Contents

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1. General information on this handbook

This booklet summarises the WIKA temperature transmitters T32.10 / T32.11 / T32.30 with firmware version 2.0.5 solely as part of a safety-related system. This documentation is valid with the documentation listed in chapter 1.1. Please also note the safety instructions listed in the operating manual

1.1 Other applicable documentation

Head version	Rail version	Hazardous Area Classification	Approval – No.	Manual	Countries
T32.1*.**2	T32.30.**2	II 1G EEx ia IICT4/T5/T6	DMT 99 ATEX E 007X	2383336	Europe
T32.1*.**9	T32.30.**9	II 1G EEx nL/nA IIC T4/T5/T6 X	--------	2383336	Europe
T32.1*.**6	T32.30.**6	Intrinsically safe	CSA 1248412	2383336	Canada
T32.1*.**8	--------	Intrinsically safe	FM 3000040	2383336	USA
T32.1*.**2	T32.30.**2	II 1G EEx ia IICT4/T5/T6	20003EC02CP028X INMETRO	2383336	Brasil
T32.1*.**2	T32.30.**2	II 1G EEx ia IICT4/T5/T6	GYJ04431X, GYJ04432, NEPSI	2383336	China
T32.1*.**9	--------	Ex nL/nA IIC T4~T6	GYJ05141U NEPSI	2383336	China

1.2 Abbreviations

Acr.	Designation	Description
HFT	Hardware Fault Tolerance	Capability of a functional unit to continue the execution of the demanded function in the case of faults or anomalies,
MTBF	Mean Time Between Failures	Mean interval between two failures
MTTR	Mean Time To Repair	Mean interval between the occurrence of the failure in a device or system and its repair
PFD	Probability of Failure on Demand	Likelihood of dangerous safety function failures occurring on demand
PFD_{avg}	Average Probability of Failure on Demand	Average likelihood of dangerous safety function failures occurring on demand
SIL	Safety Integrity Level	The international standard IEC 61508 specifies four discrete safety integrity levels (SIL 1 to SIL 4). Each level corresponds to a specific probability range with respect to the failure of a safety function. The higher the integrity level of the safety-related system, the lower the likelihood of the demanded safety functions not occurring.
SFF	Safe Failure Fraction	Safe Failure Fraction summarises the proportion of failures which lead to a safe state, and the proportion of failures which will be detected by diagnostic measures and lead to a defined safety action.
T_{Proof}	Life testing of the safety function	Time interval between the functional test of the safety function.
XooY	„X out of Y“ Voting (e.g. 2oo3)	Classification and description of the safety-related system regarding redundancy and the selection procedure used. “Y” indicates how often the safety function is carried out (redundancy). “X” determines how many channels must work properly.

Further relevant abbreviations are listed in the IEC 61508-4 standard.

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1.3 Relevant standards

Acr.	English	German
IEC61508, Teil 1 bis 7	Functional safety of electrical/ electronic/programmable electronic safety-related systems Target group: Manufacturers, Suppliers of Devices	Sicherheitstechnische Systeme für die Prozessindustrie Zielgruppe: Hersteller und Lieferanten von Geräten
IEC61511, Teil 1	Safety Instrumented Systems for the process industry Target group: Safety Instrumented Systems Designers, Integrators and Users	Funktionale Sicherheit sicherheitsbezogener elektrischer/ elektronischer/programmierbarer elektronischer Systeme Zielgruppe: Planer, Errichter Nutzer

2. General safety information on SIL/SIS

2.1 Definition of Safety Integrity Level (SIL)

IEC 61508 defines four Safety Integrity Levels (SIL). Each SIL-Level corresponds to the statistical probability of the failure of a safety-related system. (IEC 61508-4, part 4.5.6). The higher the SIL of the safety-related system, the higher the probability that the safety-related system will work on demand and the higher the risk reduction. Or described differently, the higher the safety integrity level of the safety-related system, the lower the probability that the safety-related system won't work.

The achievable safety integrity level depends on the following safety-related characteristics:

- This value depends on the value of T_{Proof} between the functional test of the safety-related system.
- Hardware Fault Tolerance - HFT (Hardware Fault Tolerance - HFT)
- Safe Failure Fraction – SFF (Safe Failure Fraction – SFF)

The following table shows the interrelation of the safety integrity level (SIL) with the whole safety-related system (IEC 61508-1, chapter 7.6.2.9).

Safety Integrity Level (SIL	Low demand mode of operation (PFD_{avg}) (Average probability of failure to perform its design function on demand)	High demand or continuous mode of operation (PFD_{avg}) (Probability of a dangerous failure per hour)	Risk Reduction Factor
4	$\geq 10^{-5}$ to $\geq 10^{-4}$	$\geq 10^{-9}$ to $\geq 10^{-8}$	100000 to 10000
3	$\geq 10^{-4}$ to $\geq 10^{-3}$	$\geq 10^{-8}$ to $\geq 10^{-7}$	10000 to 1000
2	$\geq 10^{-3}$ to $\geq 10^{-2}$	$\geq 10^{-7}$ to $\geq 10^{-6}$	1000 to 100
1	$\geq 10^{-2}$ to $\geq 10^{-1}$	$\geq 10^{-6}$ to $\geq 10^{-5}$	100 to 10

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If the demand from the process is not higher than once per year, the measuring system can be considered as subsystem in the low demand mode. Low demand mode also means that the demand on the safety-related system is not higher than twice the frequency of T_{Proof}.

If “Low Demand Mode” doesn’t apply, the measuring system can be described as a safety-related system with “High Demand Mode”. (IEC 61508-4, part 3.5.12). “High Demand Mode” means the demand on the safety-related system is used more than once per year or continuously, or the demand is higher than twice the frequency of T_{Proof}.

2.2 Determination of Safety Integrity Level (SIL)

The following table shows the SIL of the safety-related system depending on SFF and HFT for type B subsystems. Type B subsystems typically include instruments with complex components (e.g. microprocessors). Temperature transmitters match the specifications for Type B (IEC 61508-2, part 7.4.3.1.3).

SFF	HFT		
	0	1 (0) (1)	2
< 60 %	Not permitted	SIL 1	SIL 2
60 to 90 %	SIL 1	SIL 2	SIL 3
90 to 99 %	SIL 2	SIL 3	SIL 4
< 99 %	SIL 3	SIL 4	SIL 4

(1) According to IEC 61511-1, Chapter 11.4.4, the HFT of instruments with complex components can be decreased by one if the following conditions are met:
- The device is proven-in-field
- The user can only configure process-related parameters such as measuring range etc.
- The configuration level of the device is protected against accidental or unauthorised changes (Password activated)
- The function has a specified SIL of less than 4

T32.10 / T32.11 / T32.30 Temperature transmitters meet all these requirements.

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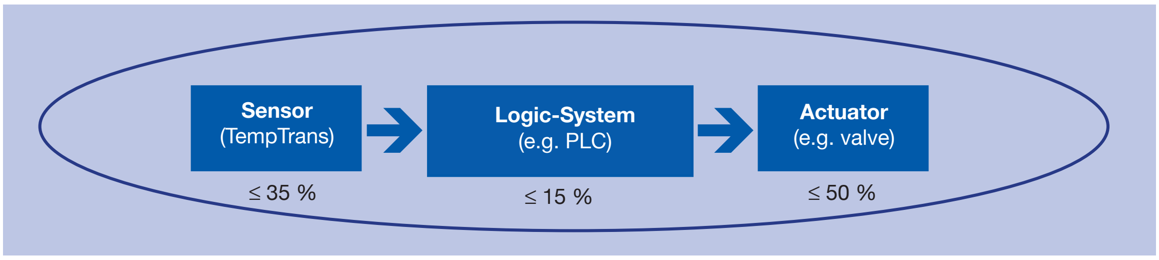
2.3 Definition of Safety Integrity System (SIS)

PFD_{avg} is the average probability of failure on demand of the safety-related protection system, which is the safety integrity failure measure for safety-related protection systems operating in a low demand mode of operation;



2.3.1 Safety-related function

The analogue signal is transmitted to a series-connected logic unit, e.g. a PLC or an alarm contact, where it is monitored as to whether it exceeds a maximum value or drops below a minimum value. The logic unit controls the process e.g. with a signal to an actuator (e.g. valve).

2.3.2 , Failure possibilities

Safe Failure (λ_{sd} und λ_{su}), (IEC 61508-4, part 3.6.8):
A safe failure occurs if the measuring system switches into the safe state or the error mode without demand from the process.

Dangerous Failure ($\lambda_{dd)}$ + $\lambda_{du)}$), (IEC 61508-4, part 3.6.7):
A dangerous failure occurs if the measuring system switches into a dangerous or functionally inoperable condition.

Dangerous Undetected Failure ($\lambda_{du)}$):
A dangerous undetected failure occurs if the measuring system does not switch into a safe condition or into the error mode on a demand from the process.

2.3.3 Proof test (T_{Proof})

According to IEC 61508-4, part 3.8.5, T_{Proof} is defined as periodic tests for exposing errors in a safety-related system

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3. Device-specific safety information

3.1 Intended use

The instrument is a universal, configurable transmitter for resistance thermometers (RTD), thermocouples (TC) as well as resistance and voltage calibration sources. The temperature transmitter converts a resistance or voltage value into a proportional current signal between 3.8mA and 20.5mA.

The analogue signal is transmitted to a series-connected logic unit, e.g. a PLC or an alarm contact, where it is monitored as to whether it exceeds a maximum value or drops below a minimum value.

The temperature transmitter monitors the connected sensor and the internal hardware for errors. If an error is detected, the transmitter generates both a digital error signal via HART®-Protocol and an analogue signal at the defined output current (error current for fail low / fail high).
Note: HART® Information must not be used for safety-related operations.
The T32 generates an error current for the following error conditions.
- Sensor burn-out
- Sensor short-circuit (only for resistance sensor)
- Internal hardware error
- Sensor measuring range exceeded or below sensor measuring range
- Invalid cold-junction compensation temperature (for thermocouples)

For the error current, the following conditions are defined by NAMUR NE43:
- error current, Fail Low: < 3,6 mA (Downscale)
- error current, Fail High: < 21,5 mA (Upscale)

If the transmitter delivers the “fail high” or “fail low output current, the user must assume there is a failure in the system.
The logic unit must be capable of recognising the Fail-High error current (adjustable from 21...22.5 mA) as well as the Fail-Low error current (3.6 mA). The logic unit must give an appropriate alarm signal.

A measured value is to be assumed in the range of the output current of 7.8 mA < x < 20,5 mA .

The transmitter fulfils, in particular, the requirements for:
- functional safety according to IEC 61508/IEC 61511-1
- explosion protection (depending on the instrument version)
- electromagnetic compatibility according to EN 61326 and NAMUR recommendation NE 21
- analogue output error-signalling according to NAMUR recommendation NE 43
- Sensor burnout signalling according to NAMUR recommendation NE 89.

3.2 Device parameters / Write protection

Because the process and equipment conditions affect the safety of the whole measuring system, the instrument parameters have to be set according to the application needs.
The specified limits must be followed; the T32’s specifications must not be exceeded.
To protect against inadvertent and/or unauthorised changes in the configuration, alterable parameters must be write-protected (password activated).

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The write protection (password) can be used with the following configuration tools:

- WIKA_T32 Configuration-Software
- AMS
- SIMATIC PDM
- DTM (Version: DTM Betaversion V1.0.2 January 2003) in combination with FDT/DTM-Standard user software, e.g PACTware™
- HART®- Handterminal FC375, FC275
- and further tools (this list is regulary enhanced)

3.4 Inadmissible safety-related use

Measured value transmission via HART® protocol and the HART® "Multidrop-network" can only be used for setup, calibration, and diagnostic purposes, not during normal safety-related operation.

3.5 Installation

For installation and mounting instructions please refer to the operating instructions.

3.6 Commissioning and periodic tests

Function tests are intended to demonstrate the correct function of the whole safety-related system, including all instruments (Sensor, Logic unit, and actuator). Therefore the operability and error current of the T32, as a part of the sensor, must be tested both during commissioning and at reasonable intervals.

Both the nature of the tests as well as the chosen intervals are the responsibility of the user. The intervals are set according to the PFD_{avg} values used. (Please refer to the FMEDA report). Usually T_{proof} is one year or less.

The following tests should only be carried out with write-protection activated, in order to prevent accidental configuration changes.

Recommended tests:

- Simulate a sensor-break and a sensor burnout (sensor burnout only for RTD sensors) and check the response of the transmitter (error current according to the chosen configuration).
- If the temperature sensors are simulated, the following should apply: The input signal must be generated for the start, middle and end signal of the configured sensor and measuring range. The corresponding output signal must be monitored (start, middle, span). Recommended tools for sensor simulation are resistance decades or voltage simulators.
- The sensor measuring ranges must be tested both over- and under-range (e.g. Pt100: -200 < x < 1000°C) and the response of the transmitter checked (error current according to configuration).
- The configuration of the transmitter should be altered using a suitable configuration tool (e.g. WIKA Configuration Software) and the response checked. The transmitter must respond with an error, due to the activated write-protection.

In some special cases the transmitter logic unit connection can be tested using the "Simulation" within the transmitter (i.e. without any sensor or sensor simulation connected). The desired output current of the transmitter, between 4 mA and 20 mA, can be simulated using the configuration tools described in Chapter 8.8. To use this feature, the write-protection must be disabled, which means an additional risk. The methods and procedures for these tests must be documented, as must the test results. If the outcome of the function test is negative, the whole system must be shut down. The process must be put into a safe condition using appropriate procedures.

3.7 Maintenance

The transmitter T32 is maintenance free. The electrical components of the transmitter are mounted in a plastic case and completely encapsulated. The transmitters therefore have no devices which could be changed or repaired.

3.8 Actions in case of errors

The cause of malfunctions as well as hints for resolving them are described in the operating instructions. If malfunctions cannot be resolved, the whole measuring system must be shut down. The process must be put into a safe condition using appropriate procedures.

Defective instruments must be marked to prevent inadvertent re-use.

Send the faulty instruments back to WIKA, along with a description of the cause of the fault. Please use the Product Return sheet, which can be found at www.wika.de / Service / retoure.

WIKA Alexander Wiegand GmbH & Co. KG
Alexander Wiegand Straße
63911 Klingenberg
Tel: 09372 / 132-0
www.wika.de

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3.9 Safety-related variables

The failure rates of the electronics were determined using FMEDA according to IEC61508. The failure rates used in this analysis are the basic failure rates from the Siemens standard SN 29500.

The following assumptions have been made:
- All modules are operated in the Low Demand Mode of operation.
- External power supply failure rates are not included.
- The logic unit must be capable of recognising the Fail-High error current (adjustable from 21...22.5 mA) as well as the Fail-Low error current (3.6 mA) and must give an appropriate alarm signal.
- The values for SFF und PFD_{avg} obtained from the FMEDA-report have been used.
- HART®-protocol is only used for setup, calibration, and diagnostic purposes, not during safety-related normal operation.
- The mean ambient temperature during the period of operation is 40°C.
- The environmental conditions / stress levels are average for an industrial environment
- The temperature transmitter is locked against unintentional and unauthorised change/use (password protected).
- The repair time after a safe failure is 8 hours.

Safety-related figures

Examination for a type B component, with low demand mode and a Hardware Fault Tolerance (HFT) of 0.

		T32.**.*** (1)	T32.**.*** with thermocouple connected (4) (TC)	T32.**.*** with 4-wire RTD connected (4) (4-wire)	T32.**.*** with 2/3-wire RTD connected (4) (2-, 3-wire)
SFF	Safe Failure Fraction	> 63 %	> 91,75 %	> 90,95 %	> 76,21 %
PFD_{avg}	Average Probalility of dangerous Failure on demand	9,4-E04 (2)	2,02-E03 (2)	1,02-E03 (2)	2,69-E03 (2)
λ_{sd}	Failure rate λ safe failure detected	Note (3)	4.929 FIT	2.158 FIT	1.775 FIT
λ_{su}	Failure rate λ safe failure undetected	Note (3)	135 FIT	133 FIT	135 FIT
λ_{dd}	Failure rate λ dangerous failure detected	Note (3)	60 FIT	60 FIT	60 FIT
λ_{du}	Failure rate λ dangerous failure undetected	Note (3)	461 FIT	234 FIT	615 FIT

((1) Without examination of the reliability sensor data.
(2) PFD_{avg} is valid only for the T_{Proof} – interval (1 Year), after a recurring function test was carried out
(3) Detailed values (depending on the transmitter configuration) are given in the FMEDA-report
(4) Examination using generic low stress reliability data for the temperature sensor.

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Appendix - SIL Delaration of Conformity

SIL Declaration of Conformity

Functional Safety acc. IEC61508/IEC61511

WIKA
Pressure and Temperature Measurement

WIKA Alexander Wiegand GmbH & Co. KG
63911 Klingenberg
Alexander-Wiegand-Straße 30

Declares as manufacturer, that the HART® temperature transmitter

T32.10 / T32.11 / T32.30 with Firmware 2.0.5 (in the following said as T32.XX)

is suitable for the use in a safety-instrumented system up to a Safety Integrity Level of

SIL 2

with the following parameters according to IEC 61508, if the appropriated safety instructions are observed.

The reliability data in the following table were examined by means of a FMEDA (Failure Modes, Effects and Diagnostics Analysis) done by an independent organization.

	T32.XX 3)	T32.XX with thermocouple connected 5)	T32.XX with 4-wire RTD connected 5)	T32.XX with 2/3-wire RTD connected 5)
SFF	> 63 %	> 91,75 %	> 90,95 %	> 76,21 %
HFT(1)	1 (0)	1 (0)	1 (0)	1 (0)
PFDavg(2)	0,94E-03	2,02E-03	1,02E-03	2,69-E03
λ_{sd}	note 4)	4.929 FIT	2.158 FIT	1.775 FIT
λ_{su}	note 4)	135 FIT	133 FIT	135 FIT
λ_{dd}	note 4)	60 FIT	60 FIT	60 FIT
λ_{du}	note 4)	461 FIT	234 FIT	615 FIT

1) Examination for a type B component, with low demand mode: According to IEC 61511-, Part 11.4.4, the hardware fault tolerance (HFT) of sensors and final control elements with complex components can be decreased by one, because the corresponding requirements (i.e. proven-in-field use) are met.

2) PFD_{avg} is valid only for the T_{Proof} interval (1 year) after a recurring function test was carried out.

3) Without examination of the reliability sensor data

4) Detailed values (depending on the transmitter configuration) are given in the FMEDA Report.

5) Examination using generic low stress reliability data for the temperature sensor.

Klingenberg, 31.07.2006

ppa. [signature]

Dr. Martin Hohenstatt
Director Company Division Process Instrumentation

[signature]
Thomas Gerling
Qualitymanagement

WIKA Alexander Wiegand GmbH & Co. KG • 63911 Klingenberg / Germany • Tel. 093 72 / 1 32- 0 • Fax 093 72 / 1 32-406

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Appendix - exida.com, Management summary

Failure Modes, Effects and Diagnostic Analysis

Project:
Digital Temperature Transmitter T32 HART

Customer:
WIKA – Alexander Wiegand GmbH & Co. KG
Klingenberg
Germany

Contract No.: WIKA 02/3-10
Report No.: WIKA 02/3-10 R002
Version V2, Revision R1.2, February 2005
Stephan Aschenbrenner

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Management summary

This report summarizes the results of the hardware assessment carried out on the Digital Temperature Transmitter T32 HART with firmware version 2.0.4 or 2.0.5. Table 1 gives an overview of the different types that belong to the considered Digital Temperature Transmitter T32 HART.

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

T32.10	Digital Temperature Transmitter, head mounted (standard)
T32.11	Digital Temperature Transmitter, head mounted (high ambient temperature stability)
T32.30	Digital Temperature Transmitter, rail mounted (standard)

For safety applications only the 4..20 mA output was considered.

The failure rates 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 $\geq 10^{-2}$ to $< 10^{-1}$ for SIL 1 safety functions and $\geq 10^{-3}$ to $< 10^{-2}$ 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 1 application the total PFD_{AVG} value of the SIF should be smaller than 1,00E-01, hence the maximum allowable PFD_{AVG} value for the sensor assembly consisting of T32 and a thermocouple or RTD supplied with T32 would then be 3,50E-02.

For a SIL 2 application 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 assembly consisting of T32 and a thermocouple or RTD supplied with T32 would then be 3,50E-03.

The Digital Temperature Transmitter T32 HART is considered to be a Type B[1] component with a hardware fault tolerance of 0.

For Type B components the SFF has to be between 60% and 90% for SIL 1 (sub-) systems and between 90% and 99% for SIL 2 (sub-) systems with a hardware fault tolerance of 0 according to table 2 of IEC 61508-2.

Assuming that a connected logic solver can detect both over-range (fail high) and under-range (fail low), high and low failures can be classified as safe detected failures or dangerous detected failures depending on whether the Digital Temperature Transmitter T32 HART is used in an application for “low level monitoring” (MIN), “high level monitoring” (MAX) or “range monitoring”. For these applications the following tables show how the above stated requirements are fulfilled for the worst case configuration of the Digital Temperature Transmitter T32 HART.

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

Table 2: Summary for T32 (worst case configuration) – Failure rates

Failure category (Failure rates in FIT)		Fail-safe state = "fail high"	Fail-safe state = "fail low"
Fail High (detected by the logic solver)		175	
Fail detected (int. diag.)	137		
Fail high (inherently)	38		38
Fail Low (detected by the logic solver)			197
Fail detected (int. diag.)	137		
Fail low (inherently)	60	60	
Fail Dangerous Undetected		215	215
No Effect		135	135
MTBF = MTTF + MTTR		195 years	195 years

Transmitter configured fail-safe state = "fail high" – Failure rates according to IEC 61508

Failure Categories	λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	SFF	DC_S [2]	DC_D [2]
$\lambda_{low} = \lambda_{sd}$ $\lambda_{high} = \lambda_{dd}$	60 FIT	135 FIT	175 FIT	215 FIT	63%	30%	44%
$\lambda_{low} = \lambda_{dd}$ $\lambda_{high} = \lambda_{sd}$	175 FIT	135 FIT	60 FIT	215 FIT	63%	56%	21%
$\lambda_{low} = \lambda_{sd}$ $\lambda_{high} = \lambda_{sd}$	235 FIT	135 FIT	0 FIT	215 FIT	63%	63%	0%

Transmitter configured fail-safe state = "fail low" – Failure rates according to IEC 61508

Failure Categories	λ_{sd}	λ_{su}	λ_{dd}	λ_{du}	SFF	DC_S [2]	DC_D [2]
$\lambda_{low} = \lambda_{sd}$ $\lambda_{high} = \lambda_{dd}$	197 FIT	135 FIT	38 FIT	215 FIT	63%	59%	15%
$\lambda_{low} = \lambda_{dd}$ $\lambda_{high} = \lambda_{sd}$	38 FIT	135 FIT	197 FIT	215 FIT	63%	21%	47%
$\lambda_{low} = \lambda_{sd}$ $\lambda_{high} = \lambda_{sd}$	235 FIT	135 FIT	0 FIT	215 FIT	63%	63%	0%

It is important to realize that the "don't care" failures are included in the "safe undetected" failure category according to IEC 61508. Note that these failures on its own will not affect system reliability or safety, and should not be included in spurious trip calculations.

[2] DC means the diagnostic coverage (safe or dangerous) of the safety logic solver for the Digital Temperature Transmitter T32 HART.

Stephan Aschenbrenner

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Table 3: Summary for T32 (worst case configuration) – PFD_{AVG} values

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years
PFD_{AVG} = 9,41E-04	PFD_{AVG} = 4,69E-03	PFD_{AVG} = 9,36E-03

A complete temperature sensor assembly consisting of T32 and a closely coupled thermocouple or cushioned RTD supplied with T32 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.

Section 5.5 gives typical failure rates and failure distributions for thermocouples and RTDs which were the basis for the following tables.

Assuming that T32 is programmed to drive its output high on detected failures of the thermocouple or RTD ($\lambda_{low} = \lambda_{dd}$, $\lambda_{high} = \lambda_{sd}$), the failure rate contribution or the PFD_{AVG} value for the thermocouple or RTD in a low stress environment is as follows:

Table 4: Summary for the sensor assembly T32 / thermocouple in low stress environment

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years	SFF
PFD_{AVG} = 2,02E-03	PFD_{AVG} = 1,01E-02	PFD_{AVG} = 2,02E-02	> 91%

λ_{sd} = 4929 FIT

λ_{su} = 135 FIT

λ_{dd} = 60 FIT

λ_{du} = 461 FIT

Table 5: Summary for the sensor assembly T32 / 4-wire RTD in low stress environment

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years	SFF
PFD_{AVG} = 1,02E-03	PFD_{AVG} = 5,12E-03	PFD_{AVG} = 1,02E-02	> 90%

λ_{sd} = 2158 FIT

λ_{su} = 133 FIT

λ_{dd} = 60 FIT

λ_{du} = 234 FIT

Table 6: Summary for the sensor assembly T32 / 2/3-wire RTD in low stress environment

T[Proof] = 1 year	T[Proof] = 5 years	T[Proof] = 10 years	SFF
PFD_{AVG} = 2,69E-03	PFD_{AVG} = 1,35E-02	PFD_{AVG} = 2,69E-02	> 76%

λ_{sd} = 1775 FIT

λ_{su} = 135 FIT

λ_{dd} = 60 FIT

λ_{du} = 615 FIT

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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 table 3.1 of ANSI/ISA–84.01–1996 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. The boxes marked in red ( ) mean that the calculated PFD_{AVG} values do not fulfill the requirement for SIL 2 according to table 2 of IEC 61508-1.

Where the Safe Failure Fraction (SFF) is between 60% and 90% the SIL 1 architectural constraints requirements of table 3 of IEC 61508-2 for Type B subsystems with a Hardware Fault Tolerance (HFT) of 0 are fulfilled.

Where the Safe Failure Fraction (SFF) is above 90% the SIL 2 architectural constraints requirements of table 3 of IEC 61508-2 for Type B subsystems with a Hardware Fault Tolerance (HFT) of 0 are fulfilled.

The hardware assessment has shown that the Digital Temperature Transmitter T32 HART with 4..20 mA output has a PFD_{AVG} within the allowed range for SIL 1 according to table 2 of IEC 61508-1 and table 3.1 of ANSI/ISA–84.01–1996 and a Safe Failure Fraction (SFF) of more than 63%.

A user of the Digital Temperature Transmitter T32 HART can utilize these failure rates along with the failure rates for the temperature sensing device 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 for different operating conditions is presented in section 5.1 to 5.4 along with all assumptions and temperature sensing device data.

1 Purpose and Scope

Generally three options exist when doing an assessment of sensors, interfaces and/or final elements.

Option 1: Hardware assessment according to IEC 61508

Option 1 is a hardware assessment by *exida.com* according to the relevant functional safety standard(s) like DIN V VDE 0801, IEC 61508 or EN 954-1. The hardware assessment consists of a FMEDA to determine the fault behavior and the failure rates of the device, which are then used to calculate the Safe Failure Fraction (SFF) and the average Probability of Failure on Demand (PFD_{AVG}).

This option for pre-existing hardware devices shall provide the safety instrumentation engineer with the required failure data as per IEC 61508 / IEC 61511 and does not consist of an assessment of the software development process

Option 2: Hardware assessment with proven-in-use consideration according to IEC 61508 / IEC 61511

Option 2 is an assessment by *exida.com* according to the relevant functional safety standard(s) like DIN V VDE 0801, IEC 61508 or EN 954-1. The hardware assessment consists of a FMEDA to determine the fault behavior and the failure rates of the device, which are then used to calculate the Safe Failure Fraction (SFF) and the average Probability of Failure on Demand (PFD_{AVG}). In addition this option consists of an assessment of the proven-in-use documentation of the device and its software including the modification process.

This option for pre-existing programmable electronic devices shall provide the safety instrumentation engineer with the required failure data as per IEC 61508 / IEC 61511 and justify the reduced fault tolerance requirements of IEC 61511 for sensors, final elements and other PE field devices.

Option 3: Full assessment according to IEC 61508

Option 3 is a full assessment by *exida.com* according to the relevant application standard(s) like IEC 61511 or EN 298 and the necessary functional safety standard(s) like DIN V VDE 0801, IEC 61508 or EN 954-1. The full assessment extends option 1 by an assessment of all fault avoidance and fault control measures during hardware and software development.

This option is most suitable for newly developed software based field devices and programmable controllers to demonstrate full compliance with IEC 61508 to the end-user.

This assessment shall be done according to option 1.

This document shall describe the results of the assessment carried out on the Digital Temperature Transmitter T32 HART with firmware version 2.0.4 or 2.0.5. Table 1 gives an overview of the series and explains the differences between the different types.

It shall be assessed whether the transmitter meets the average Probability of Failure on Demand (PFD_{AVG}) requirements and the architectural constraints for SIL 1 sub-systems according to IEC 61508. It **does not** consider any calculations necessary for proving intrinsic safety.

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WIKA worldwide

Europe

Austria
WIKA Messgerätevertrieb
Ursula Wiegand
GmbH & Co. KG
1230 Wien
Phone: (+43) 1-86 91 631
Fax: (+43) 1-86 91 634
E-mail: info@wika.at
www.wika.at

Benelux
WIKA Benelux
6101 WX Echt
Phone: (+31) 475-535 500
Fax: (+31) 475-535 446
E-mail: info@wika.nl
www.wika.nl

Bulgaria
WIKA Bulgaria EOOD
1309 Sofia
Phone: (+359) 2 82138-10
Fax: (+359) 2 82138-13
E-mail: t.antonov@wika.bg

Finland
WIKA Finland Oy
00210 Helsinki
Phone: (+358) 9-682 49 20
Fax: (+358) 9-682 49 270
E-mail: info@wika.fi
www.wika.fi

France
WIKA Instruments s.a.r.l.
95610 Eragny-sur-Oise
Phone: (+33) 1-34 30 84 84
Fax: (+33) 1-34 30 84 94
E-mail: info@wika.fr
www.wika.fr

Germany
WIKA
Alexander Wiegand
GmbH & Co. KG
63911 Klingenberg
Phone: (+49) 93 72-13 20
Fax: (+49) 93 72-13 24 06
E-mail: info@wika.de
www.wika.de

Italy
WIKA Italiana SRL
20020 Arese (Milano)
Phone: (+39) 02-93 86 11
Fax: (+39) 02-93 86 174
E-mail: info@wika.it
www.wika.it

Poland
Kujawska Fabryka Manometrow
-KFM S.A.
87-800 Wloclawek
Phone: (+48) 542 30 11 00
Fax: (+48) 542 30 11 01
E-mail: info@manometry.com.pl
www.manometry.com.pl

Romania
WIKA Instruments S.R.L.
Bucuresti, Sector 5
Phone: (+40) 21-456 31 38
Fax: (+40) 21-456 31 37
E-mail: m.anghel@wika.ro

Russia
ZAO „WIKA MERA“
127015 Moscow
Phone: (+7) 495-786 21 25
Fax: (+7) 495-786 21 23
E-mail: info@wika.ru
www.wika.ru

Serbia
WIKA Merna Tehnika d.o.o.
11060 Beograd
Phone: (+381) 11 27 63 722
Fax: (+381) 11 75 36 74
E-mail: info@wika.co.yu
www.wika.co.yu

Spain
Instrumentos WIKA, S.A.
08280 Sabadell (Barcelona)
Phone: (+34) 90-290 25 77
Fax: (+34) 93-393 86 66
E-mail: info@wika.es
www.wika.es

Switzerland
MANOMETER AG
6285 Hitzkirch
Phone: (+41) 41-919 72 72
Fax: (+41) 41-919 72 73
E-mail: info@manometer.ch
www.manometer.ch

Ukraine
WIKA Pribor GmbH
83016 Donetsk
Phone: (+38) 062 345 34 16
Fax: (+38) 062 345 34 16
E-mail: info@wika.donetsk.ua
www.wika.donetsk.ua

United Kingdom
WIKA Instruments Ltd
Merstham, Redhill RH13LG
Phone: (+44) 17 37 64 40 08
Fax: (+44) 17 37 64 44 03
E-mail: info@wika.co.uk
www.wika.co.uk

North America

Canada
WIKA Instruments Ltd.
Head Office
Edmonton, Alberta, T6N 1C8
Phone: (+1) 780-463 70 35
Fax: (+1) 780-462 00 17
E-mail: info@wika.ca
www.wika.ca

Mexico
Instrumentos WIKA Mexico S.A.
de C.V.
01219 Mexico D.F.
Phone: (+52) 555 020 53 00
Fax: (+52) 555 020 53 01
E-Mail ventas@wika.com.mx
www.wika.com.mx

USA
WIKA Instrument Corporation
Lawrenceville, GA 30043
Phone: (+1) 770-513 82 00
Fax: (+1) 770-338 51 18
E-mail: info@wika.com
www.wika.com

South America

Argentina
WIKA Argentina S.A.
Buenos Aires
Phone: (+54-11) 4730 18 00
Fax: (+54-11) 4761 00 50
E-mail: info@wika.com.ar
www.wika.com.ar

Brazil
WIKA do Brasil Ind. e Com.
Ltda.
CEP 18560-000 Iperó - SP
Phone: (+55) 15-3266 16 55
Fax: (+55) 15-3266 16 50
E-mail: marketing@wika.com.br
www.wika.com.br

Africa/Middle East

Egypt
WIKA Alexander Wiegand
GmbH & Co. KG
Makram Ebaid
Nasr City, Cairo
Phone: (+20) 2 - 273 31 40
Fax: (+20) 2 - 273 31 40
E-mail: ahmed.azab@wika.de

Iran
WIKA Instrumentation Pars
(KFZ) Ltd.
Anahita Tower, Tehran
Phone: (+98-21) 8878 3514-17
Fax: (+98-21) 8887 8593
E-mail: info@wika.ir
www.wika.ir

South Africa
WIKA Instruments (Pty.) Ltd.
Gardenview, Johannesburg
2047
Phone: (+27) 11-621 00 00
Fax: (+27) 11-621 00 59
E-mail: sales@wika.co.za
www.wika.co.za

United Arab Emirates
WIKA Middle East FZE
Jebel Ali, Dubai
Phone: (+971) 4 - 883 90 90
Fax: (+971) 4 - 883 91 98
E-mail: wikame@emirates.net.ae

Asia

China
WIKA International Trading
(Shanghai) Co., Ltd.
200001 Shanghai
Phone: (+86) 21 - 53 85 25 73
Fax: (+86) 21 - 53 85 25 75
E-mail: wikash@online.sh.cn
www.wika.com.cn

India
WIKA Instruments India Pvt. Ltd.
Village Kesnand, Wagholi
Pune - 412 207
Phone: (+91) 20 - 27 05 29 01
Fax: (+91) 20 - 27 05 19 25
E-mail: sales@wika.co.in
www.wika.co.in

Japan
WIKA Japan K. K.
Tokyo 105-0023
Phone: (+81) 3-54 39 66 73
Fax: (+81) 3-54 39 66 74
E-mail: t-shimane@wika.co.jp

Kazakhstan
TOO WIKA Kazakhstan
050050 Almaty
Phone: (+7) 32 72 33 08 48
Fax: (+7) 32 72 78 99 05
E-mail:
wika-kazakhstan@nursat.kz

Korea
WIKA Korea Ltd.
Seoul 153-023
Phone: (+82) 2 - 8 69 05 05
Fax: (+82) 2 - 8 69 05 25
E-mail: info@wika.co.kr

Malaysia
WIKA Instrumentation (M)
Sdn. Bhd.
Selangor Darul Ehsan
Phone: (+60) 3 - 56 36 88 58
Fax: (+60) 3 - 56 36 90 72
E-mail: info@wika.com.my
www.wika.com.my

Singapore
WIKA Instrumentation Pte. Ltd.
569625 Singapore
Phone: (+65) 68 44 55 06
Fax: (+65) 68 44 55 07
E-mail: info@wika.com.sg
www.wika.com.sg

Taiwan
WIKA Instrumentation Taiwan
Ltd.
Pinjen, Taoyuan
Phone: (+886) 034 20 60 52
Fax: (+886) 034 90 00 80
E-mail: info@wika.com.tw
www.wika.com.tw

Australia

Australia
WIKA Australia Pty. Ltd.
Rydalmere, NSW 2116
Phone: (+61) 2 - 88 45 52 22
Fax: (+61) 2 - 96 84 47 67
E-mail: sales@wika.com.au
www.wika.com.au

11188546 11/2006 GB

WIKA Alexander Wiegand GmbH & Co. KG
Alexander-Wiegand-Straße 30
63911 Klingenberg Germany
Phone (+49) 93 72/132-0
Fax (+49) 93 72/132-406
E-Mail info@wika.de
www.wika.de