

JUMO Safety Manual for RTD temperature probes and thermocouples connected at JUMO safetyM STB/STW 70115X *with Safety Integrity Level (SIL) and Performance Level (PL) classification*



Safety Manual
B900010.9



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V4.00/EN/00638932

Safety Manual for Temperature Probe for Connection to JUMO safetyM with Functional Safety

Field of application This Safety Manual applies to JUMO temperature probes for connection with JUMO safetyM STB/STW 70115X with SIL certification, and is only valid together with the manufacturer's declaration for the applicable temperature probe (shown on page 8) in connection with the extra code 058.
The operating instruction 70115X00T90Z00XK000 is also an applicable document.

Note:

Head sensors are equipped with yellow terminal heads.

Exception: the terminal heads are silver when used in alkaline environments (such as for product groups 901006 and 902006).

Furthermore, type examination certificates in accordance with ATEX or IEC-Ex are required for explosion protection applications.

Area of application With this combination, a safe temperature measurement in the sense of functional safety within the safety levels SIL 2 or SIL 3 or performance level d is possible in accordance with the standards

-DIN EN 61508 section 1 to 7 "Functional safety of electrical/electronic/programmable electronic safety-related systems"

-DIN EN ISO 13849 -1 "Safety of machinery – Safety-related parts of control systems". Conformity to SIL and PL is documented by the TÜV report SEBS-A.20121130.120443TB-1.

Abbreviations, terms

Terms and abbreviations in accordance with DIN EN 14597:

Abbreviation	Explanation
Type 2	Mode of operation for which the manufacturing deviation and drifting from operating value, operating life, or operational procedure has been tested.
Type B	Micro-disconnection in operation, corresponding contact disconnection in at least one pole in order to deliver functional safety.
Type D	A free trip mechanism which temporarily cannot be closed as long as the error remains.
Type F (STB)	A mode of operation which can only be reset using a tool once the RS has been installed.
Type J (STB)	A free trip mechanism with contacts that cannot be prevented from opening and which may not function as an automatically resetting RS if the means of resetting is held in the "Reset" or "On" position.
Type K	A mode of operation for probes whereby a sensor break or an interruption in the connection between the probe head and the switch head does not cause an increase in the operating value.
Type N	A mode of operation for which there is no increase in the operating value as a result of a leak in the sensor or in the parts which connect the probe and the switch head. This is applied correspondingly to the electrical fault models.
Type V (STB)	A fault shutdown which can only be reactivated by manual reset.
Type P	A mode of operation which is effective in accordance with a specified test through a change in temperature, as stipulated in 17.101 of DIN EN 60730-2-9.

Terms and abbreviations in accordance with DIN EN 61508 and DIN EN 61511:

Name	Description
Actuator	Part of a technical safety system which intervenes in the process in order to achieve a safe state.
EUC	Equipment Under Control Device, machine, apparatus or unit used for production, remodeling of materials, transportation, or for medicinal or other activities.
E/E/PE	Electrical/Electronic/Programmable Electronic (E/E/EP): based on electrical

Safety Manual for Temperature Probe for Connection to JUMO safetyM with Functional Safety

	(E) and/or electronic (E) and/or programmable electronic (PE) technology
Failure	The end of the capability of a functional unit to carry out a requested function.
Diagnostic Coverage	Partial reduction of the probability of a hazardous hardware failure due to the application of automatic diagnostic tests.
Fault	Abnormal condition which can result in a reduction or the loss of the capability of a functional unit to carry out a requested function.
Functional Safety	Part of the overall safety, based on the EUC and the EUC control system, which depends on the correct functioning of the E/E/PE safety-related system, safety-related systems of other technologies, and external devices for risk reduction.
Functional Unit	Unit of hardware, software, or both which is suitable for the execution of a stipulated task.
Dangerous Failure	Failure with the potential to put the safety-related system in a dangerous state or a state in which it cannot carry out its function.
Safe Failure	Failure without the potential of placing the safety-related system into a dangerous state or one where it cannot carry out its function.
Hazard	Potential sources of damage
Safety	Freedom from unacceptable risk
Safety Function	Function which is executed by an E/E/PE safety-related system, a safety-related system of other technologies, or external devices for the reduction of risk, with the aim of achieving or maintaining a safe state for the EUC by taking into consideration a defined dangerous event.
Safety Integrity	Probability that a safety-related system executes the required safety function under all stipulated conditions within a given time frame and in line with requirements.
Safety Integrity Level (SIL)	One of four discreet levels to specify the requirements for the safety integrity of safety functions which are assigned to the E/E/PE safety-related system; SIL 4 corresponds to the highest level of integrity safety; SIL 1 the lowest.
Safety-Related System	System which both <ul style="list-style-type: none"> - executes the required safety functions necessary for reaching and maintaining a safe state for the EUC, and - is intended to achieve the necessary safety integrity for the required safety functions either on its own or with other E/E/PE safety-related systems, safety-related systems of other technologies, or external devices used for the reduction of risk.
Safety Instrumented System (SIS)	Safety instrumented system for the execution of one or more safety-related functions. A SIS consists of sensor(s), logic systems, and actuator(s).
Lambda: λ	Failure rate per hour
Lambda dangerous: λ_D	Dangerous failure rate per hour
Lambda Dangerous Detect: λ_{DD}	Detected dangerous failure rate per hour
Lambda Dangerous Undetect: λ_{DU}	Undetected dangerous failure rate per hour
Lambda: λ_S	Non-dangerous failure rate per hour
Lambda: λ_{SD}	Detected non-dangerous failure rate per hour

Safety Manual for Temperature Probe for Connection to JUMO safetyM with Functional Safety

Lambda: λ_{SU}	Undetected non-dangerous failure rate per hour
BPCS	Basic Process Control System
DC	D iagnostic C overage
FIT	Failure in Time (1×10^{-9} per h)
HFT	Hardware Fault Tolerance
PFD	Probability of Failure on Demand
PFD _{avg}	Average Probability of Failure on Demand
MooN	M out of N channel architecture
MTBF	Mean time between two failures
MTTR	Mean time between occurrence of a failure and repair
SFF	Safe Failure Fraction
SIL	Safety Integrity Level

Terms and abbreviations in accordance with DIN EN ISO 13849:

Symbols or abbreviation	Description
PL (a, b, c, d, e)	Denotation of Performance Level
B, 1, 2, 3, 4	Denotation of categories
B _{10d}	Number of cycles at which 10% of the components of a sample fail dangerously for wearing, pneumatic, or electromechanical components (mean time to dangerous failure)
CCF	C ommon C ause of F ailure
DC	D iagnostic C overage
DC _{avg}	Average diagnostic coverage
F, F1, F2	Frequency and/or time of exposure to the hazard
FMEA	Failure Mode and Effects Analysis
MTTF	Mean Time to Failure
MTTF _c	Mean Time to Hazardous Failure
MTTF _d	Mean Time to Dangerous Failure
P, P1, P2	Possibility of avoiding the hazard
PES	Programmable Electronic System
PL	Performance Level
PLC	Programmable Logic Controller
PL _{low}	Lowest Performance Level of a SRP/CS in a SRP/CS combination
PL _f	Required Performance Level
r _a	Demand Rate
S, S1, S2	Severity of injury
SIL	Safety Integrity Level
SK (Cat.)	Category (B, 1, 2, 3, 4), structure as basis to achieve a certain PL
SRASW	Safety-Related Application Software
SRESW	Safety-Related Embedded Software
SRP	Safety-Related Part

Safety Manual for Temperature Probe for Connection to JUMO safetyM with Functional Safety

SRP/CS	Safety Related Part of (a) Control System(s)
Sub-PL/Sub-SIL	PL or SIL on sub-system level A sub-system is a system which – in relation to a sub-task – already executes a safety function appropriately (for example, an input module which safely records the inputs).
TE	Test Equipment
T _M	Length of operation, anticipated period of use (Mission Time)
T _{10d} value	Guide value for a preventative replacement (10% of the B _{10d} value). At this value, 63 % of all components have already failed dangerously. In such cases, the standard DIN EN ISO 13849-1:2006 recommends replacement.

Further abbreviations and terms are outlined in IEC 61508-4.

Safety requirements

Failure tolerances for a safety function, depending on the SIL group (IEC 61508-1, 7.6.2)

Safety Integrity Level	Operating mode with low demand rate	Operating mode with high demand rate
SIL	PFD	PFH
4	$\geq 10^{-5}$ to $< 10^{-4}$	$\geq 10^{-9}$ to $< 10^{-8}$
3	$\geq 10^{-4}$ to $< 10^{-3}$	$\geq 10^{-8}$ to $< 10^{-7}$
2	$\geq 10^{-3}$ to $< 10^{-2}$	$\geq 10^{-7}$ to $< 10^{-6}$
1	$\geq 10^{-2}$ to $< 10^{-1}$	$\geq 10^{-6}$ to $< 10^{-5}$

Safety integrity of hardware for type B safety-related sub-systems (IEC 61508-2, 7.4.3)

Safe Failure Fraction	Fault tolerance		
	HFT = 0	HFT = 1	HFT = 2
< 60 %	-	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)

Qualitative requirements

Resistance thermometer

The platinum resistance thermometers meet the requirements of the standard DIN EN 60751.

Thermocouples

The thermocouples meet the requirements of the standard DIN EN 60584.

The temperature probes are developed and manufactured in a production process which is certified to ISO 9001.

Permissible versions

Only thermometers which **do not** contain a **transmitter** are permitted.

Please ensure that the following extra codes are **not** contained in the order codes:

/330, /331, /332, /333, /334, /335, /336, /337, /338, /550, /551, and 859.

Reaction time

The information regarding reaction times is based on measurement in accordance with DIN EN 60751 in air at a flow rate of 2 m/s, and water at a flow rate of 0.4 m/s. The corresponding reaction times t_{05} and t_{09} are given. This is the time that the temperature probe needs in order to display 50 % or 90 % of the temperature jump.

The entire reaction time is comprised of the reaction time of the temperature probe and the reaction time of the JUMO safetyM STB/STW 70115X combined and can be found in the operating instruc-

Safety Manual for Temperature Probe for Connection to JUMO safetyM with Functional Safety

tions of the JUMO safetyM STB/STW 70115X (chapter on "Technical Data").

Guide values for temperature probes depend on external diameter

Diameter/mm	Air		Water	
	t ₀₅ /s	t ₀₉ /s	t ₀₅ /s	t ₀₉ /s
< 2 mm	10	25	1	3
< 3 mm	15	50	3	7
< 6 mm	40	140	6	18
< 9 mm	85	300	20	55
< 12 mm	210	750	50	140

Note: These are typical values from the standard design (for example, in accordance with DIN 43772) and should be used as reference values.

Before using the temperature probe together with the JUMO safetyM STB/STW 70115X, the user must check whether the complete reaction time for the application can ensure safe switch-off of the entire system. Furthermore, the fault tolerance time of the JUMO safetyM STB/STW 70115X must be observed.

Overheating resistance

Based on the maximum operating temperature of the respective temperature probe, a 10 % overheating resistance must be taken into account.

For example:

- maximum operating temperature of the temperature probe 400 °C
- 10 % overheating resistance = 40 °C
- maximum operating temperature for functional safety 400 °C - 40 °C = 360 °C

Safety-related calculations

The calculation is based on the usual breakdown of 35 % sensor, 15 % logic and 50 % actuator. The calculation therefore results in 50 % for the temperature probes being used together with the JUMO safetyM STB/STW 70115X.

The failure rate and fault models are calculated based on existing experience in the field and the analysis of data collected annually from complaints statistics.

Achievable SIL and PL

This table shows the options for connecting the probe to the JUMO safetyM STB/STW 70115X, as well as the maximum achievable SIL and/or PL level.

Variants of connections of sensors with JUMO safetyM STB/STW 70115X

Variant	Connected sensors	Sensor architecture	Logic architecture	Achievable SIL/PL
Var 1	1× Pt100 (two-wire circuit)	1oo1	1oo2D	SIL 2/PL d oder SIL 2/PL c
Var 1a	2× Pt100/1000 (two-wire circuit)	1oo2	1oo2D	SIL 3/PL e oder SIL 3/PL d
Var 2	2× Pt100/1000 (three-wire circuit)	1oo2	1oo2D	SIL 3/PL e oder SIL 3/PL d
Var 3	2× thermocouple	1oo2	1oo2D	SIL 3/PL d
Var 4	1× Pt100/1000 (two and three-wire circuit) + 1× thermocouple	1oo2	1oo2D	SIL 3/PL e

Safety Manual for Temperature Probe for Connection to JUMO safetyM with Functional Safety

The calculation of reliability data was made by taking into account a fault model for the interruption, short circuit, and drift of the JUMO temperature probe for the JUMO safetyM STB/STW 70115X. The following table demonstrates the reliability data of the individual variants of the JUMO safetyM STB/STW 70115X in combination with the connected temperature probe.

Variant	PFH [1/h]	PFD _{avg}	SFF	MTTF _d [years]	DC _{avg} [%]	PL
STB/STW701150 230 V – Var 1	1,12E-07	5,00E-03	94	62	91	d
STB/STW701150 230 V – Var 1a	1,21E-08	5,00E-04	93	62	91	e
STB/STW701150 230 V – Var 2	1,21E-08	5,00E-04	93	62	91	e
STB/STW701150 230 V – Var 3	1,12E-08	5,00E-04	90	24	85	d
STB/STW701150 230 V – Var 4	1,21E-08	5,00E-04	93	24	85	e

Variant	PFH [1/h]	PFD _{avg}	SFF	MTTF _d [years]	DC _{avg} [%]	PL
STB/STW 701150 24 V – Var 1	1,12E-07	5,00E-03	93	171 (100)	90	d
				88	89	c
STB/STW 701150 24 V – Var 1a	1,19E-08	5,00E-04	92	171 (100)	90	e
				71	89	d
STB/STW 701150 24 V – Var 2	1,19E-08	5,00E-04	92	266 (100)	90	e
				76	88	d
STB/STW 701150 24 V – Var 3	1,19E-08	5,00E-04	90	24	85	d
STB/STW 701150 24 V – Var 4	1,19E-08	5,00E-04	92	24	85	d

Variant	PFH [1/h]	PFD _{avg}	SFF	MTTF _d [years]	DC _{avg} [%]	PL
STB/STW701155 230 V – Var 1	1,12E-07	5,00E-03	94	62	91	d
STB/STW701155 230 V – Var 1a	1,20E-07	5,00E-04	93	62	91	e
STB/STW701155 230 V – Var 2	1,20E-07	5,00E-04	90	62	90	e
STB/STW701155 230 V – Var 3	1,21E-08	5,00E-04	93	24	85	d
STB/STW701155 230 V – Var 4	1,21E-08	5,00E-04	93	24	85	e

Variant	PFH [1/h]	PFD _{avg}	SFF	MTTF _d [years]	DC _{avg} [%]	PL
STB/STW701155 24 V – Var 1	1,12E-07	5,00E-03	94	62	91	d
STB/STW701155 24 V – Var 1a	1,18E-08	5,00E-04	93	62	91	e
STB/STW701155 24 V – Var 2	1,19E-08	5,00E-04	93	62	90	e
STB/STW701155 24 V – Var 3	1,18E-08	5,00E-04	90	24	85	d
STB/STW701155 24 V – Var 4	1,18E-08	5,00E-04	93	24	85	e

Periodic testing In order to ensure safe and reliable operation of the thermometer, the following service and maintenance work must be carried out:

At stipulated intervals, the following tests are recommended:

Every 12 months, the insulation resistance of the measuring circuit should be measured against the protective fitting (for thermocouples: only for the insulated measuring circuit; for several measuring circuits, the insulation test should also be carried out between the individual measuring circuits).

Safety Manual for Temperature Probe for Connection to JUMO safetyM with Functional Safety

The minimum insulation resistance at room temperature should be 100 MΩ at 100 V.

- Damage and corrosion of thermometer protective tubes
- Corrosion and correct position of contacts and terminals of wiring connections
- Seal of connection heads and cable ducts
- Interruption by "tapping" on the thermometer/measuring element

As the maximum operational temperature has an impact on the drift behavior, the thermometer should be recalibrated or replaced at specified intervals to ensure reliable and precise measurement of temperature. The test intervals are listed in the following table:

Maximum operational temperature	Pt resistance thermometer	Thermocouples
200 °C	5 years	5 years
550 °C	2 years	5 years
700 °C	1 year	2 years
1000 °C		Non-precious metal 1 year
		Precious metal 2 years
1500 °C		1 year

The testing intervals stipulated here are suggestions which should be adapted according to the particular conditions at the location where they are used, and may have to be shortened by the user.

Safety Manual for Temperature Probe for Connection to JUMO safetyM with Functional Safety

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More than automation

Herstellereklärung Manufacturer's declaration

Für das folgende Produkt
For the following product

Gegenstand
Object

Widerstandsthermometer / Thermoelement

Hersteller
Manufacturer

JUMO GmbH & Co KG, Fulda

Typ
Type

902020/10-402-2003-1-9-160-104/000 **Musterbeispiel**

Teilenummer
Part number

000xxxxxx

QW- Nummer
Quality number

15-04-01

Fabrikationsnummer
serial number

0200xxxxx

erklären wir als Hersteller, dass die folgende Kombination aus dem oben genannten Temperaturfühler zusammen mit dem safetyM – STB / STW 70.1150/55 in Variante 3 in einer sicherheitsrelevanten Anwendung in den Sicherheitsstufen SIL 3 bzw. Performancelevel PL e die Anforderungen der Funktionalen Sicherheit erfüllen und eingesetzt werden dürfen. Voraussetzung ist die Beachtung der Bedingungen und Sicherheitshinweise in den Safety – Manuals B900010.9, B701150.0 oder B701155.0 (explosiongeschützte Ausführung).

we declare as manufacturer, that the following combination of above – mentioned temperature probe and the safetyM – temperature limiter / temperature monitor 70.1150/55 in variation 3 in a safety – relevant application of security level SIL 3 or performance level PL e fulfills the requirements of the Functional Safety and can be used. Requirement is the attention of the conditions and safety instructions in the safety manuals B900010.9, B701150.0 or B701155.0 (explosion proofed version)

Diese Bescheinigung darf nur unverändert weiterverbreitet werden.
This certificate may only be reproduced in unchanged form.

Datum
Date

09.09.2015

Stempel / stamp

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Im Auftrag
by order

Qualitätsdepartment

Dieses Dokument ist ohne Unterschrift gültig
This certificate will be valid without sign

VL „SIL/PL Herstellereklärung“

Variante: 3

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with Functional Safety***

Safety Manual for Temperature Probe for Connection to JUMO safetyM with Functional Safety



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