note: SFF should be calculated for the sensor subsystem. This SFF is only for reference.

[6] DC means the diagnostic coverage (safe or dangerous) for the temperature transmitters by the safety logic solver.

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A complete temperature sensor assembly consisting of the temperature transmitters TT*200-*H and TT*3*0-*H and a thermocouple or RTD can be modeled by considering a series subsystem where a failure occurs if there is a failure in either component. For such a system, failure rates are added.

Appendix 3 gives typical failure rates and failure distributions for thermocouples and RTDs which were the basis for the following tables.

Assuming that the temperature transmitter TT*200-*H and TT*3*0-*H will go to the pre-defined alarm state on detected failures of the thermocouple or RTD, the failure rate contribution or the PFD_{AVG} value (T[Proof] = 1 year) for the thermocouple or RTD in a **low stress environment** is as follows:

Table 5: TT*200-*H and TT*3*0-*H with thermocouple (close coupled)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	110 FIT	422 FIT	46 FIT	92%	2,01E-04

Table 6: TT*3*0-*H with two thermocouples (close coupled)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	113 FIT	533 FIT	38 FIT	94%	1,68E-04

Table 7: TT*200-*H and TT*3*0-*H with 2/3-wire RTD (close coupled)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	110 FIT	366 FIT	50 FIT	90%	2,17E-04

Table 8: TT*3*0-*H with two 2/3-wire RTDs (close coupled)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	113 FIT	428 FIT	39 FIT	93%	1,70E-04

Table 9: TT*3*0-*H with thermocouple and 2/3-wire RTD (close coupled)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	113 FIT	481 FIT	43 FIT	93%	1,90E-04

Table 10: TT*200-*H and TT*3*0-*H with 4-wire RTD (close coupled)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	110 FIT	375 FIT	44 FIT	91%	1,90E-04

Table 11: TT*200-*H and TT*3*0-*H with thermocouple (with extension wire)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	110 FIT	1227 FIT	141 FIT	90%	6,17E-04

Table 12: TT*3*0-*H with two thermocouples (with extension wire)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	113 FIT	2323FIT	48 FIT	98%	2,10E-04

Table 13: TT*200-*H and TT*3*0-*H with 2/3-wire RTD (with extension wire)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	110 FIT	707 FIT	136 FIT	85%	5,95E-04

Table 14: TT*3*0-*H with two 2/3-wire RTDs (with extension wire)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	113 FIT	1274 FIT	47 FIT	96%	2,08E-04

Table 15: TT*3*0-*H with thermocouple and 2/3-wire RTD (with extension wire)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	113 FIT	1799 FIT	48 FIT	97%	2,09E-04

Table 16: TT*200-*H and TT*3*0-*H with 4-wire RTD (with extension wire)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	110 FIT	822 FIT	46 FIT	95%	2,01E-04

Assuming that the temperature transmitters TT*200-*H and TT*3*0-*H will go to the pre-defined alarm state on detected failures of the thermocouple or RTD, the failure rate contribution or the PFD_{AVG} value (T[Proof] = 1 year) for the thermocouple or RTD in a **high stress environment** is as follows:

Table 17: TT*200-*H and TT*3*0-*H with thermocouple (close coupled)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	110 FIT	2227 FIT	141 FIT	94%	6,17E-04

Table 18: TT*3*0-*H with two thermocouples (close coupled)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	113 FIT	4323 FIT	48 FIT	98%	2,10E-04

Table 19: TT*200-*H and TT*3*0-*H with 2/3-wire RTD (close coupled)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	110 FIT	1114 FIT	214 FIT	85%	9,36E-04

Table 20: TT*3*0-*H with two 2/3-wire RTDs (close coupled)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	113 FIT	2236 FIT	55 FIT	97%	2,42E-04

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Table 21: TT*3*0-*H with thermocouple and 2/3-wire RTD (close coupled)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	113 FIT	3280 FIT	146 FIT	95%	6,38E-04

Table 22: TT*200-*H and TT*3*0-*H with 4-wire RTD (close coupled)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	110 FIT	1277 FIT	91 FIT	93%	3,98E-04

Table 23: TT*200-*H and TT*3*0-*H with thermocouple (with extension wire)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	110 FIT	18327 FIT	2041 FIT	90%	8,94E-03

Table 24: TT*3*0-*H with two thermocouples (with extension wire)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	113 FIT	40133 FIT	238 FIT	99%	1,04E-03

Table 25: TT*200-*H and TT*3*0-*H with 2/3-wire RTD (with extension wire)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	110 FIT	7927FIT	1941 FIT	80%	8,50E-03

Table 26: TT*3*0-*H with two 2/3-wire RTDs (with extension wire)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	113 FIT	19143 FIT	228 FIT	98%	9,98E-04

Table 27: TT*3*0-*H with thermocouple and 2/3-wire RTD (with extension wire)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	113 FIT	29638 FIT	233 FIT	99%	1,02E-03

Table 28: TT*200-*H and TT*3*0-*H with 4-wire RTD (with extension wire)

λ_{SD}	λ_{SU}	λ_{DD}	λ_{DU}	SFF	PFD_{AVG}
0 FIT	110 FIT	10227 FIT	141 FIT	98%	6,17E-04

The boxes marked in yellow (▭) mean that the calculated PFD_{AVG} values are within the allowed range for SIL 2 according to table 2 of IEC 61508-1 but do not fulfill the requirement to not claim more than 35% of this range, i.e. to be better than or equal to 3,50E-03. The boxes marked in green (▭) mean that the calculated PFD_{AVG} values are within the allowed range for SIL 2 according to table 2 of IEC 61508-1 and do fulfill the requirement to not claim more than 35% of this range, i.e. to be better than or equal to 3,50E-03.

A user of the temperature transmitters TT*200-*H and TT*3*0-*H with 4..20 mA output can utilize these failure rates in a probabilistic model of a safety instrumented function (SIF) to determine suitability in part for safety instrumented system (SIS) usage in a particular safety integrity level (SIL). A full table of failure rates is presented in section 5.1 along with all assumptions.

It is important to realize that the "no effect" failures are included in the "safe undetected" failure category according to IEC 61508, Edition 2000. Note that these failures on its own will not affect system reliability or safety, and should not be included in spurious trip calculations.

The failure rates are valid for the useful life of the temperature transmitters TT*200-*H and TT*3*0-*H with 4..20 mA output (see Appendix 2).

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