JUMO Safety Manual for RTD Temperature Probes and Thermocouples for Connection to JUMO dTRANS T06 Type 707071.../58

with Safety Integrity Level (SIL) and Performance Level (PL) classification

Safety Manual

JUMO

90000001T99Z001K000

V1.00/EN/00698966

Safety Manual for Temperature Probe for Connection to: JUMO dTRANS T06 Type 70707X with Functional Safety

Field of application

This Safety Manual applies to JUMO temperature probes for connection to the JUMO dTRANS T06 Type 707071 with SIL certification, and is only valid together with the manufacturer's declaration for the applicable temperature probe (shown on page 10) for the combination of a JUMO dTRANS T06 Type 707071 with extra code 058 and a temperature probe (e.g. 902020/1X) with extra code 659!
The operating manual 70707100T90Z00XK000 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 and in the case of product groups 901006 and 902006.

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 c or 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.132553TB.

Terms and abbreviations in accordance with DIN EN 60730-2-9:

Safety characteristic	Requirement
Modes of operation and software class in accordance with DIN EN 60730-2-9	System 2K
	Only in the case of redundancy 2N
	Software class C

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 (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 discrete 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 safety integrity; SIL 1 the lowest.
Safety-Related System	System which both - 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 [FIT]
Lambda **D**angerous: λ_D	Dangerous failure rate
Lambda **D**angerous **D**etect: λ_{DD}	Detected dangerous failure rate
Lambda **D**angerous **U**ndetect: λ_{DU}	Undetected dangerous failure rate
Lambda: λ_S	Safe failure rate
Lambda: λ_{SD}	Detected safe failure rate
Lambda: λ_{SU}	Undetected safe failure rate
BPCS	Basic Process Control System
DC	**D**iagnostic **C**overage
FIT	**F**ailure **I**n **Ti**me (1×10^{-9} per h)
HFT	**H**ardware **F**ailure **T**olerance
PFD	**P**robability of **F**ailure on **D**emand
PFD_{avg}	**P**robability of **F**ailure on **D**emand average
PFH	**P**robability of dangerous **F**ailure per **H**our
PTC	**P**roof **T**est **C**overage
MooN	Architecture with M out of N voting, i.e. N indicates how often the safety function has been executed, and M indicates how many channels need to be operating correctly.
MRT	Mean Repair Time
$MTTF_D$	Mean Time To Failure (Dangerous)
MTTR	Mean Time To Restoration
SFF	Safe Failure Fraction
SIL	Safety Integrity Level
SC	Systematic Capability

PTC	Proof Test Coverage
T_i	Proof Test interval

Terms and abbreviations in accordance with DIN EN ISO 13849:

Symbol 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)
Cat.	Category
CCF	Modeled by what is known as the beta factor. (stands for **C**ommon **C**ause **F**ailure)
DC	**D**iagnostic **C**overage
DC_{avg}	**D**iagnostic **C**overage **av**era**g**e
MTTF	Mean Time to Failure
$MTTF_c$	Mean Time to Hazardous Failure
$MTTF_d$	Mean Time to Dangerous Failure
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
T_M	Length of operation, anticipated period of use (**M**ission **T**ime)
T_{10d} value	Guide value for a preventative replacement (10% of the B_{10d} value). At this value, approx. 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**		
SFF	**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 for RTD temperature probes

The platinum RTD temperature probes meet the requirements of the standard DIN EN 60751.

Qualitative requirements for 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, /859, /867 and /869.

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 dTRANS T06 combined and can be found in the operating manual of the JUMO dTRANS T06 (chapter on "Technical Data").

Guide values for temperature probes depending on the 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 dTRANS T06, 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 dTRANS T06 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 safety function 400 °C - 40 °C = 360 °C

The failure rates are calculated based on JUMO's existing experience in the field and the analyses of data collected annually from complaints statistics, as well as the Exida failure model.

Explanation of probe types and failure models

The letter a (highlighted in blue) indicates the JUMO failure model; the letters b to i denote the Exida failure model. The number 1 denotes an RTD temperature probe; the number 2 indicates a thermocouple

Variant	Failure model	Probe type
Variant 1a	JUMO	RTD temperature probe with manufacturer's declaration from JUMO.
Variant 1b	Exida	RTD Close Coupled Low Stress, 2-wire and 3-wire technology
Variant 1c	Exida	RTD Close Coupled Low Stress, 4-wire technology
Variant 1d	Exida	RTD Close Coupled High Stress, 2-wire and 3-wire technology
Variant 1e	Exida	RTD Close Coupled High Stress, 4-wire technology
Variant 1f	Exida	RTD Extension Wire Low Stress, 2-wire and 3-wire technology
Variant 1g	Exida	RTD Extension Wire Low Stress, 4-wire technology
Variant 1h	Exida	RTD Extension Wire High Stress, 2-wire and 3-wire technology
Variant 1i	Exida	RTD Extension Wire High Stress, 4-wire technology
Variant 2a	JUMO	Double thermocouples with manufacturer's declaration from JUMO.
Variant 2b	Exida	Double thermocouple Close Coupled, Low Stress
Variant 2c	Exida	Double thermocouple Close Coupled, High Stress
Variant 2d	Exida	Double thermocouple Extension Wire, Low Stress
Variant 2e	Exida	Double thermocouple Extension Wire, High Stress

The following definition applies here for Low Stress, High Stress, Close Coupled, and Extension Wire:

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

This table shows the maximum achievable SIL and PL

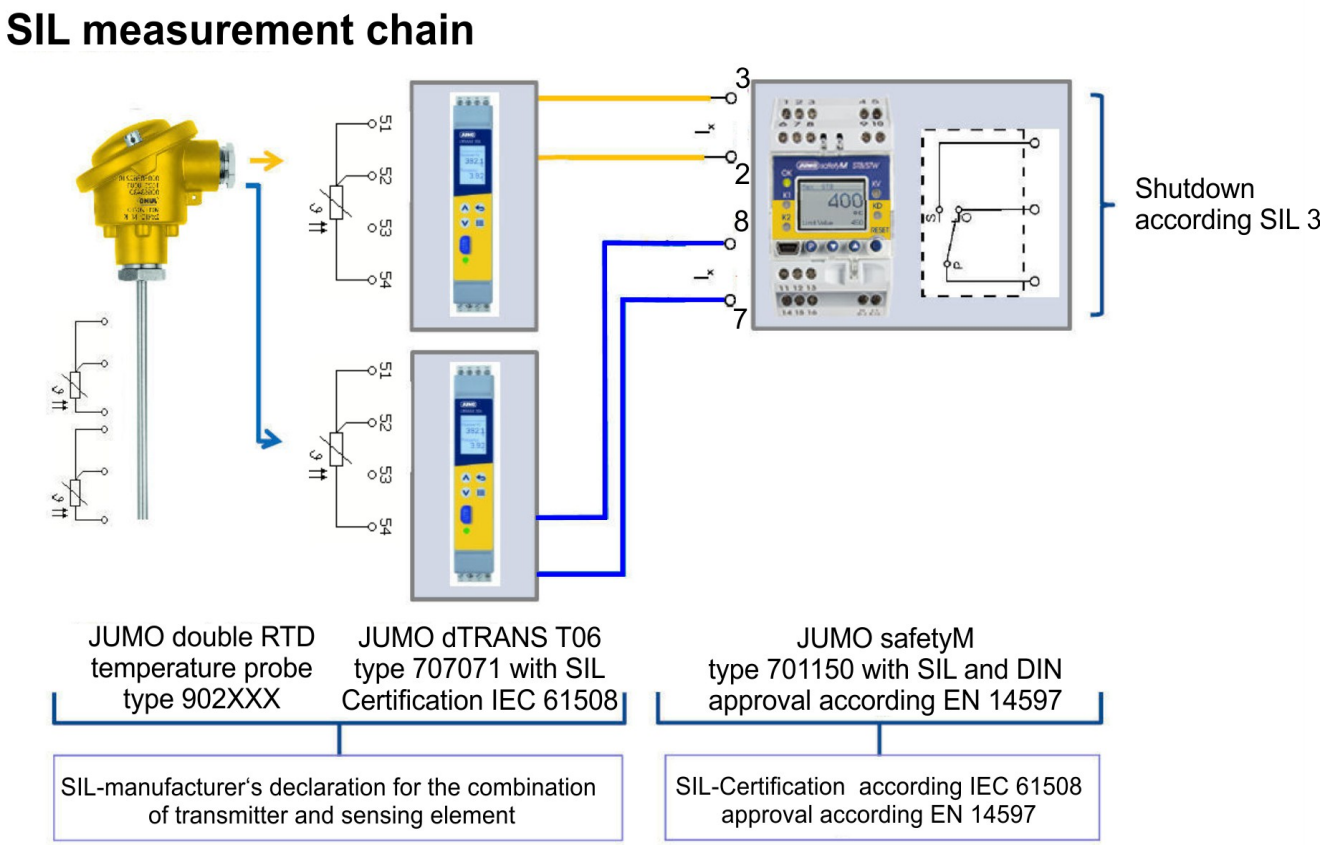
Device variant AC 240V RTD temperature probes with 2-wire, 3-wire technology	**PFH** [1/h]	**PFD_{avg}**	**PTC C** [%]	**SFF** [%]	**SIL**	**$MTTF_d$** [years]	**DC_{avg}** [%]	**PL**
Variant 1a	3.09×10^{-7}	4.87×10^{-3}	73	90	2	35	90	c
Variant 1b	1.56×10^{-7}	4.09×10^{-3}	47	93	2	50	93	c
Variant 1c	1.55×10^{-7}	4.09×10^{-3}	47	93	2	50	93	c
Variant 1d	2.55×10^{-7}	4.59×10^{-3}	68	92	2	36	92	c
Variant 1e	2.36×10^{-7}	4.52×10^{-3}	65	93	2	35	93	c
Variant 1f	2.05×10^{-7}	4.34×10^{-3}	60	92	2	42	92	c
Variant 1g	1.96×10^{-7}	4.31×10^{-3}	58	93	2	42	93	c
Variant 1h	1.24×10^{-6}	9.54×10^{-3}	93	89	2	9	89	b
Variant 1i	1.07×10^{-6}	8.84×10^{-3}	92	91	2	9	91	b

Device variant AC 240V Double thermocouples	**PFH** [1/h]	**PFD_{avg}**	**PTC C** [%]	**SFF** [%]	**SIL**	**$MTTF_d$** [years]	**DC_{avg}** [%]	**PL**
Variant 2a	2.10×10^{-7}	4.40×10^{-3}	61	94	2	35	93	c
Variant 2b	1.53×10^{-7}	4.08×10^{-3}	46	94	2	49	93	c
Variant 2c	1.81×10^{-7}	4.34×10^{-3}	54	96	2	27	96	c
Variant 2d	1.86×10^{-7}	4.29×10^{-3}	56	94	2	35	94	c
Variant 2e	8.41×10^{-7}	8.53×10^{-3}	90	96	2	5	96	a

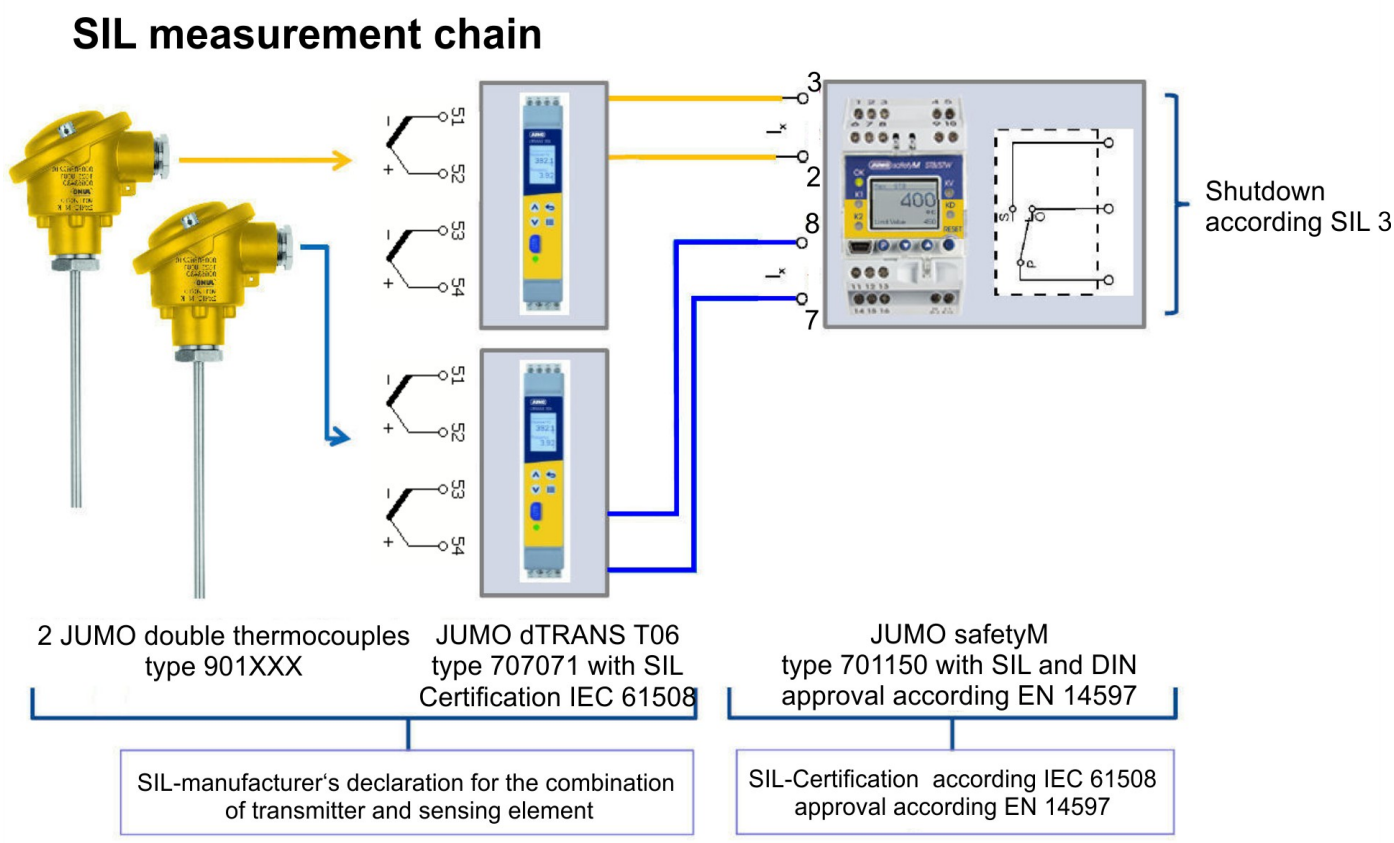
Device variant DC 24V RTD temperature probes	**PFH** [1/h]	**PFD_{avg}**	**PTC C**	**SFF**	**SIL**	**$MTTF_d$** [years]	**DC_{avg}** [%]	**PL**
Variant 1a	3.16×10^{-7}	5.14×10^{-3}	72	90	2	35	90	c
Variant 1b	1.63×10^{-7}	4.37×10^{-3}	46	93	2	49	93	c
Variant 1c	1.62×10^{-7}	4.36×10^{-3}	45	93	2	49	93	c
Variant 1d	2.61×10^{-7}	4.87×10^{-3}	66	92	2	35	92	c
Variant 1e	2.43×10^{-7}	4.79×10^{-3}	63	93	2	35	93	c
Variant 1f	2.12×10^{-7}	4.61×10^{-3}	58	92	2	41	92	c
Variant 1g	2.04×10^{-7}	4.58×10^{-3}	56	93	2	41	93	c
Variant 1h	1.24×10^{-6}	9.81×10^{-3}	93	89	2	9	89	b
Variant 1i	1.07×10^{-6}	9.12×10^{-3}	92	91	2	9	91	b

Device variant DC 24V Double thermocouples	**PFH** [1/h]	**PFD_{avg}**	**PTC C**	**SFF**	**SIL**	**$MTTF_d$** [years]	**DC_{avg}** [%]	**PL**
Variant 2a	2.17×10^{-7}	4.67×10^{-3}	59	93	2	35	93	c
Variant 2b	1.60×10^{-7}	4.36×10^{-3}	44	93	2	48	93	c
Variant 2c	1.88×10^{-7}	4.62×10^{-3}	53	96	2	26	96	c
Variant 2d	1.92×10^{-7}	4.56×10^{-3}	54	94	2	35	94	c
Variant 2e	8.48×10^{-7}	8.80×10^{-3}	90	96	2	5	96	a

Example application of redundant use with a double RTD temperature probe with a three-wire circuit:



Example application of redundant use with two double thermocouples:



Periodic testing

n 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 protection fitting (for thermocouples: only for the insulated measuring circuit; in the case of several measuring circuits the insulation test should also be carried out between the individual measuring circuits). The minimum insulation resistance at room temperature should be 100 MΩ at 100 V.

- Damage and corrosion of thermometer protection tubes
- Corrosion and correct position of contacts and terminals of wiring connections
- Seals of terminal heads and cable ducts
- Interruption by "tapping" on the thermometer/measuring insert

As the maximum operating temperature has an impact on the drift behavior, the thermometers 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 operating temperature	**Pt RTD temperature probe**	**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.

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Herstellererklärung
Manufacturer's declaration

Für das folgende Produkt *For the following product*

Gegenstand *Object*	**Widerstandsthermometer / Thermoelement**
Hersteller *Manufacturer*	**JUMO GmbH & Co KG , Fulda**
Typ *Type*	**902020/1X-XXX-XXXX-X-XX-XXX-XXX / 659** **in Kombination mit / in combination with** **dTRANS T06 Typ 707071../058**
Teilenummer *Part number*	**000xxxxxx**
QW- Nummer *Quality number*	**15-04-01**
Fabrikationsnummer *serial number*	**02002xxx**

erklären wir als Hersteller, dass die folgende Kombination aus dem oben genannten Temperaturfühler zusammen mit dem Messumformer "707071../058" in einer sicherheitsrelevanten Anwendung **Sicherheitsstufe SIL 2 / PL c** die Anforderungen der Funktionalen Sicherheit erfüllen und eingesetzt werden dürfen. Voraussetzung ist die Beachtung der Bedingungen der mathematischen Berechnung und Konfiguration, die Inbetriebsetzung und die Sicherheitshinweise aus dem **Sicherheitshandbuch (90000001T99Z000K000) und der Betriebsanleitung (70707100T90Z000K000)**

we declare as manufacturer, that the following combination of above – mentioned temperature probe and the temperature transmitter "707071../058" in a safety – relevant application of security level **SIL 2 / PL c** fulfills the requirements of the Functional Safety and can be used. Requirement is the attention of the conditions, the mathematics calculation and configuration, the starting and safety instructions from the **safety manuals (90000001T99Z001K000) and the instructionsterms (70707100T90Z001K000)**

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Datum
Date

09.01.2019

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 Herstellererklärung" Version: dTRANS T06

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