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TEMPERATURE TRANSMITTER

Model: iTEMP® HART® TMT162

Manufacturer: Endress + Hauser Wetzer GmbH+Co. KG

Germany

INTERNATIONAL INSTRUMENT USERS' ASSOCIATIONS - EWE

EVALUATION INTERNATIONAL (EI) / WIB / EXERA

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Subject **EVALUATION OF TEMPERATURE TRANSMITTERS, model: iTEMP® HART® TMT162**

Manufacturer: Endress+Hauser Wetzer GmbH+Co. KG, Germany

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Generale des Eaux	E	Universite De Genes	E
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Contents

Photographs of the instrument

Front side

Terminal compartment

Manufacturer’s photographs

TEMPERATURE TRANSMITTERS, model iTEMP® HART® TMT162
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Evaluated by TNO on behalf of International Instrument Users' Association – WIB and the manufacturer		Author Approved	G.H.W.M. Helmich, B.Sc. Dr M.C.A.M. Peters
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The full report comprises 39 pages. The Abridged Report comprises the chapters 1 and 2 of the full report (8 pages).

July 2005

1. INTRODUCTION

This report describes the evaluation of the iTEMP® HART® TMT162 field transmitters for temperature. They are standard production models, manufactured by Endress+Hauser Wetzer GmbH+Co. KG in Germany.

The instruments were evaluated in accordance with the WIB Test Programme for Temperature Transmitters, version May 2003. Some tests of the programme were replaced by Aggravated tests of which the severity exceeded the levels of the standard WIB tests. Instrument #1, configured for thermocouple input, was evaluated according to the complete programme. Instrument #2, configured for resistance thermometer input, was evaluated with a limited number of tests.

The test results refer to these instruments. They were characterized as follows.
1. Type TMT162-B2621JBAB, serial number 6B0065 04223, TC input, type J,
2. Type TMT162-B26241BAB, serial number 6B0066 04223, RTD input, type Pt100,
Both: Software revision 1.03.00; Hardware revision 1.01.05
Display units: PCB number 14 12 01 020.

Two sensors can be connected to the instrument. They can be independently configured as thermocouple (TC) or mV or as resistance thermometer (RTD) or resistance. One process value is available as 4…20 mA output current with HART® protocol. The input signal is measured with a resolution of 18 bits. The accuracy for the TC input, type K, J, T, E is 0,25 K, excluding the accuracy for the cold junction compensation according to Pt100, class B. The accuracy for the RTD input is 0,1 K. The accuracy for analogue output is 0,02 % of span.

Instruments without display module are designed to operate at ambient temperatures ranging from -40 °C to +85 °C. With display module, the maximum temperature is +70 °C. The climate classification is per IEC 60654-1, Class C. The degree of protection of the enclosure is IP 67 or NEMA 4x. The EMC is per IEC 61326 and NAMUR NE 21. The ATEX classification for hazardous area is [Ex] II 1G EEx ia IIC T6.

The operation of the setup was demonstrated on December 7, 2004 after which the evaluation was started. The tests were performed in laboratories of TNO in Delft, The Netherlands, except for the EMC tests. The manufacturer and Senton EMC Test Centre performed this group of tests. Their results were commented and included.

A draft report was issued in April 2005.

2. MAJOR FINDINGS AND COMMENTS

These findings are summarized for ready reference and give an overview of the tests. For a complete assessment of the instruments, the report must be read and considered as a whole.

2.1 Instrument performance

General notes:

- All errors and shifts are expressed as percentages of span.
- The TC - transmitter was such configured that the digital output and analogue output followed the temperature, measured by a thermocouple, type J, connected to terminals 1-2, in the range of 0…50 °C.
- The RTD - transmitter was such configured that the digital output and analogue output followed the temperature, measured by a Pt100 element, connected to terminals 1-2-3-4, in the range of 0…20 °C.
- Tests 1 to 20 are Standard tests. Tests 21 to 24 are EMC tests. Tests 25 to 28 are aggravated WIB tests.
- The TC transmitter was subjected to all tests, the RTD transmitter to a limited number of tests.
- The accuracy tests were carried out at two additional input ranges.
- Three types of output were distinguished:
  Digital output — the value follows the temperature input and is read from the display or Communicator.
  Analogue output — the mA output follows the temperature input.
  Manual mode — the analogue output as manually commanded.

2.1.1 Tests at which the results were within the specification

Accuracy test - TC

The table below shows the average errors as measured at the start of the evaluation (initially) and at the end of the evaluation (finally).

	Extreme values of average error, initially		Extreme values of average error, finally	
Range TC	Digital	Analogue	Digital	Analogue
0…50 °C	+0,08 % and +0,30 %	+0,07 % and +0,29 %	+0,22 % and +0,29 %	+0,22 % and +0,28 %
0…500 °C	+0,01 % and +0,03 %	+0,01 % and +0,04 %	+0,01 % and +0,02 %	0,00 % and +0,02 %
–180…760 °C	+0,01 % and +0,03 %	+0,01 % and +0,03 %	0,00 % and +0,04 %	–0,01 % and +0,04 %
Manual mode	N.A.	–0,01 % and +0,01 %	N.A.	–0,01 % and 0,00 %

For the digital output, the maximum repeatability was 0,09 %, 0,01 % and 0,00 % at the three temperature ranges respectively.
For the analogue output, the maximum repeatability was 0,08 %, 0,01 % and 0,01 % at the three temperature ranges respectively.

Accuracy test - RTD

The table below shows the average errors as measured at the start of the evaluation (initially) and at the end of the evaluation (finally).

	Extreme values of average error, initially		Extreme values of average error, finally	
Range RTD	Digital	Analogue	Digital	Analogue
0…20 °C	–0,04 % and –0,10 %	–0,04 % and –0,08 %	–0,08 % and –0,13 %	–0,08 % and –0,13 %
0…100 °C	–0,01 % and –0,02 %	0,00 % and –0,02 %	–0,01 % and –0,02 %	0,00 % and –0,03 %
–200…850 °C	0,00 %	0,00 % and +0,01 %	0,00 %	–0,01 % and +0,01 %
Manual mode	N.A.	0,00 % and +0,01 %	N.A.	–0,01 % and +0,01 %

For the digital output, the maximum repeatability was 0,06 %, 0,01 % and 0,00 % at the three temperature ranges respectively.
For the analogue output, the maximum repeatability was 0,05 %, 0,01 % and 0,00 % at the three temperature ranges respectively.

Line resistance effect - TC
A resistance of 1000 Ω in the input circuit had no effect in the output.

Line resistance effect - RTD
A resistance of 50 Ω/line had no effect.

Output load variations - TC
The variations of the output load from 10 Ω to the maximum value at a supply voltage of 40 V had no effect on the analogue output. An output load of at least 60 Ω was required to have communication with the Handheld communicator Fischer-Rosemount 275.

Power supply variations - TC
Variations of the power supply voltage between 11 and 40 V had no effect on the analogue output.

Long-term drift - TC
The drift over 30 days was 0,10 %, both for the digital output and analogue output. The drift was a random drift.

Long term drift - RTD
The drift over 30 days was 0,10 % for the digital output and 0,08 % for the analogue output. The drift was a random drift.

EMC tests - RTD
Endress+Hauser Wetzer and the accredited testing laboratory of Senton in Straubing, Germany, performed the EMC tests. The test set-ups and equipment used are well documented and the results are specified clearly. The tests were carried out for an instrument, configured for dual input: TC input -100…+100 °C and RTD input 0…+100 °C. The output was coupled to the RTD input. Results of tests, at which the output was coupled to the TC input, as requested by the test plan, were not included.[1]
It should be noted that the input range of the instruments evaluated was 4 to 5 times more sensitive than the input range of the instruments for the EMC tests.
The following effects were noted in their test reports.

EMC: Burst (fast transients) - RTD
Fast transients of 2 kV, both polarities, coupled into the sensor lines or the output lines, caused no discernable effect on the output.

EMC: Surge test - RTD
Surges of 1 kV in unsymmetrical mode were applied to all terminals in turn. On the output terminals, they caused short disturbances of maximum 0,3 mA (2 %). On the sensor terminals, they caused sporadically short disturbances.

EMC: Magnetic field - RTD
This test is no longer required according to IEC 61326. The test was not performed.

EMC: Electrostatic discharges - RTD
Discharges of 6 kV and 8 kV contact/air on the outside of the instrument caused no discernable effect on the output.

EMC: HF interference/conducted - RTD
Interference of a signal of 0,15…80 MHz, 80 %AM, 10 V, injected in the sensor lines and output lines caused no discernable effects on the output.

[1] Manufacturer’s comment: No other effects on the output were observed than listed for RTD input-output.

EMC: HF interference/radiated - RTD
Interference of a signal of 80…1000 MHz, 80 %AM, 10 V, horizontal and vertical polarisation, caused a shift of the analogue output of maximum 0,03 %.

Ambient humidity test, cyclic (aggravated) - TC
The test was carried out with 6 cycles of 24 h. At each cycle, the temperature varied between 25 °C and 55 °C at a relative ambient humidity of 95 %. During the test, the input was kept constant at 50 % while the analogue output was recorded. A temporary shift of +0,8 % was found when the temperature was increasing at a rate of 10 K/h. A temporary shift of –0,4 % was found when the temperature was decreasing at 6,7 K/h. After the test, the remaining zero shift was +0,01 %; the remaining span shift was –0,07 %.

Enclosure test (aggravated) - TC
No water was found inside the instrument after the Enclosure test according to Class IP x6.

2.1.2 Tests at which the results were outside or partly outside the specification

Ambient temperature test - TC
The ambient temperature was increased to +85 °C and decreased to –40 °C. Two full cycles were made. The table below shows the shifts at the extreme temperatures and at the +20 °C after each part of the test. From the results, the shifts and errors were calculated.

	Shift at 0 % input			Shift at 100 % input		
Temperature	Digital output	Analogue output	Manual mode	Digital output	Analogue output	Manual mode
+85 °C	–0,89 %	–0,86 %	+0,01 %	–0,63 %	–0,57 %	+0,04 %
+20 °C (1a)	0,00 %	+0,03 %	0,00 %	–0,03 %	–0,03 %	0,00 %
–40 °C	–0,37 %	–0,36 %	0,00 %	–0,38 %	–0,30 %	+0,07 %
+20 °C (1b)	+0,02 %	+0,03 %	–0,01 %	+0,02 %	+0,01 %	–0,02 %
+85 °C	–0,77 %	–0,75 %	+0,01 %	–0,59 %	–0,50 %	+0,04 %
+20 °C (2a)	+0,02 %	+0,02 %	0,00 %	–0,02 %	–0,01 %	0,00 %
–40 °C	–0,39 %	–0,38 %	–0,01 %	–0,36 %	–0,28 %	+0,07 %
+20 °C (2b)	+0,02 %	+0,04 %	–0,01 %	0,00 %	–0,02 %	–0,03 %

Digital output	Shift at 0 %	The maximum shift was found at +85 °C: –0,89 %. The shift exceeded the specification.[2]	Specification: 0,65 %
	Shift at 100 %	The maximum shift was found at +85 °C: –0,63 %.	Specification: 0,74 %
	Span shift	The maximum shift was found at +85 °C: +0,26 %.	No specification
	Total error	The sum of the accuracy error and temperature drift varied between –0,67 % and +0,34 %. This was within specification.	
Analogue output	Shift at 0 %	The maximum shift was found at +85 °C: –0,86 %. The shift exceeded the specification.	Specification: 0,75 %
	Shift at 100 %	The maximum shift was found at +85 °C: –0,54 %.	Specification: 0,84 %
	Span shift	The maximum shift was found at +85 °C: +0,29 %.	No specification
	Total error	The sum of the accuracy error and temperature drift varied between –0,65 % and +0,34 %. This was within specification.	
Manual mode	Shift at 0 %	The shifts remained within 0,01 %.	
	Shift at 100 %	The maximum shift was found at –40 °C: +0,07 %.	Specification: 0,09 %
	Span shift	The maximum shift was found at –40 °C: +0,08 %.	No specification

[2] Manufacturer's comment: The technical data will be updated.

Other	Shift at 50 %	A change of the temperature of 20 K/h caused a temporary shift of 1,3 %.
	Linearity	The test had no effect on linearity and hysteresis.
	Display	The display was unreadable at +85 °C. It was very slow at –40 °C.[3]

Ambient temperature test - RTD

The ambient temperature was increased to +85 °C and decreased to –40 °C. Two full cycles were made. The table below shows the shifts at the extreme temperatures and at the +20 °C after each part of the test. From the results, the shifts and errors were calculated.

	Shift at 0 % input			Shift at 100 % input		
Temperature	Digital output	Analogue output	Manual mode	Digital output	Analogue output	Manual mode
+85 °C	+0,02 %	+0,08 %	+0,05 %	+0,06 %	+0,03 %	0,00 %
+20 °C (1a)	–0,03 %	–0,02 %	–0,01 %	+0,06 %	0,00 %	–0,01 %
–40 °C	–0,38 %	–0,37 %	0,00 %	–0,37 %	–0,25 %	+0,14 %
+20 °C (1b)	–0,03 %	–0,06 %	–0,01 %	–0,02 %	–0,05 %	–0,03 %
+85 °C	+0,02 %	+0,06 %	+0,04 %	+0,08 %	+0,05 %	0,00 %
+20 °C (2a)	–0,06 %	–0,08 %	–0,01 %	–0,02 %	–0,04 %	–0,01 %
–40 °C	–0,36 %	–0,37 %	0,00 %	–0,39 %	–0,27 %	+0,13 %
+20 °C (2b)	–0,03 %	–0,02 %	–0,01 %	–0,02 %	–0,04 %	–0,03 %

Digital output	Shift at 0 %	The maximum shift was found at –40 °C: –0,38 %.	Specification: 0,75 %
	Shift at 100 %	The maximum shift was found at –40 °C: –0,39 %.	Specification: 0,81 %
	Span shift	The maximum shift was found at +60 °C: +0,09 %.	No specification
	Total error	The sum of the accuracy error and temperature drift varied between –0,52 % and –0,01 %. This was within specification.	
Analogue output	Shift at 0 %	The maximum shift was found at –40 °C: –0,37 %.	Specification: 0,84 %
	Shift at 100 %	The maximum shift was found at –40 °C: –0,27 %.	Specification: 0,90 %
	Span shift	The maximum shift was found at –40 °C: +0,12 %.	No specification
	Total error	The sum of the accuracy error and temperature drift varied between -0,47 % and -0,01 %. This was within specification.	
Manual mode	Shift at 0 %	The maximum shift was found at +85 °C: +0,05 %.	Specification: 0,10 %
	Shift at 100 %	The maximum shift was found at –40 °C: +0,14 %. The shift exceeded the specification.	Specification: 0,09 %
	Span shift	The maximum shift was found at –40 °C: +0,14 %.	No specification
Other	Shift at 50 %	A change of the temperature of 20 K/h caused no temporary shift.	
	Linearity	The test had no effect on linearity and hysteresis.	
	Display	The display was unreadable at +85 °C. It was very slow at –40 °C.[3]	

[3] The operating limits for the display unit are: –40 °C to +70 °C.

Vibration test (aggravated) - TC

The instrument was fixed to a vibrating table by means of its standard mounting kit for wall/pipe. Mechanical vibrations were generated for the instrument in three mutual perpendicular directions with maximum amplitude of 3,1 mm (5…15 Hz) and maximum acceleration of 3 g (15…500 Hz). The sweep rate was 0,5 octave/minute.

H-T = Horizontal-Transversal
H-L = Horizontal-Longitudinal
V = Vertical

Resonance searches Sharp resonances of the transmitter were found at 91 Hz, 78 Hz and 97 Hz with amplification factors of 8,3, 14 and 20 respectively. The display unit stopped operation during the first test before the frequency of 80 Hz was reached. The connector for energizing the display unit was torn off from its printed circuit board. The display unit was removed for the remaining part of the test. See footnote.[4]

Endurance tests The endurance tests of 30 minutes at the resonance frequency for each direction did not damage the instrument.

After the test The display unit was affixed in one of the other three positions. It operated correctly.

The shift of the analogue output was +0,03 %.

2.1.3 Tests for which effects were not specified

Open / short circuited input - TC

An open input caused an alarm condition with error 0050. The output current increased to 21,7 mA.
A short circuit at the input terminals caused the indication of the ambient temperature.

Open / short circuited input - RTD

An open input caused an alarm condition with error 0050 and an output current of 21,7 mA.
A short circuit of the sensor caused an alarm condition with error 0051 and an output current of 21,7 mA.

Series mode interference - TC

An analogue output shift of 0,1 % was caused by a series mode voltage of 0,05 Vrms, 50 Hz.
A series mode voltage of 0,15 Vrms caused the output to go to 21,7 mA and generation of the alarm condition with Error 0081.

Common mode - TC and RTD

A common mode voltage of 250 Vac had no effect and did not cause a ripple on the analogue output.
A common mode voltage of 50 V had no effect.

Power supply interruption - TC

After an interruption of the supply voltage for 500 ms, the analogue output returned to 21,7 mA within 1 s and it remained at that value for 5 s. Then, the analogue output returned to the correct value. This was reached within 6 s after the interruption.
The display unit showed normal values and disappearance of alarms within 16 s after the interruption.

Power supply depression - TC

A sharp depression had no effect as long as the supply voltage remained above the specified minimum value of 22 Vdc at the maximum load of 591 Ω and 20 mA output. When the supply voltage became below its minimum value, a depression for 5 ms to 500 ms caused a restart as described at power supply interruption.

Earthing - TC and RTD

Earthing of one input terminal or one output has no effect.

Start-up - TC

The start-up drift was +0,01 % for zero shift and no span shift.

[4] Manufacturer's comment: The connector has been improved, now.

Ripple on the output - TC
The ripple content on the analogue output was 0,1 % p-p, 50 kHz

Overranging - TC
An input signal of 1 V for 1 min generated alarms and errors on the display and an analogue output of 21,7 mA. After 5 min recovery time, there were no remaining effects.

Step response time - TC
The time to reach and remain within 1 % of span varied between 0,7 s and 1,5 s.

Power supply reversal - TC
A reversal of the power supply voltage did not damage the instrument.

Salt spray test (aggravated test) - TC
The instrument was subjected to three cycles of a salt spray for 2 h followed by 22 h at 40 °C and 95 % r.h. The polyester coating on the device was not affected except for the edges with contact to the cable glands and the mounting bracket. Blisters were observed over 15 % of that area. The average diameter was 1,5 mm and the maximum diameter was 6 mm.

2.2 Comments on construction and use

The electronics are housed in an enclosure of die-cast aluminium with powder coating on polyester basis. It can be mounted on a wall or a 2” pipe by means of a stainless steel mounting kit.

The terminal compartment is wide enough for accommodation of the sensor wires and the output wires. The gold-plated contacts can hold leads of maximum 2,5 mm^2.
Two sensors can be connected to the six input terminals, except for 4-wire RTD input. The process value, PV, can be configured as linear with one of the two inputs or linear with the difference or average of the two inputs, or linear with the secondary input when the primary fails or is overranged. The PV is available as an analogue output current and as digital value via the HART® protocol.

The optional display unit can be affixed to the electronics in 90° steps. The LC display shows the process variables, input or output, in 20 mm characters. If more than one variable must be shown, they are alternatively displayed with adjustable interval. Status and tag information are shown in smaller characters or symbols. A circular bar graph, with 10 % blocks, is available over 180 degrees. The display is backlit, which makes it readable in the dark. In case of an alarm or an error, the code number is shown and also a caution mark. The bar graph flashes at an alarm.

When the supply voltage becomes too low, a Low Supply Voltage error, 0019, is generated and the output current switches to 3,6 mA. The instrument tries to re-initialize each 3 s. If the voltage is still too low, the error is generated again.
When the resistance in one of the four sensor connections of a Pt100 becomes high, i.e. >2 kΩ, warning 0206, Sensor Corrosion, is generated while the output remains still correct. When the resistance becomes >3 kΩ, error 0052, Sensor Corrosion, is generated while the output current switches to 21,6 mA. For a thermocouple sensor, same type errors are generated at resistances of >10 kΩ and >15 kΩ, respectively.

The instrument can be configured by means of:
- A universal HART® communicator DXR 275/375,
- The manufacturer’s modem Commubox FXA191 and a personal computer with Readwin® 2000 software.
- A personal computer and operating software of other manufacturers.

The configuration can be locked by means of a jumper on the electronics.
Connection of the Commubox FXA191 caused a zero shift of +0,03 % and a span shift of -0,01 %.
Connection of the Rosemount 275/375 caused a zero shift of +0,007 % and a span shift of -0,003 %.

The status bit in the HART® protocol was not correctly reset after a switch back from the manual mode to the automatic mode. This caused no update of the process value at the handheld communicator and personal computer.[5]

2.3 Comments on documentation and identification

2.3.1 Documentation

Both instruments were supplied with one set of the following documentation.

- Technical Information, TI086R/09/en (English)
- Operating Manual, BA132R/09/a3/09.04 (German, English and French)
- Safety Instructions, XA033R/09 (German, English and French)
- Configuration Report (German and English)

The Technical Information contained information regarding specification, installation and ordering. The Operating Manual contained information regarding specification, installation, maintenance, parameter setting and configuration, troubleshooting and spare parts. It was noted that the figure for connection of the HART® communicator to the output lines, when a standard supply unit is used, is incorrect.
The Safety Instructions contained instructions for installation in a Hazardous area. Additionally, it also contained a copy of the manufacturer's Declaration of Conformity.

2.3.2 Identification

A stainless steel legend plate attached to the housing identified the instrument. The plate informed about order code, series number, supply voltage, output range, ambient temperature limits, degree of protection and approvals with voltage, current and power information.

The identification can also be read in the instrument's memory via the HART® protocol.

2.4 Manufacturer's comments

Technical comments from the manufacturer are contained in various footnotes in the report.
The manufacturer advised that he did not wish to add further formal comments.

[5] Manufacturer's comment: In software revision 1.03.01 the status bit is correctly reset.

3. TEST RESULTS

3.1 General

Unless otherwise stated the reference conditions for the tests were:

Ambient temperature	20 °C ±2 K
Ambient humidity	45…75 % relative humidity
Power supply	24 Vdc ±1 %
Output load	500 Ω
Parameter configuration	Factory defaults, see chapter 5.
TC, input	0…50 °C, thermocouple type J, input at terminals 1-2.
TC, output, digital	value on display follows the TC input; resolution: 0,01 K
TC, output, analogue	4…20 mA, follows the TC input
RTD, input	0…20 °C, resistance thermometer type Pt100, input at terminals 1-2-3-4
RTD, output, digital	value on display, follows the RTD input; resolution: 0,01 K
RTD, output, analogue	4…20 mA, follows the RTD input

All errors are quoted as a percentage of span.
The manufacturer's specifications for error in the table must be read as a positive and negative, i.e. ±value.
Range adjustments were made through the ReadWin® 2000 software on the PC.
Chapter 6.1.2 gives detailed information of the tests. Chapter 6.1.1 gives detailed information of the test set-up and uncertainties. The conclusions for the uncertainties are:

Estimated uncertainty of the set-up for TC

Input generation	±0,2 % at 0…50 °C, ±0,02 % at 0…500 °C
Analogue output	±0,012 %
Total	±0,2 % at 0…50 °C, ±0,03 % at 0…500 °C, <±0,03 % at a larger range

Estimated uncertainty of the set-up for RTD

Input	±0,03 % at 0…20 °C, ±0,006 % at 0…100 °C
Analogue output	±0,012 %
Total	±0,03 % at 0…20 °C, ±0,013 % at 0…100 °C, <±0,013 % at a larger range

3.2 Results' summary for the TC transmitter

Test number and subject	Measured and observed, TC	Manufacturer's specifications
01 – Accuracy, initial (at the start of the evaluation)		Specifications are including CJC-error.
Range: 0...50 °C		
Digital output		
- Average error, extreme values	+0,08 % and +0,30 %; see graph 1.1	1,30 %
- Max. hysteresis	0,06 %	
- Max. repeatability	0,09 %	0,07 %
Analogue output		
- Average error, extreme values	+0,07 % and +0,29 %; see graph 1.1	1,32 %
- Max. hysteresis	0,05 %	
- Max. repeatability	0,08 %	0,07 %

Test number and subject	**Measured and observed, TC**	**Manufacturer's specifications**
Range: 0...500 °C Digital output - Average error, extreme values - Max. hysteresis - Max. repeatability Analogue output - Average error, extreme values - Max. hysteresis - Max. repeatability	 +0,01 % and +0,03 %; see graph 1.2 0,01 % 0,01 % +0,01 % and +0,04 %; see graph 1.2 0,01 % 0,01 %	 0,13 % 0,007 % 0,15 % 0,007 %
Range: -180...760 °C Digital output - Average error, extreme values - Max. hysteresis - Max. repeatability Analogue output - Average error, extreme values - Max. hysteresis - Max. repeatability	 +0,01 % and +0,03 %; see graph 1.3 0,01 % 0,01 % +0,01 % and +0,03 %; see graph 1.3 0,01 % 0,01 %	 0,07 % 0,004 % 0,09 % 0,004 %
Manual mode Analogue output - Average error, extreme values - Max. hysteresis - Max. repeatability	 –0,01 % and +0,01 %; see graph 1.4 0,01 % 0,01 %	 0,02 %
Output update rate	0,77 s	
Accuracy, final (at the end of the evaluation) *Range: 0…50 °C* - Digital output, extreme values - Analogue output, extreme values *Range: 0…500 °C* - Digital output, extreme values - Analogue output, extreme values *Range: -180…760 °C* - Digital output, extreme values - Analogue output, extreme values *Manual mode* - Analogue output, extreme values	 +0,22 % and +0,29 % +0,22 % and +0,28 % +0,01 % and +0,02 % 0,00 % and +0,02 % 0,00 % and +0,04 % –0,01 % and +0,04 % –0,01 % and 0,00 %	

Test number and subject	Measured and observed, TC	Manufacturer's specifications
02 - Dead band Dead band / Resolution - Digital output - Analogue output	 Dead band is equal to the resolution: 0,01 K 0,02 %	
03 - Open/short circuited input *Open input* - Digital - Analogue *Short circuit at input terminals* - Digital and analogue	 Alarm/Error 0050[6] Output to 21,7 mA Indication of the ambient temperature	
04 - Line resistance effect Both lines, total: 1000 Ω	 No effect	 Max. 10 kΩ
05 - Output load variations Maximum load: 1318 Ω	 0 Ω to 60 Ω: no HART® communication 60 Ω to max.: no effect	 Volt / mA: (Ub-11) / 0,022
06 - Series mode interference *Effect of 0,7 Vrms* - Digital - Analogue	 Alarm/Error 0081[7] and 0053[8] Output to 21,7 mA	
Effects at <0,7 Vrms - Analogue output, shift ≤0,1 % at - Analogue output, shift 5 % at - Digital output	 ≤0,05 Vrms, no 50 Hz ripple Output jumped to 21,7 mA at ≥0,15 Vrms Alarm/Error 0081[7] at ≥0,15 Vrms	
07 - Common mode interference 250 Vac 50 Vdc	 No effect, no 50 Hz ripple No effect	
08 - Power supply variations Effect on analogue output	 No effect	Ub = 11…40 V 0,005 %/V
09 - Power supply interruption 500 ms, input 50 % - Display information	 Effects after return of the power supply voltage: Initializing while displaying: Alarm/Error 0209[9], 0019[10], 0105[11], 0300[12] Normal display after 16 s	

[6] 0050: Sensor 1 open circuit
[7] 0081: Alarm: measuring range undershoot
[8] 0053: Outside sensor range
[9] 0209: Device initialisation
[10] 0019: Supply voltage too low
[11] 0105: Code for internal use
[12] 0300: Code for internal use

Test number and subject	Measured and observed, TC			Manufacturer's specifications	
- Analogue output	During 1 s output to 21,7 mA During 5 s output at 21,7 mA Normal output after 6 s			Within 4 s ≥4 mA	
10 - Power supply depression					
Input = 100 % Load = 591 Ω, max. at 24 Vdc					
- Depression time: 5 ms	As long as U_{low} >22 V: no effect When U_{low} ≤22 V: Interruption, re-initialisation as described at test 09.				
- Depression time: 500 ms	As long as U_{low} >22 V: no effect When U_{low} ≤22 V: Interruption, re-initialisation as described at test 09.				
11 - Earthing					
One input terminal to earth	No effect				
12 - Ambient temperature				Operating limits:	
Between +85 °C and –40 °C Rate of change: 0,33 K/min Reference: 20 °C at cycle 1	LRV = lower range value URV = upper range value			maximum: +85 °C minimum: –40 °C	
Digital output	Shift at LRV	Shift at URV	Span shift	LRV [13]	URV
- Shift at +40 °C, cycle 1	–0,03 %	–0,02 %	+0,01 %	0,20 %	0,23 %
- Shift at +60 °C, cycle 1	–0,23 %	–0,18 %	+0,06 %	0,40 %	0,46 %
- Shift at +85 °C, cycle 1	–0,89 %	–0,63 %	+0,26 %	0,65 %	0,74 %
- Shift at +20 °C, cycle 1	0,00 %	–0,03 %	–0,03 %	---	---
- Shift at 0 °C, cycle 1	–0,09 %	–0,07 %	+0,02 %	0,20 %	0,23 %
- Shift at –20 °C, cycle 1	–0,20 %	–0,20 %	0,00 %	0,40 %	0,46 %
- Shift at –40 °C, cycle 1	–0,37 %	–0,38 %	0,00 %	0,60 %	0,68 %
- Shift at +20 °C after cycle 1	+0,02 %	+0,02 %	0,00 %	---	---
- Shift at +40 °C, cycle 2	–0,03 %	–0,04 %	–0,01 %	0,20 %	0,23 %
- Shift at +60 °C, cycle 2	–0,18 %	–0,18 %	0,00 %	0,40 %	0,46 %
- Shift at +85 °C, cycle 2	–0,77 %	–0,59 %	+0,19 %	0,65 %	0,74 %
- Shift at +20 °C, cycle 2	+0,02 %	–0,02 %	–0,04 %	---	---
- Shift at 0 °C, cycle 2	–0,07 %	–0,07 %	0,00 %	0,20 %	0,23 %
- Shift at –20 °C, cycle 2	–0,20 %	–0,20 %	0,00 %	0,40 %	0,46 %
- Shift at –40 °C, cycle 2	–0,39 %	–0,36 %	+0,03 %	0,60 %	0,68 %
- Shift at +20 °C after cycle 2	+0,02 %	0,00 %	–0,02 %	---	---
	Graph 1.5 shows the shifts of the digital output at LRV and URV, and the specification.				
Total error: sum of the accuracy error and the temperature drift, after stabilisation	Minimum error: –0,67 %, found at +85 °C Maximum error, +0,34 %, found at +20 °C			Max. at <u>–40 °C</u> 1,98 %	Max. at <u>+85 °C</u> 2,04 %
	Graph 1.8 shows the total error of the digital output at several ambient temperatures.				

13 Manufacturer's comment: The technical data will be updated.

Test number and subject	Measured and observed, TC			Manufacturer's specifications	
Analogue output	Shift at LRV	Shift at URV	Span shift	LRV	URV
- Shift at +40 °C, cycle 1	–0,02 %	–0,03 %	–0,01 %	0,23 %	0,26 %
- Shift at +60 °C, cycle 1	–0,23 %	–0,16 %	+0,08 %	0,46 %	0,52 %
- Shift at +85 °C, cycle 1	–0,86 %	–0,57 %	+0,29 %	0,75 %	0,84 %
- Shift at +20 °C, cycle 1	+0,03 %	–0,03 %	–0,06 %	---	---
- Shift at 0 °C, cycle 1	–0,08 %	–0,06 %	+0,02 %	0,23 %	0,26 %
- Shift at –20 °C, cycle 1	–0,20 %	–0,15 %	+0,05 %	0,46 %	0,52 %
- Shift at –40 °C, cycle 1	–0,36 %	–0,30 %	+0,06 %	0,69 %	0,77 %
- Shift at +20 °C after cycle 1	+0,03 %	+0,01 %	–0,02 %	---	---
- Shift at +40 °C, cycle 2	–0,03 %	–0,06 %	–0,04 %	0,23 %	0,26 %
- Shift at +60 °C, cycle 2	–0,18 %	–0,19 %	–0,01 %	0,46 %	0,52 %
- Shift at +85 °C, cycle 2	–0,75 %	–0,50 %	+0,25 %	0,75 %	0,84 %
- Shift at +20 °C, cycle 2	+0,02 %	–0,01 %	–0,04 %	---	---
- Shift at 0 °C, cycle 2	–0,06 %	–0,05 %	+0,01 %	0,23 %	0,26 %
- Shift at –20 °C, cycle 2	–0,18 %	–0,17 %	+0,02 %	0,46 %	0,52 %
- Shift at –40 °C, cycle 2	–0,38 %	–0,28 %	+0,10 %	0,69 %	0,77 %
- Shift at +20 °C after cycle 2	+0,04 %	–0,02 %	–0,06 %	---	---
	Graph 1.6 shows the shifts of the analogue output at LRV and URV, and the specification.				
Total error: sum of the accuracy error and the temperature drift, after stabilisation	Minimum error: –0,65 %, found at +85 °C Maximum error: +0,34 %, found at +20 °C			Max. at –40 °C 2,09 %	Max. at +85 °C 2,16 %
	Graph 1.9 shows the total error of the analogue output at several ambient temperatures.				
Error during a temperature change Rate of change: 20 K/h Input: 50 %					
- During temperature rise	Additional shift of the analogue output: +1,3 %				
- During temperature fall	Additional shift of the analogue output: –1,3 %				
Manual mode	Shift at LRV	Shift at URV	Span shift	LRV	URV
- Shift at +40 °C, cycle 1	0,00 %	–0,01 %	–0,01	0,03 %	0,03 %
- Shift at +60 °C, cycle 1	+0,01 %	0,00 %	–0,01	0,06 %	0,06 %
- Shift at +85 °C, cycle 1	+0,01 %	+0,04 %	+0,03	0,10 %	0,10 %
- Shift at +20 °C, cycle 1	0,00 %	0,00 %	0,00	---	---
- Shift at 0 °C, cycle 1	0,00 %	+0,01 %	+0,02	0,03 %	0,03 %
- Shift at –20 °C, cycle 1	0,00 %	+0,04 %	+0,04	0,06 %	0,06 %
- Shift at –40 °C, cycle 1	0,00 %	+0,07 %	+0,08	0,09 %	0,09 %
- Shift at +20 °C after cycle 1	–0,01 %	–0,02 %	–0,02	---	---
- Shift at +40 °C, cycle 2	–0.01 %	–0,03 %	–0,03	0,03 %	0,03 %
- Shift at +60 °C, cycle 2	0,00 %	–0,01 %	–0,01	0,06 %	0,06 %
- Shift at +85 °C, cycle 2	0,01 %	+0,04 %	+0,02	0,10 %	0,10 %
- Shift at +20 °C, cycle 2	0,00 %	0,00 %	0,00	---	---
- Shift at 0 °C, cycle 2	0,00 %	+0,01 %	+0,01	0,03 %	0,03 %
- Shift at –20 °C, cycle 2	0,00 %	+0,04 %	+0,04	0,06 %	0,06 %
- Shift at –40 °C, cycle 2	–0,01 %	+0,07 %	+0,07	0,09 %	0,09 %
- Shift at +20 °C after cycle 2	–0,01 %	–0,03 %	–0,02	---	---
	Graph 1.7 shows the shifts of the manual output at LRV and URV, and the specification.				

Test number and subject	**Measured and observed, TC**	**Manufacturer's specifications**
Total error: sum of the accuracy error and the temperature drift, after stabilisation	Minimum error: –0,02 %, found at +40 °C Maximum error: +0,09 %, found at –40 °C	Max. at –40 °C: 0,11 % Max. at +85 °C: 0,12 %
Linearity effect - For all temperatures *Hysteresis effect* - For all temperatures *Readability of the display*	 Digital and analogue: No discernable effect Digital and analogue: No discernable effect at +85 °C: unreadable at –40 °C: slow response	 Limits display unit: –40 °C…+70 °C
13 - Ambient humidity	Replaced by the aggravated test number 25: Ambient humidity, cyclic	
14 - Vibration test	Replaced by the aggravated test number 26: Vibration / Endurance test	
15 - Start-up drift Shift 1 h after switching on	 Zero shift: +0,01 % Span shift: 0,00 %	
16 - Long term drift - Drift, digital output - Drift, analogue output	 0,10 %, random effect 0,10 %, random effect	 ≤0,2 %/year
17 - Ripple content on the output At 10 %, 50 % and 90 % input	 0,1 % p-p, 50 kHz	
18 - Overranging Maximum 1 Vdc during 1 minute Overrange: 100…103 % input Overrange: 103 %…1200 °C Overrange: 1200 °C…133 mV Overrange: 133 mV…1 V After 5 minutes recovery time	 Alternating: measured value Alarm/Error 0202[14], current is correct Alternating: measured value Alarm/Error 0082[15], current to 21,7 mA Continuously: Alarm/Error 0053[16], current to 21,7 mA Continuously: Alarm/Error 0050[17], current to 21,7 mA No remaining effect	
Underrange: 0…–1,2 % input Underrange: below –1,2 % After 5 minutes recovery time	Alternating: measured value / Alarm/Error0201[18], current is correct Alternating: measured value / Alarm/Error0081[19], current to 21,7 mA No remaining effect	

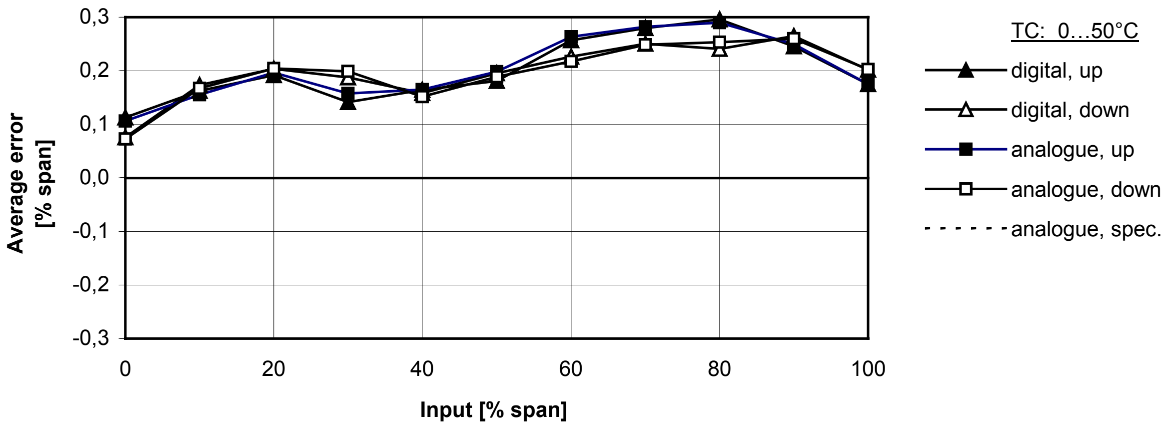
[14] 0202: Warning: measured value too high
[15] 0082: Alarm: measuring range overshoot
[16] 0053: Outside sensor range
[17] 0050: Sensor 1 open circuit
[18] 0201: Warning: measured value too small
[19] 0081: Alarm: measuring range undershoot

Test number and subject	Measured and observed, TC	Manufacturer’s specifications
19 - Step response time - 10 % to 90 %, and vice versa - 45 % to 55 %, and vice versa	 Minimum 0,7 s, maximum 1,1 s Minimum 0,7 s, maximum 1,5 s	
20 - Power supply reversal During the test After 5 minutes recovery time	 Current to 0 mA; no damage No remaining effect	
21…24 - EMC tests Results to be taken from the manufacturer’s tests	 The test report does not describe test results, at which the output followed the TC input. See the EMC tests for RTD. See footnote.[20]	
25 - Ambient humidity, cyclic 6 cycles between 25 °C and 55 °C at 95 % r.h., input 50 % Additional error during a rise or a fall of the temperature - During temperature rise (10 K/h) - During temperature fall (6,7 K/h) Shift of the analogue output after the test	 Shift of the analogue output: +0,8 % Shift of the analogue output: –0,4 % Zero shift: +0,10 % Span shift: –0,07 %	 Condensation permitted
26 - Vibration / Endurance Input 50 %; output on line recorder 2 tests in each direction: *1. Resonance search* Range: 5…500 Hz Velocity: 0,5 octave/minute Amplitude: 3,1 mm @ 5…15 Hz Acceleration: 3 g @ 15…500 Hz *2. Endurance test* Duration: 30 min at the lowest resonance frequency with amplification factor Q >2, found at the resonance search		

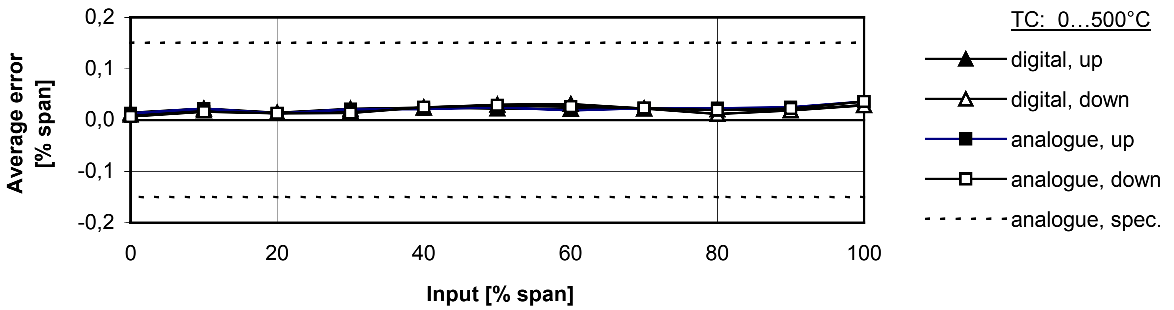
20 Manufacturer’s comment: No other effects on the output were observed than listed for RTD input-output.

Test number and subject	Measured and observed, TC	Manufacturer's specifications
1. Vertical - Resonance freq. / amplification - Transients during search - Transients during endurance - Mechanical damage	 91 Hz, Q = 8,3 No effect on the analogue output No effect on the analogue output Damage on the display unit was noticed during the resonance search before the frequency of 80 Hz was reached. Information was no longer displayed. The connector for energizing the display unit was torn off from the printed circuit board at the rear of the display unit. The display unit was not replaced. See footnote.[21]	Max. 3 g at 2…150 Hz
2. Horizontal–Transversal - Resonance freq. / amplification - Transients during search - Transients during endurance - Mechanical damage	 78 Hz, Q = 14 No effect on the analogue output No effect on the analogue output No additional damage	
3. Horizontal–Longitudinal - Resonance freq. / amplification - Transients during search - Transients during endurance - Mechanical damage	 97 Hz, Q = 20 No effect on the analogue output No effect on the analogue output No additional damage	
4. After the test - Display unit - Shift of the analogue output	 The unit operated correctly after remounting it in one of the other three positions. +0,03 %	
27 - Enclosure test Ref.: Class IP x6, Ingress of water	 No ingress of water	 IP 67, NEMA 4x
28 - Salt spray test Ref.: IEC 60068-2-52, 3 cycles 2 h at 35 °C and 22 h storage at 40 °C, 93 % r.h.	 The polyester coating on the device was not affected except for the edges with contact to the cable glands and to the mounting bracket. Blisters were observed over 15 % of that area. The average diameter was 1,5 mm and the maximum diameter was 6 mm.	

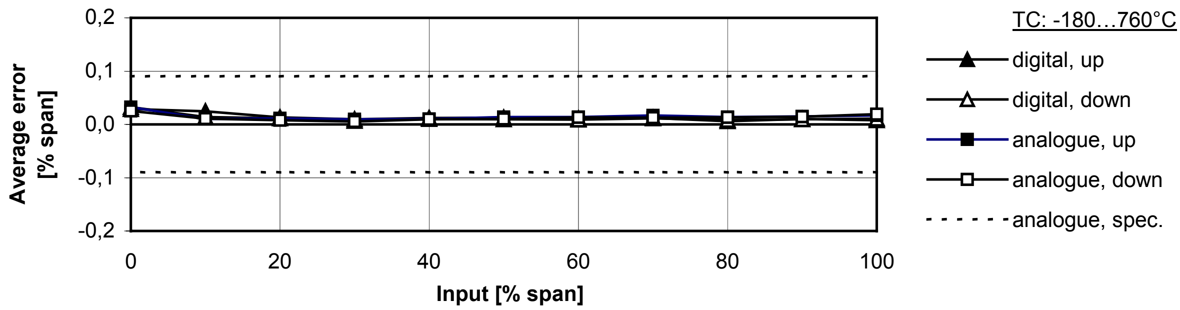
[21] Manufacturer's comment: The connector has been improved, now.



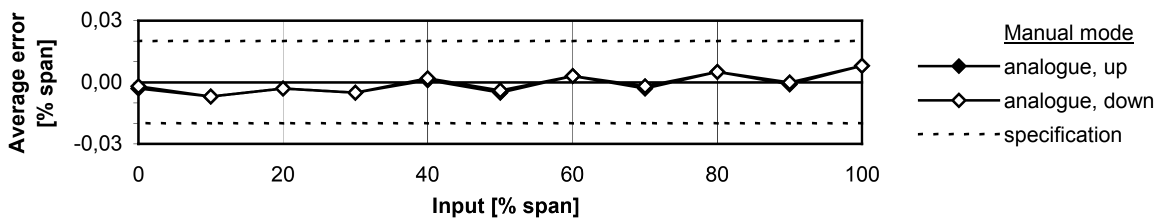
Graph 1.1 Accuracy TC transmitter, 0…50 °C; specification: ±1,32 % (outside graph)



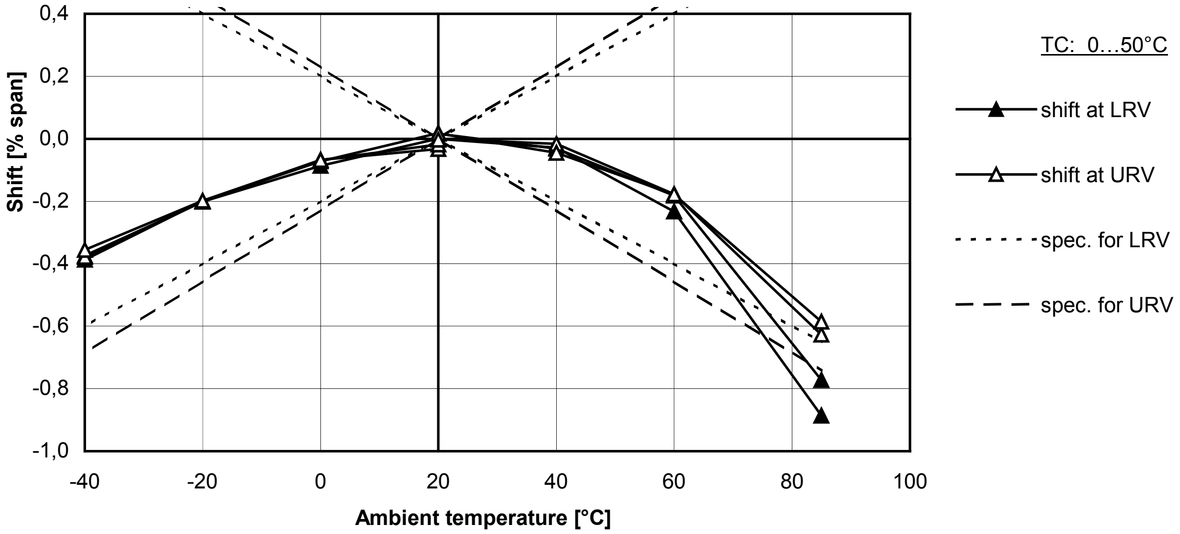
Graph 1.2 Accuracy TC transmitter, 0…500 °C; specification: ±0,15 %



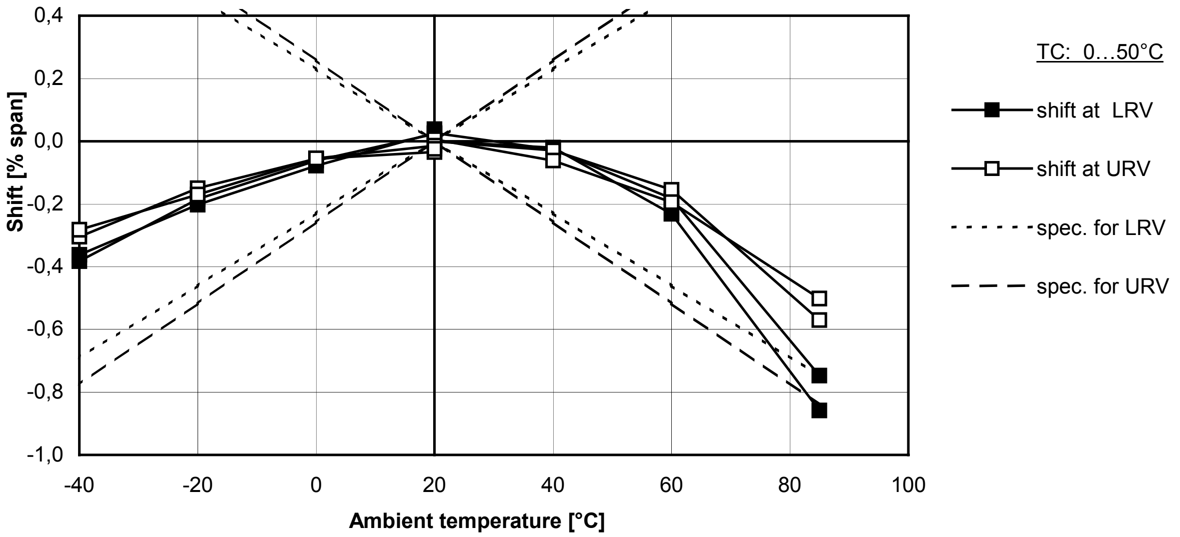
Graph 1.3 Accuracy TC transmitter, -180…760 °C; specification: ±0,09 %



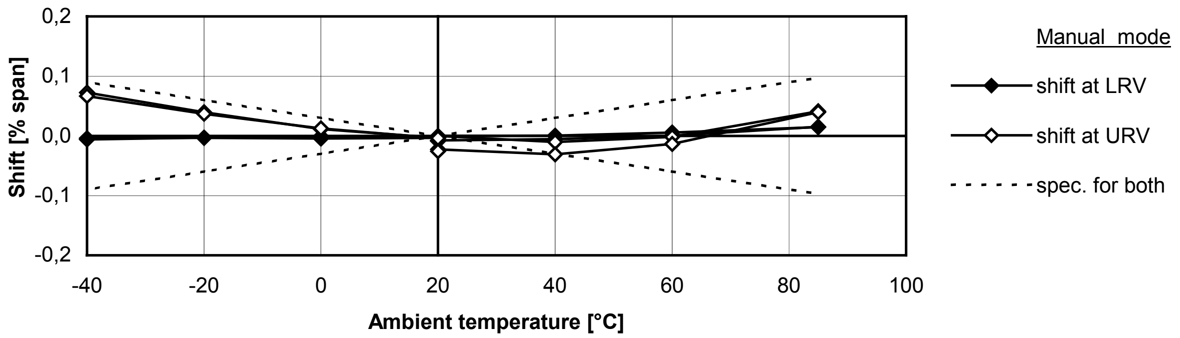
Graph 1.4 Accuracy TC transmitter, manual mode; specification: ±0,02 %



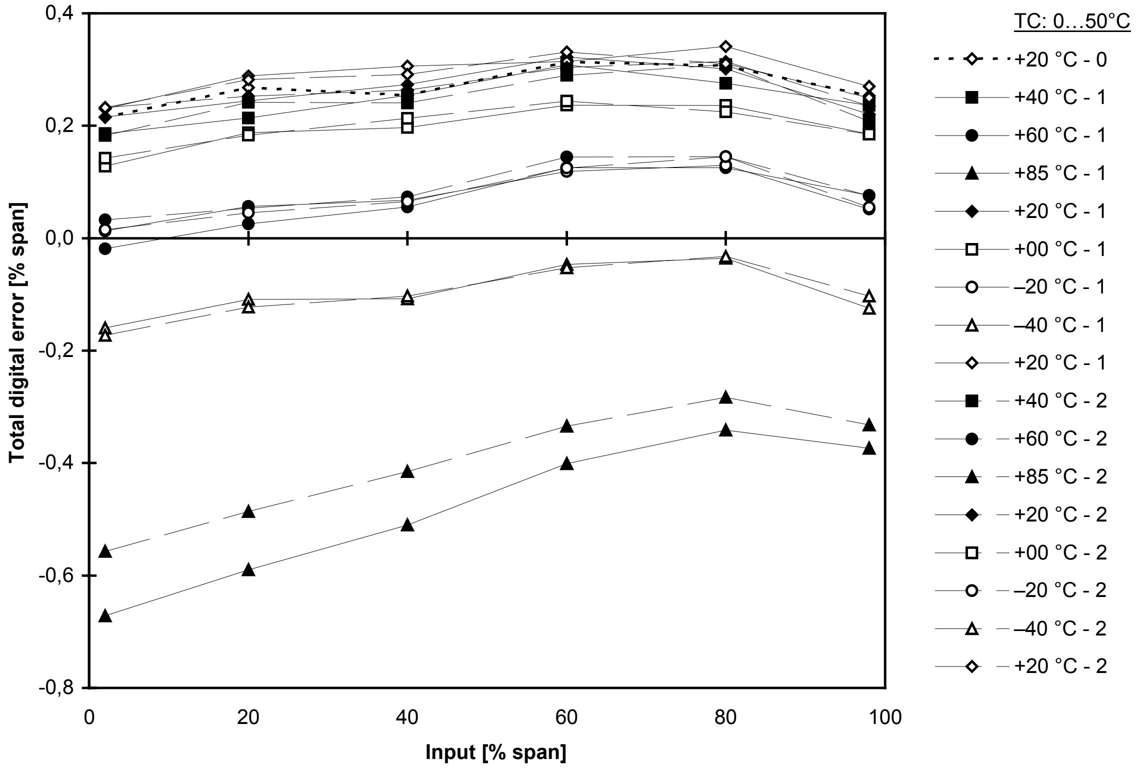
Graph 1.5 Temperature effect TC transmitter on digital output, two cycles



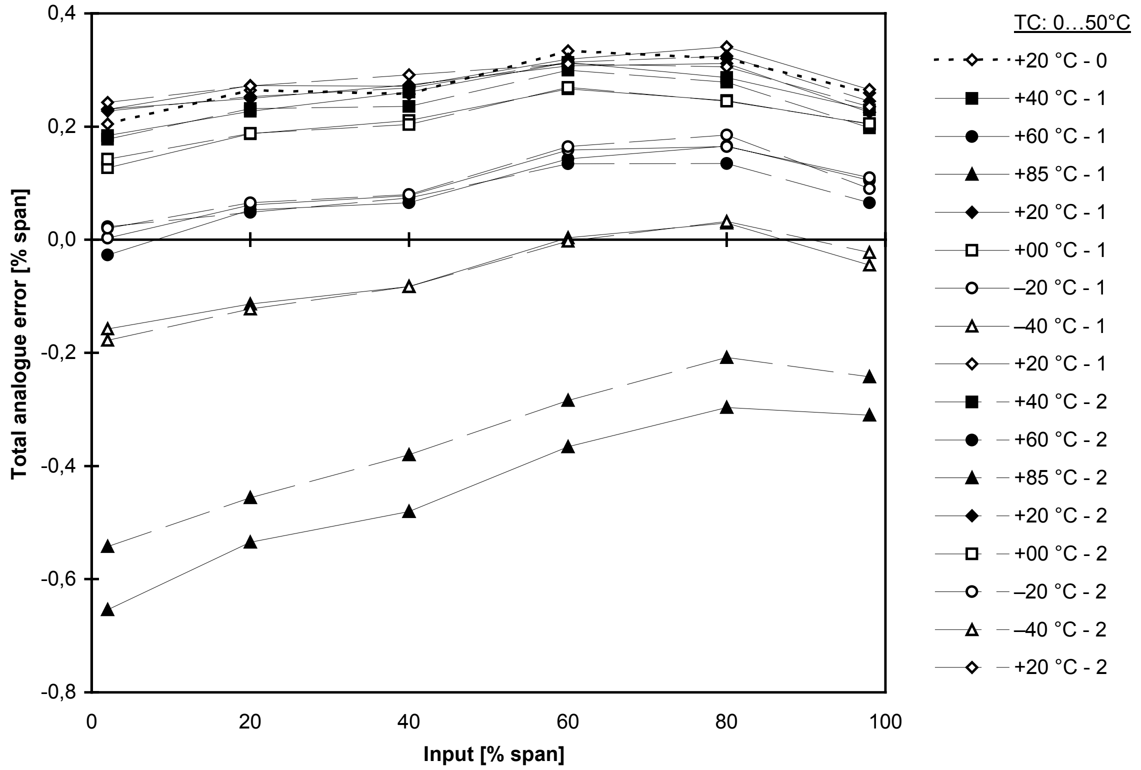
Graph 1.6 Temperature effect TC transmitter on analogue output, two cycles



Graph 1.7 Temperature effect TC transmitter in manual mode, two cycles



Graph 1.8 Accuracy error plus ambient temperature error, digital output



Graph 1.9 Accuracy error plus ambient temperature error, analogue output

3.3 Results' summary for the RTD transmitter

Test number and subject	Measured and observed, RTD	Manufacturer's specifications
01 – Accuracy, initial (at the start of the evaluation)		
Range: 0...20 °C		
Digital output		
- Average error, extreme values	–0,04 and –0,10 %; see graph 2.1	0,50 %
- Max. hysteresis	0,02 %	
- Max. repeatability	0,06 %	0,08 %
Analogue output		
- Average error, extreme values	–0,04 and –0,08 %; see graph 2.1	0,52 %
- Max. hysteresis	0,01 %	
- Max. repeatability	0,05 %	0,08 %
Range: 0...100 °C		
Digital output		
- Average error, extreme values	–0,01 and –0,02 %; see graph 2.2	0,10 %
- Max. hysteresis	0,01 %	
- Max. repeatability	0,01 %	0,016 %
Analogue output		
- Average error, extreme values	0,00 and –0,02 %; see graph 2.2	0,12 %
- Max. hysteresis	0,00 %	
- Max. repeatability	0,01 %	0,016 %
Range: -200...850 °C		
Digital output		
- Average error, extreme values	0,00 %	0,01 %
- Max. hysteresis	0,00 %	
- Max. repeatability	0,00 %	0,0015 %
Analogue output		
- Average error, extreme values	0,00 and +0,01 %; see graph 2.3	0,03 %
- Max. hysteresis	0,00 %	
- Max. repeatability	0,00 %	0,0015 %
Manual mode		
Analogue output		
- Average error, extreme values	0,00 and +0,01 %; see graph 2.4	0,02 %
- Max. hysteresis	0,00 %	
- Max. repeatability	0,00 %	
Accuracy, final (at the end of the evaluation)		
Range: 0…20 °C		
- Digital output, extreme values	–0,08 % and –0,13 %	
- Analogue output, extreme values	–0,08 % and –0,13 %	
Range: 0…100 °C		
- Digital output, extreme values	–0,01 % and –0,02 %	
- Analogue output, extreme values	0,00 % and –0,03 %	

Test number and subject	Measured and observed, RTD	Manufacturer's specifications
Range: -200…850 °C - Digital output, extreme values - Analogue output, extreme values *Manual mode* - Analogue output, extreme values	 0,00 % and 0,00 % –0,01 % and +0,01 % –0,01 % and +0,01 %	
02 - Dead band Dead band / Resolution - Digital output - Analogue output	 Dead band is equal to the resolution: 0,01 K 0,02 %	
03 - Open/short circuited input *Open input* - Digital - Analogue *Short circuit at input terminals* - Digital - Analogue	 Alarm/Error 0050[22] Output to 21,7 mA Alarm/Error 0051[23] Output to 21,7 mA	
04 - Line resistance effect Each wire: 50 Ω	 No effect Current through element: 0,274 mA	 Max. 50 Ω/line ≤0,3 mA
07 - Common mode 250 Vac 50 Vdc	 No effect No effect	
11 - Earthing One input terminal to earth	 No effect	

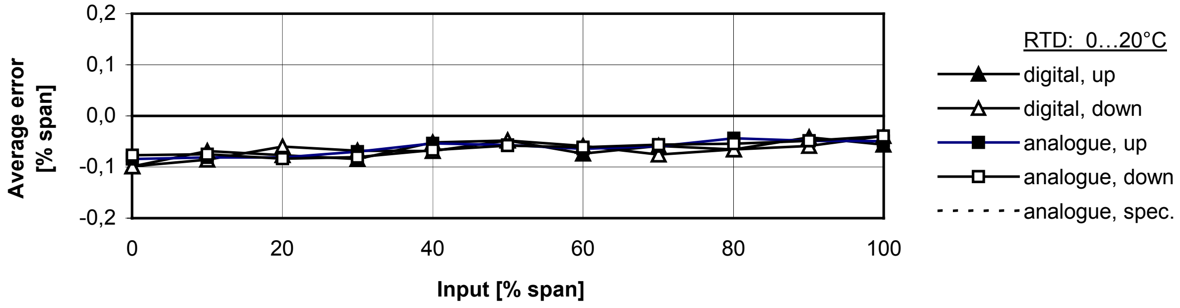
[22] 0050: Sensor 1 open circuit
[23] 0051: Sensor 1 short circuit

Test number and subject	Measured and observed, RTD			Manufacturer's specifications	
12 - Ambient temperature				Operating limits:	
Between +85 °C and –40 °C Rate of change: 0,33 K/min Reference: 20 °C at cycle 1	LRV = lower range value URV = upper range value			maximum: +85 °C minimum: –40 °C	
Digital output	Shift at LRV	Shift at URV	Span shift	LRV	URV
- Shift at +40 °C, cycle 1	+0,02 %	+0,11 %	+0,09 %	0,25 %	0,27 %
- Shift at +60 °C, cycle 1	+0,02 %	+0,08 %	+0,07 %	0,50 %	0,54 %
- Shift at +85 °C, cycle 1	+0,02 %	+0,06 %	+0,04 %	0,81 %	0,88 %
- Shift at +20 °C, cycle 1	–0,03 %	+0,06 %	+0,09 %	---	---
- Shift at 0 °C, cycle 1	–0,08 %	–0,04 %	+0,04 %	0,25 %	0,27 %
- Shift at –20 °C, cycle 1	–0,21 %	–0,22 %	–0,01 %	0,50 %	0,54 %
- Shift at –40 °C, cycle 1	–0,38 %	–0,37 %	+0,02 %	0,75 %	0,81 %
- Shift at +20 °C after cycle 1	–0,03 %	–0,02 %	+0,02 %	---	---
- Shift at +40 °C, cycle 2	+0,02 %	+0,03 %	+0,02 %	0,25 %	0,27 %
- Shift at +60 °C, cycle 2	+0,02 %	+0,11 %	+0,09 %	0,50 %	0,54 %
- Shift at +85 °C, cycle 2	+0,02 %	+0,08 %	+0,07 %	0,81 %	0,88 %
- Shift at +20 °C, cycle 2	–0,06 %	–0,02 %	+0,04 %	---	---
- Shift at 0 °C, cycle 2	–0,08 %	–0,07 %	+0,02 %	0,25 %	0,27 %
- Shift at –20 °C, cycle 2	–0,23 %	–0,19 %	+0,04 %	0,50 %	0,54 %
- Shift at –40 °C, cycle 2	–0,36 %	–0,39 %	–0,03 %	0,75 %	0,81 %
- Shift at +20 °C after cycle 2	–0,03 %	–0,02 %	+0,02 %	---	---
	Graph 2.5 shows the shifts of the digital output at LRV and URV, and the specification.				
Total error: sum of the accuracy error and the temperature drift, after stabilisation	Minimum error: –0,52 %, found at –40 °C Maximum error: –0,01 %, found at +60 °C			Max. at –40 °C 1,31 %	Max. at +85 °C 1,38 %
	Graph 2.8 shows the total error of the digital output at several ambient temperatures.				
Analogue output	Shift at LRV	Shift at URV	Span shift	LRV	URV
- Shift at +40 °C, cycle 1	+0,02 %	+0,03 %	+0,01 %	0,28 %	0,30 %
- Shift at +60 °C, cycle 1	+0,04 %	+0,02 %	–0,02 %	0,56 %	0,60 %
- Shift at +85 °C, cycle 1	+0,08 %	+0,03 %	–0,05 %	0,91 %	0,97 %
- Shift at +20 °C, cycle 1	–0,02 %	0,00 %	+0,02 %	---	---
- Shift at 0 °C, cycle 1	–0,11 %	–0,06 %	+0,06 %	0,28 %	0,30 %
- Shift at –20 °C, cycle 1	–0,26 %	–0,14 %	+0,12 %	0,56 %	0,60 %
- Shift at –40 °C, cycle 1	–0,37 %	–0,25 %	+0,12 %	0,84 %	0,90 %
- Shift at +20 °C after cycle 1	–0,06 %	–0,05 %	+0,01 %	---	---
- Shift at +40 °C, cycle 2	+0,02 %	–0,04 %	–0,06 %	0,28 %	0,30 %
- Shift at +60 °C, cycle 2	+0,08 %	+0,01 %	–0,07 %	0,56 %	0,60 %
- Shift at +85 °C, cycle 2	+0,06 %	+0,05 %	–0,02 %	0,91 %	0,97 %
- Shift at +20 °C, cycle 2	–0,08 %	–0,04 %	+0,04 %	---	---
- Shift at 0 °C, cycle 2	–0,11 %	–0,06 %	+0,05 %	0,28 %	0,30 %
- Shift at –20 °C, cycle 2	–0,25 %	–0,17 %	+0,08 %	0,56 %	0,60 %
- Shift at –40 °C, cycle 2	–0,37 %	–0,27 %	+0,10 %	0,84 %	0,90 %
- Shift at +20 °C after cycle 2	–0,02 %	–0,04 %	–0,02 %	---	---
	Graph 2.6 shows the shifts of the analogue output at LRV and URV, and the specification.				

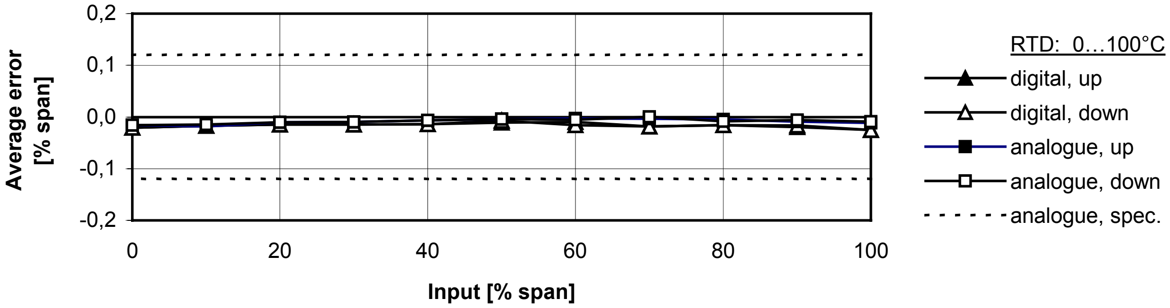
Test number and subject	**Measured and observed, RTD**			**Manufacturer's specifications**	
Total error: sum of the accuracy error and the temperature drift, after stabilisation				Max. at	Max. at
	Minimum error: –0,47 %, found at –40 °C			<u>–40 °C</u>	<u>+85 °C</u>
	Maximum error: –0,01 %, found at +60 °C			1,42 %	1,49 %
	Graph 2.9 shows the total error of the analogue output at several ambient temperatures.				
Error during a temperature change Rate of change: 20 K/h Input: 50 %					
- During temperature rise	Additional shift of the analogue output: <0,05 %				
- During temperature fall	Additional shift of the analogue output: <0,05 %				
Manual mode	<u>Shift at LRV</u>	<u>Shift at URV</u>	<u>Span shift</u>	<u>LRV</u>	<u>URV</u>
- Shift at +40 °C, cycle 1	+0,01 %	–0,02 %	–0,03 %	0,03 %	0,03 %
- Shift at +60 °C, cycle 1	+0,02 %	–0,02 %	–0,04 %	0,06 %	0,06 %
- Shift at +85 °C, cycle 1	+0,05 %	0,00 %	–0,04 %	0,10 %	0,10 %
- Shift at +20 °C, cycle 1	–0,01 %	–0,01 %	0,00 %	---	---
- Shift at 0 °C, cycle 1	–0,01 %	+0,03 %	+0,04 %	0,03 %	0,03 %
- Shift at –20 °C, cycle 1	–0,01 %	+0,08 %	+0,08 %	0,06 %	0,06 %
- Shift at –40 °C, cycle 1	0,00 %	+0,14 %	+0,14 %	0,09 %	0,09 %
- Shift at +20 °C after cycle 1	–0,01 %	–0,03 %	–0,03 %	---	---
- Shift at +40 °C, cycle 2	0,00 %	–0,05 %	–0,06 %	0,03 %	0,03 %
- Shift at +60 °C, cycle 2	+0,02 %	–0,04 %	–0,06 %	0,06 %	0,06 %
- Shift at +85 °C, cycle 2	+0,04 %	0,00 %	–0,05 %	0,10 %	0,10 %
- Shift at +20 °C, cycle 2	–0,01 %	–0,01 %	–0,01 %	---	---
- Shift at 0 °C, cycle 2	–0,01 %	+0,02 %	+0,03 %	0,03 %	0,03 %
- Shift at –20 °C, cycle 2	–0,01 %	+0,07 %	+0,08 %	0,06 %	0,06 %
- Shift at –40 °C, cycle 2	0,00 %	+0,13 %	+0,13 %	0,09 %	0,09 %
- Shift at +20 °C after cycle 2	–0,01 %	–0,03 %	–0,03 %	---	---
	Graph 2.7 shows the shifts of the manual output at LRV and URV, and the specification.				
Total error: sum of the accuracy error and the temperature drift, after stabilisation				Max. at	Max. at
	Minimum error: –0,03 %, found at +40 °C			<u>–40 °C</u>	<u>+85 °C</u>
	Maximum error: +0,16 %, found at –40 °C			0,11 %	0,12 %
Linearity effect - For all temperatures	Digital and analogue: No discernable effect				
Hysteresis effect - For all temperatures	Digital and analogue: No discernable effect				
Readability of the display	at +85 °C: unreadable at –40 °C: slow response			Limits display unit: –40 °C…+70 °C	
16 - Long term drift					
- Drift, digital output	0,10 %, random effect			≤0,2 %/year	
- Drift, analogue output	0,08 %, random effect				

Test number and subject	**Measured and observed, RTD**	**Manufacturer’s specifications**
21…24 EMC tests E+H Wetzer carried out tests 21, 21+, 23 and 24a. The results are described in test report E+H 03960950. Senton Test Centre in Straubing carried out test 24b. The results are described in their test report 50515-20709. The results of the tests, described in both reports, were commented and included. The input during the EMC tests was 50 %.	**General notes** The test set-ups and equipment used for the tests are well documented. The test results obtained are sufficiently and clearly specified. Senton is an accredited testing laboratory (February 2005). The transmitter tested by the manufacturer and Senton, was configured differently with respect to the configuration at this evaluation. The differences were: – Dual input, 1x TC and 1x RTD – TC input range: -100…+100 °C – RTD input range: 0…+100 °C, 3-wire circuit – The output, PV, followed the RTD input. By that, the manufacturer’s tests could cause other effects. They have to be divided in: 1. Effects on the input circuit The effects reported will also be valid for the instrument as evaluated, if specified in Kelvin. If the shift is specified in % of span, the effects will be larger as the span of the instrument evaluated is more sensitive: 4 times for TC and 5 times for RTD. 2. Effects on the output circuit The effects reported will also be valid for the instrument as evaluated.	
Effect after each EMC test	No remaining effect	
21 - EMC: Burst (fast transients) ±2kV, 5 kHz, 2 min Into the TC input line Into the RTD input line Into the output/supply line ±4kV, 5 kHz, 1 min, extra test Into the TC input line Into the RTD input line Into the output/supply line	Reference: Test report E+H 03960950, § 4 See general notes (above) No discernable effect on the output No discernable effect on the output No discernable effect on the output Maximum shift of the TC output: 0,5 K No discernable effect on the output No discernable effect on the output	±4 kV not required in IEC 61326
21+ - EMC: Surge test 1kV, unsymmetrical mode between enclosure and, in turn: Each input terminal, effect Each output terminal+, effect	Reference: Test report E+H 03960950, § 5 See general notes (above) Sporadically: short disturbances Short disturbances of 0,3 mA (2 %)	
22 - EMC: Magnetic field	Test not required according to IEC 61326. Test not carried out.	

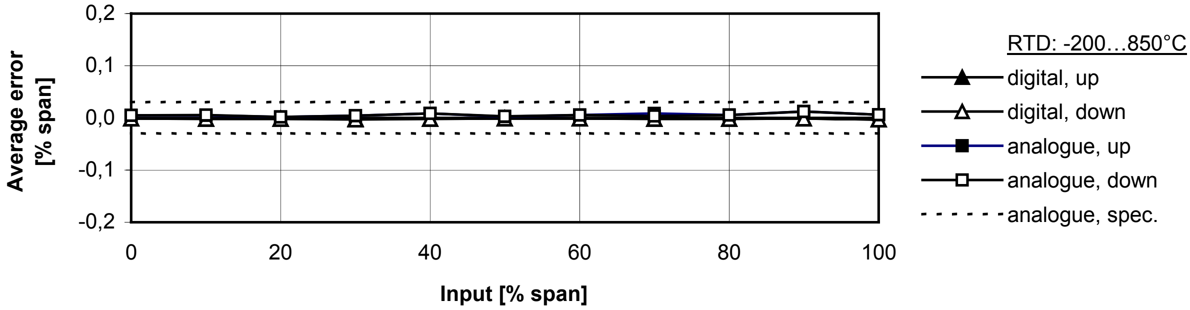
Test number and subject	Measured and observed, RTD	Manufacturer's specifications
23 - EMC: Electrost. discharges 6 kV / 8 kV contact/air on the outside of the instrument Effect on the analogue output	Reference: E+H test report 03960950, § 2 See general notes (above) No discernable effect	
24a EMC: HF interference *Conducted* 0,15…80 MHz, 80 % AM, 10 V Successively in TC input lines, RTD input lines, output/supply lines, earth connection line Effect on the analogue output	Reference: E+H test report 03960950, § 6 See general notes (above) No discernable effect	
24b EMC: HF interference *Radiated* 80…1000 MHz, 80 %AM, 10 V Horizontal & vertical polarisation Effect on analogue output	Reference: Senton test report 50515-20709, §12 See general notes (above) ≤0,03 % shift	
25 - Ambient humidity, cyclic 6 cycles between 25 °C and 55 °C at 95 % r.h., 50 % input Maximum shift of the analogue output during the test Shift of the analogue output after the test	<0,1 % Zero shift: –0,05 % Span shift: +0,04 %	Condensation is permitted



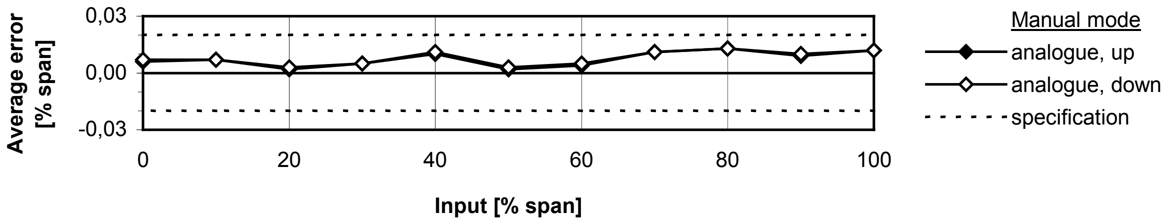
Graph 2.1 Accuracy RTD transmitter, 0…20 °C; specification: ±0,52 % (outside graph)



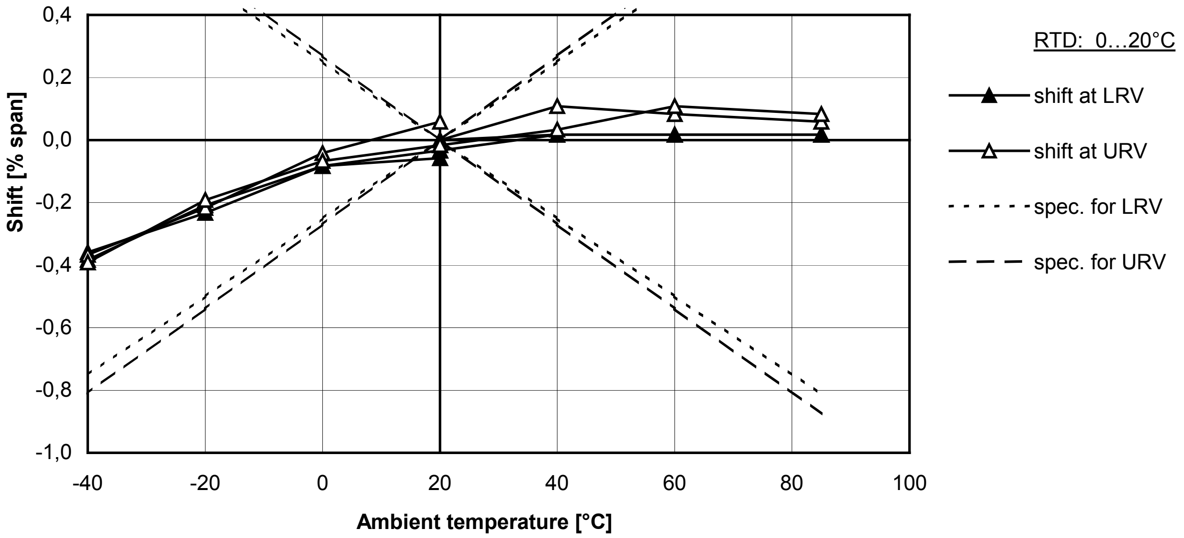
Graph 2.2 Accuracy RTD transmitter, 0…100 °C; specification: ±0,12 %



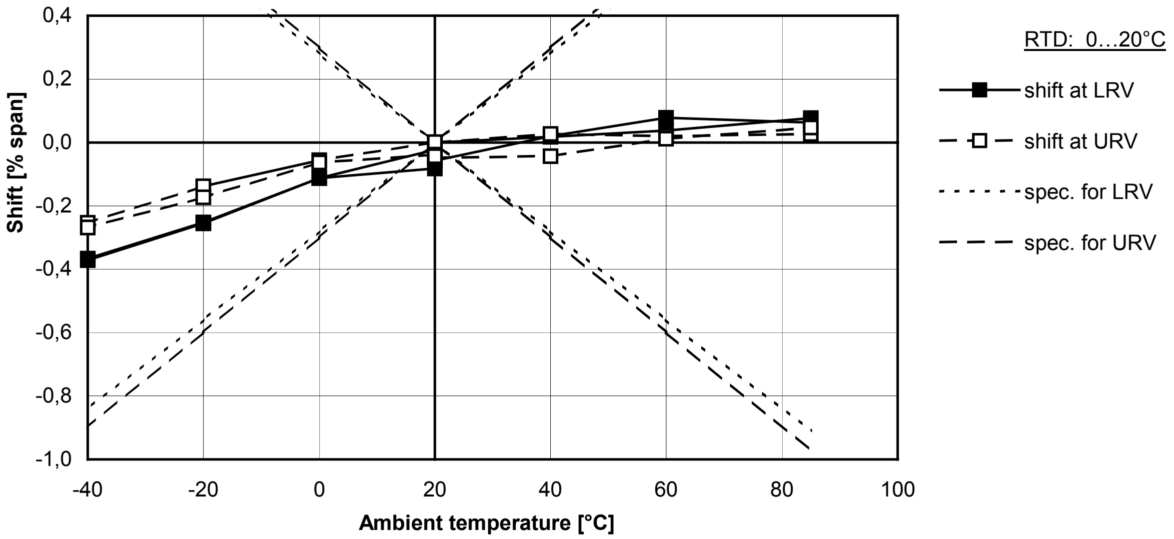
Graph 2.3 Accuracy RTD transmitter, -200…850 °C; specification: ±0,03 %



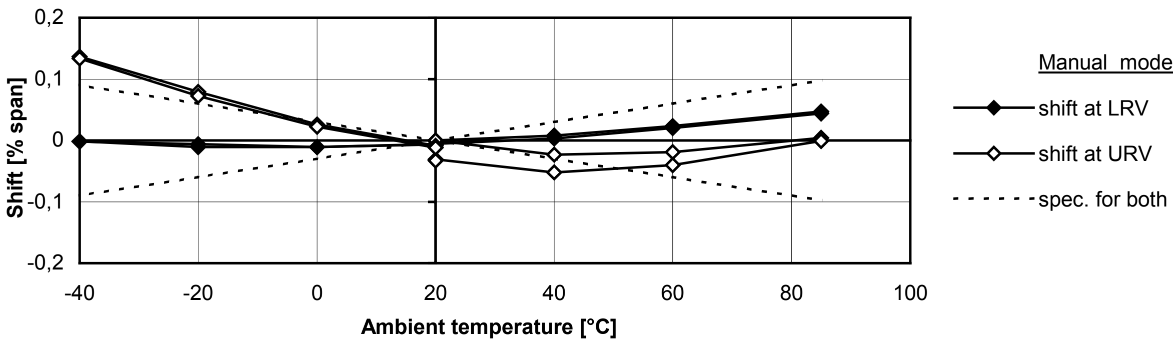
Graph 2.4 Accuracy RTD transmitter, manual mode; specification: ±0,02 %



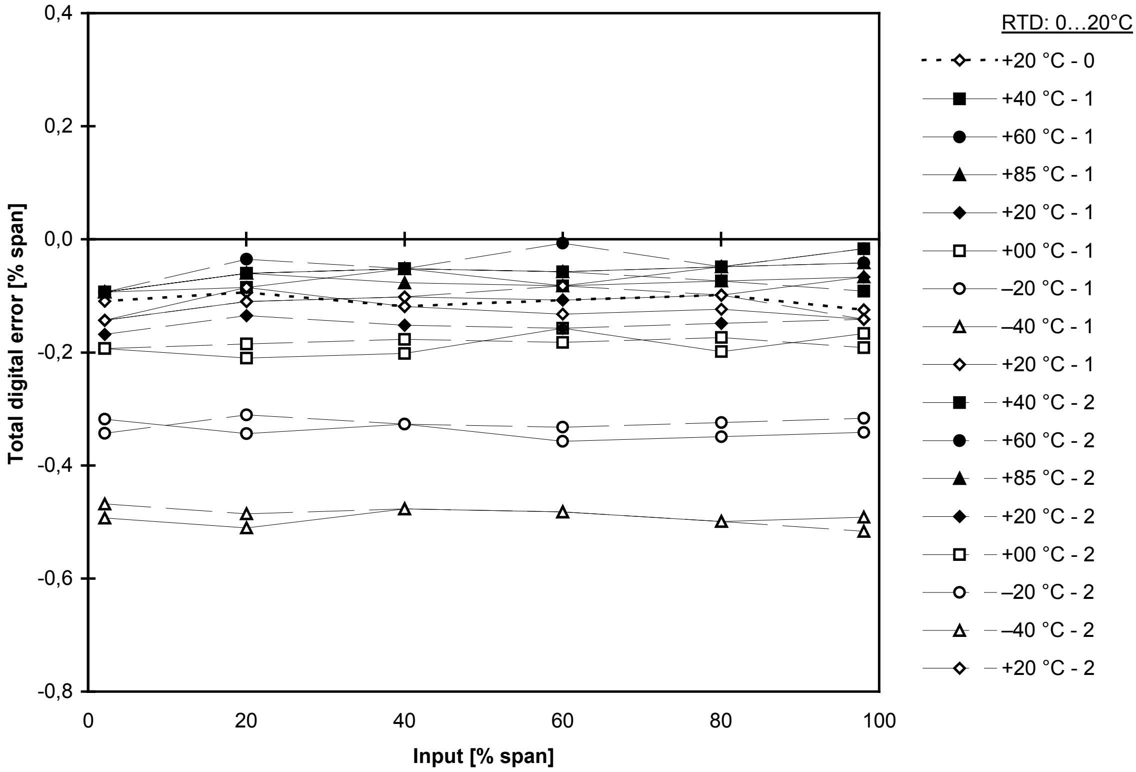
Graph 2.5 Temperature effect RTD transmitter on digital output, two cycles



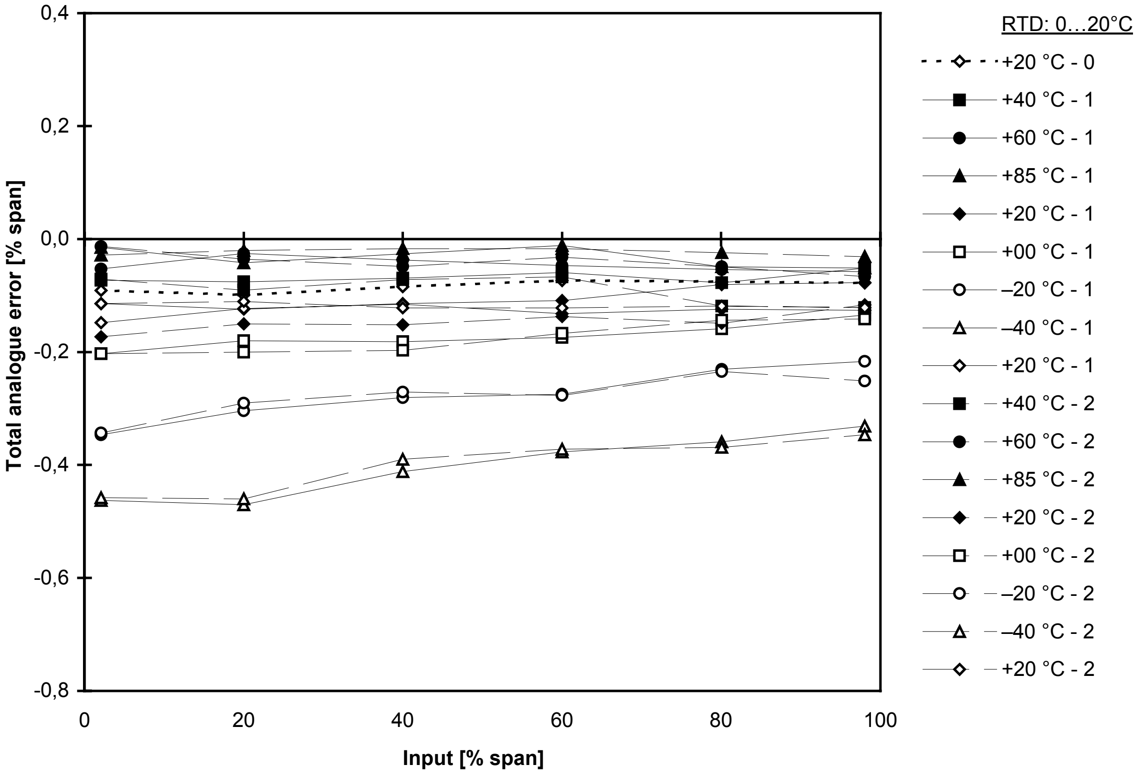
Graph 2.6 Temperature effect RTD transmitter on analogue output, two cycles



Graph 2.7 Temperature effect RTD transmitter in manual mode, two cycles



Graph 2.8 Accuracy error plus ambient temperature error, digital output



Graph 2.9 Accuracy error plus ambient temperature error, analogue output

4. MANUFACTURER'S DATA

Instrument specifications and other details provided by the manufacturer.

	Manufacturer	Supplier in the Netherlands
Name	Endress+Hauser Wetzer GmbH+Co. KG	Endress+Hauser BV
	Obere Wank 1	Nikkelstraat 6-12, Postbus 5102
	D - 87484 Nesselwang	1410 AC Naarden
Phone	+49-8361-308-0	+31-35-6958611
Internet	www.wetzer.endress.com	www.nl.endress.com
	TC transmitter	**RTD transmitter**
Type	TMT162-B2621JBAB	TMT162-B26241BAB
Serial No./ CPU No.	6B0065 04223	6B0066 04223
Order No.	32009767/0001	32009767/0001
Configuration	Thermocouple	Resistance thermometer
Sensor type	J (Fe-CuNi) to IEC 584	Pt100 to IEC 751, 4-wire
Sensor connection	Terminals 1, 2 (sensor 1)	Terminals 1, 2, 3, 4
Accuracy, digital	Typical 0,25 K	0,1 K
Accuracy, analogue	0,02 % of span	0,02 % of span
Accuracy, cold junction	Acc. to Pt100, IEC 751, Cl. B	N.A.
Temperature drift input, max.	0,0015 % of input per K	0,001 % of the resistance per K
Temperature drift CJC, max.	According to Pt100, IEC 751, Cl. B	N.A.
Temperature drift output, max.	0,0015 % of span per K	0,0015 % of span per K

The Internet site, www.endress.com, shows the following general information:

- Temperature field transmitter with HART® -protocol for converting various input signals to an analogue, scalable 4 to 20 mA output signal
- Inputs: Resistance thermometer (RTD), Thermocouples (TC), Resistance (Ohm) and Voltage (V or mV)
- HART®-protocol for operating the device on site using handheld terminal (DXR275/DXR375) or remotely via the PC
- Universally programmable with HART® -protocol for various input signals
- Illuminated display
- Operation, visualisation and maintenance with PC, using FieldCare or ReadWin® 2000 operating software
- Two-wire technology, analogue output 4…20 mA. Highly accurate in entire operating temperature range
- Low voltage detection
- Sensor monitoring: Breakdown information, sensor backup, drift alarm, corrosion detection to NAMUR NE 89
- Breakdown information in event of sensor break or sensor short-circuit, adjustable to NAMUR NE 43
- EMC to NAMUR NE 21, CE
- Approvals: 1) ATEX Ex ia, Ex d and dust; 2) FM IS, XP and DIP; 3) CSA IS, XP and DIP
- SIL2 compliant
- Ship building approval GL
- Galvanic isolation
- Output simulation
- Min./max. process value recorded
- Customised measuring range setup or expanded SETUP
- Optional: two input channels, e.g. for 2 x Pt100, 3-wire connection
- Optional: stainless steel housing

5. OPERATING PRINCIPLE AND CONSTRUCTION

Please, refer to the manufacturer's Technical Information, appended to this report.
During the evaluation, the set-up parameters for the TC transmitter and the RTD transmitter were:

		TC transmitter	RTD transmitter
	Standard set-up		
1010	Function mode	single sensor mode	single sensor mode
1200	PV mode	PV=Sensor1	PV=Sensor1
1300	PV unit	°C	°C
	Sensor 1 (S1)		
2000	Sensor type	TC J (Fe-Cu45Ni)	Pt100 IEC751 (α=0,003850)
2100	Unit	°C	°C
2200	Sensor connection		4-wire
2300	Cold junction	internal	
2600	Offset	0,00 °C	0,00 °C
2700	Sensor serial No.	-	-
	Output		
4000	PV lower range value	0,00 °C	0,00 °C
4100	PV upper range value	50,00 °C	20,00 °C
4200	Analogue output	4…20 mA	4…20 mA
4300	Filter	0,0 sec	0,0 sec
	Safety / Maintenance		
5200	Fault condition	≥21,6 mA	≥21,6 mA
5250	High alarm setting	21,70 mA	21,70 mA
5260	Alarm hysteresis	0 sec	0 sec
5300	Alarm ambient temperature	off	off
5400	Corrosion detection	off	off
5450	Alarm in over- / underrange	on	on
5500	Main filter	50 Hz	50 Hz
	Display		
6000	Display: PV	on	on
6100	Display: Sensor1 value	off	off
6050	Display: Decimal places	2	2
6300	Display: RJ value	off	off
6400	Display: Analogue output value	off	off
6450	Display: Percentage	off	off
6500	Display: Status	off	off
6550	Display: Time	2 sec	2 sec
6600	Display: PV text	PV-TC	PV
	Diagnostics		
7000	Device status	0	0
7100	Last diagnosis	202	201
7400	Configuration changed	yes	yes
7500	Sensor1 max value	1000,00 °C	1000,00 °C
7600	Sensor1 min value	-200,00 °C	-250,00 °C
7900	RJ max value	23,98 °C	22,73 °C
7A00	RJ min value	21,23 °C	19,77 °C
	Identification		
8010	TAG	___TC___	___RTD___
8020	Descriptor	Descrip=TC-J	PT100
8120	E+H Serial No.	6B006504223	6B006604223
8130	E+H Software revision	1.03.00	1.03.00
8140	E+H Hardware revision	1.01.05	1.01.05
	Service functions		
9000	Security locking	261	261
9100	Reset to default	0	0
9200	Output simulation	off	off
9400	Trim 4 mA	0,000 mA	0,000 mA
9500	Trim 20 mA	0,000 mA	0,000 mA

6. TEST METHODS AND REFERENCES

6.1 Test methods

6.1.1 Test set-ups

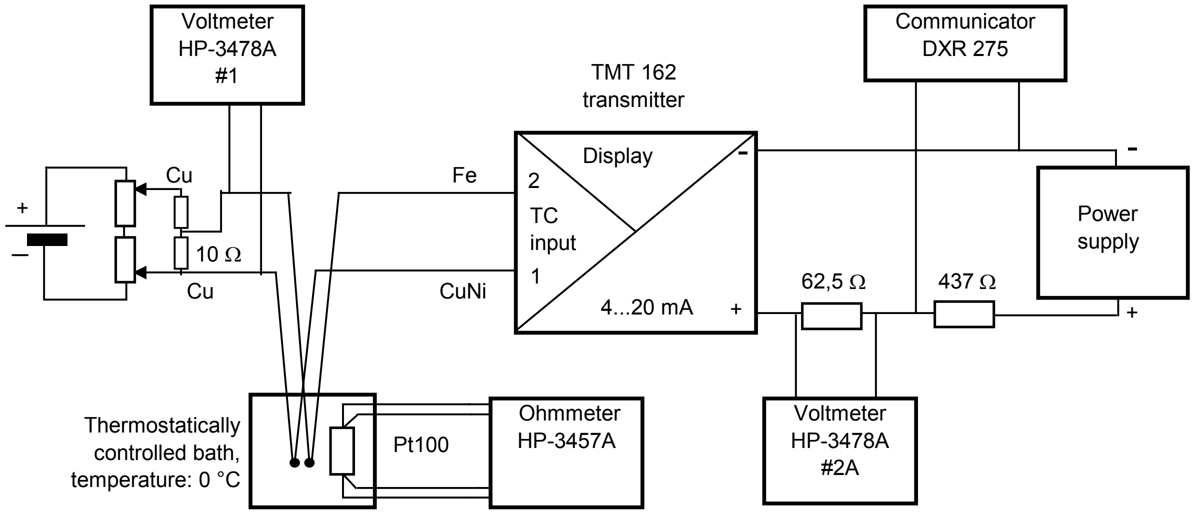


Figure 1: General test set-up for the TC transmitter

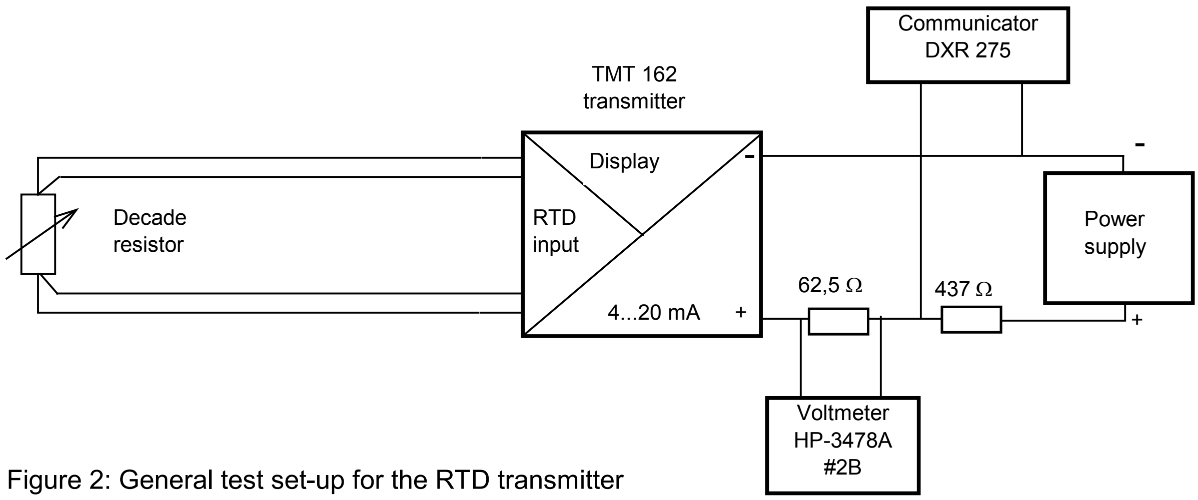


Figure 2: General test set-up for the RTD transmitter

<u>Equipment for TC transmitter</u>

mV input	Battery	Power supply, HP-E3620A, ch 1, TNOnr. 14106
	Voltage adjust	Two 10-turn potentiometers, coarse and fine, R_{out} = 10 Ω
	Voltmeter	HP-3478A, #1, TNOnr. 10705
	- Range & Accur.	±30 mV, resolution: 0,1 µV & ±(0,0275 % + 4 µV)
		±300 mV, resolution 1 µV & ±(0,005 % + 5 µV)
		The temperature equivalent for both accuracies is ±0,1 K
Bath temperature	Pt100 element	VSL 95 T004, TNOnr. 13197, calibr. 11-2004
	Location	Element and both couples in an aluminium block in the bath
	Ohmmeter	HP-3457A, TNOnr. 13410
	- Range	300 Ω, resolution: 0,1 mΩ, 10 PLC
	- Accuracy	±(0,0055 % + 3,5 mΩ) @ 100 Ω

	Temperature	0 °C; short-term stability: ±0,005 K
	Compensation	Each measurement: arithmetic for deviation from 0 °C
Thermocouple cable	Type	Extension wire J, Class 1, i.e. ±1,5 K[24]
	- Connections	soldered to copper leads and isolated from the fluid
Analogue output	Supply	24 Vdc, HP-E3620A, ch 2, TNOnr. 14106
	Resistance	Vishay, 62,5 Ω, ±0,01 %, TNOnr. 12962
	Voltmeter	HP-3478A, #2A, TNOnr. 10704
		Circuit: via DPDT switch to one transmitter
	- Range & Accur.	3 V, resolution: 0,01 mV & ±(0,004 % + 0,02 mV)

Equipment for RTD transmitter

Resistance input	Decade resistor	Tettex, 1108A-YY, resolution 0,01 Ω, TNOnr. 11404
	- Accuracy	After calibration with HP-3458A: ±0,0023 Ω at 100 Ω
Analogue output	Supply	24 Vdc, HP-E3620A, ch 2, TNOnr. 14106
	Resistance	Vishay, 62,5 Ω, ±0,01 %, TNOnr. 13663
	Voltmeter	HP-3478A, #2B, TNO No. 10704
		Circuit: via DPDT switch to one transmitter
	- Range & Accur.	3 V, resolution: 0,01 mV & ±(0,004 % + 0,02 mV)

Other equipment

HART® signal readout	Communicator	Fisher-Rosemount 00275
	Update	Endress+Hauser: DXR 275, November 2004
		Circuit: via DPDT switch to one transmitter
Line recorders	Type	6 channel, Kipp BD101, TNO No. 11429
	Ranges	- voltage across the 62,5 Ω: 0,5 V
		- Pt100: -100…+100 °C
	Type	2 channel, Kipp BD112, TNO No. 13264
	Ranges	- voltage across the 62,5 Ω: 0,5 V or 0,2 V
	Note for both	disconnected during accurate measurements

Estimated uncertainty of the set-up for TC

Input generation	±0,2 % at 0…50 °C, ±0,02 % at 0…500 °C
Analogue output	±0,012 %
Total	±0,2 % at 0…50 °C, ±0,03 % at 0…500 °C, <±0,03 % at a larger range

Estimated uncertainty of the set-up for RTD

Input	±0,03 % at 0…20 °C, ±0,006 % at 0…100 °C
Analogue output	±0,012 %
Total	±0,03 % at 0…20 °C, ±0,013 % at 0…100 °C, <±0,013 % at a larger range

[24] From the Accuracy tests can be concluded that the Tolerance Value for the extension wire was better than ±1,5 K; it came close to zero at 20 °C ambient temperature.

6.1.2 Tests

The test schedule gives an overview of the tests and measurements carried out and characteristic values calculated. The tests are described thereafter.

Measurements				A	B	C	D	E	F	G	H
	Standard tests	**TC**	**RTD**								
1	Accuracy, 3 ranges	x	x	x							
2	Dead Band	x	x								
3	Open/short circuited input	x	x						x	x	
4	Line resistance effect	x	x		x				x	x	
5	Output load	x			x				x		
6	Series mode interference	x				x		x		x	
7	Common mode	x	x			x		x		x	
8	Power supply variations	x			x						
9	Power supply interruptions	x					x		x	x	x
10	Power supply depressions	x					x		x	x	x
11	Earthing	x	x		x		x		x	x	
12	Ambient temperature	x	x		x					x	x
13	Ambient humidity, See test 25										
14	Vibration, See test 26										
15	Start-up drift	x				x					
16	Long term drift	x	x			x				x	
17	Ripple content on output	x						x			
18	Overranging	x			x				x	x	x
19	Step response	x									
20	Power supply reversal	x			x				x	x	x
--	Constructional aspects	x	x						x	x	
	EMC tests										
21	Burst (Fast transients)	x				x	x		x	x	x
21+	Surge test	x				x	x		x	x	x
22	Magnetic field interference	x				x		x			
23	Electrostatic discharges	x				x	x		x	x	x
24	HF interference	x	x			x	x		x	x	x
	Aggravated tests										
25	Ambient humidity, cyclic	x				x				x	x
26	Vibration/Endurance	x				x	x			x	x
27	Enclosure/Ingress of water	x									x
28	Salt spray	x									x

A I/O characteristic
B Zero/span shift during and/or after test
C Shift at 10...50...90...% Input
D Transient effects
E A.C. component on the output
F Message on the interface system
G Qualitative observation during the test
H Qualitative observation after the test

Range setting

The input type and span adjustments were set at the interface without simulation of a measured value.

TC, type J	Accuracy test:	0...+50 °C, 0...+500 °C, -180...+760 °C
	Other tests:	0...+50 °C, (ΔU = 2585 μV)
RTD, Pt100	Accuracy test:	0...+20 °C, 0...+100 °C, -200...+850 °C
	Other tests:	0...+20 °C, (ΔR = 7,7935 Ω)

Description of the tests

1 Accuracy

The measurements were carried out three times with intervals of 10 % for rising and falling inputs, separately. From the measurements the I/O characteristic was determined, as far as possible, of:

- The complete instrument (temperature input versus current output)
- The input block (temperature input versus digitized input
- The output block (manual input command versus current output)

In addition, the accuracy of the output block (manual output command versus output current) was determined in addition.

2 Dead band

The largest change of input that can be generated without causing a detectable change of output was determined at 10 % and 90 % input. This test was carried out for all ranges of the accuracy test.

3 Open/short circuited input

The effect of open/short circuited input terminals was determined.
In case of multi-variable input, the hot backup feature was tested, including bump less transfer.

4 Line resistance effect

TC input: The effect of a resistance of 1000 Ω in the TC input circuit was determined. The resistance in the Fe-line was 200 Ω, the resistance in the CuNi-line was 800 Ω.
RTD input: The effect of a resistance of 50 Ω ± 0,01 % in each input line was determined. The test was repeated for the maximum line resistance specified by the manufacturer if different from 50 Ω.

5 Output load

The supply voltage applied was adjusted to the maximum value. The load resistance of the instrument, was varied from 10 Ω to the maximum value.
The effects of connecting and disconnecting the modem will also be determined for resistances above 250 Ω. The smallest load was determined at which the modem still operates.

6 Series mode interference

A series mode voltage of maximum 1 V peak, 50 Hz, (0,7 Vrms) was applied across a 10 Ω resistance in series with an input signal of 50 %. The rms voltage was determined at which the mean dc shift is 0,1 % and 5 %. Also, the rms voltage was determined at which the peak of the ripple on the output is 0,5 %, 1 % and 5 %, as far as applicable.

7 Common mode

An a.c. voltage of 250 V r.m.s., 50 Hz, (or the maximum value specified by the manufacturer, if less) was applied, in turn, between the earth connection and the input terminals and between the earth connection and output terminals. During the test, the instrument was supplied from a battery, isolated from earth.
The test was repeated with a 50 Vd.c. signal (or the maximum value specified by the manufacturer, if less). During the test, the input was 50 %.

8 Power supply variations

The output load was adjusted to 250 Ω. The supply voltage was varied from the minimum value to the maximum value specified at this load.

9 Power supply interruption

The power supply was interrupted for maximum 500 ms and the start-up time behaviour was determined.

10 Power supply depression

The power supply voltage was depressed to values between 24 V and 0 V during 5...500 ms. Effects were determined at an input of 100 %. The load was the maximum value at 24 V.

11 Earthing

Each input and output terminal will, in turn, be connected to earth. If applicable, both for the modem plus PC was connected and disconnected from the instrument output.

12 Ambient temperature

The instrument was subjected to the following ambient temperatures: +20/ +40/ +60/ +85/ +20/ +0/ -20/ -40/ +20 °C. The rate of change was 1/3 K/min. After a dwell time of at least 3 hours at each temperature the output was determined at 20 % steps of the input. The minimum and maximum inputs were 2 % and 98 % instead of 0 % and 100 %. A second temperature cycle, identical to the first, was performed without re-adjustment of the instrument. From the measurements the shifts were determined, as far as possible, of:

- The complete instrument (temperature input versus current output).
- The input block (temperature input versus digitised input).
- The output block (manual output command versus output current).

13 Ambient humidity

The instrument was maintained at 40 °C and a relative humidity of not less than 95 % for a period of at least 2 days. The instrument was switched on for the final 4 h of the above period. With the transmitter still in operation the temperature and humidity were allowed to fall to the reference conditions. From the measurements the shift was determined, as far as possible, of:

- The complete instrument (temperature input versus current output).
- The input block (temperature input versus digitised input).
- The output block (manual output command versus output current).

14 Vibration

Note: The test is not applicable for head mounted instruments without enclosure.
The instrument was vibrated in three directions, perpendicular to the instrument’s main axes, in the range 5…500 Hz. In the range 5…60 Hz the amplitude was 0,07 mm. In the range 60…500 Hz the acceleration was 1 g. The sweep rate was 0,5 octave per minute.
During the test, the input was 50 % and the output was recorded. Resonance frequencies and their G-factor were noted for each direction.

15 Start-up drift

The instrument was subjected to reference conditions for a period of 24 h with the power supply switched off. Then, with a 10 % input signal applied to the instrument, the supply was switched on. the output signal noted after 5 min. and 1 h. The test was repeated with a 90 % input signal.

16 Long term drift

The instrument was operated for 30 days with a steady 90 % input signal. The output was measured daily.

17 Ripple content of output

The peak-to-peak value and the main frequency component of any a.c. ripple content of the output were measured with 10 % , 50 % and 90 % input signals.

18 Overranging

An over range signal of 1 Vdc was applied to the input terminals for 1 min. A recovery period of 5 min. was allowed.

19 Step response

Input steps between 45 % and 55 % and between 10 % and 90 % of span were applied up and down. The time taken for the output to reach and remain within 1 % of span of its final steady value were measured for each test condition. Test to be done with the time constant set to minimum.

20 Power supply reversal

The effects of incorrect connection of the power supply wires during 1 minute were determined.

xx Constructional aspects

Comments were given on procedures for installation, maintenance, adjustment and repair. The manufacturer's documentation was examined. Any identification difficulties and/or ambiguities were noted. The accuracy of the range setting on the interface was checked before and after the evaluation.

EMC tests (general remarks)

- The severity levels for the EMC tests were in accordance with the current CE demands of IEC61326, Annex A: Immunity test requirements for equipment intended for use in industrial locations.
- The effects, both during and after application of the disturbance, were noted as indicated in the EN Standard under ‘Performance criterion A’.
- The results of test 21 – 24/Conducted are taken from the test report with results of tests carried out by the manufacturer: EMV-Prüfbericht 03960950 (EMC Test report 03960950) of 30 November 2004.
- The results of test 24/Radiated are taken from a test report, prepared by Senton, EMC Test centre, Germany: Prüfbericht no. 50515-20709 (EMC Test report 50515-20709) of 28 November 2002.
- Configuration: One instrument was configured for dual input. The output followed the RTD input.
- Cabling:
  An unscreened cable of 2 m was connected to the TC terminals. The ambient temperature was the input temperature.
  An unscreened 3-wire cable of 2 m was connected to the RTD terminals. A fixed resistor of 121 Ω simulated the Pt100 element, i.e. 53,5 °C.
  An unscreened cable of 2 m was used for the supply/output.

21 Burst (Fast transients)

Fast transients, according to IEC 61000-4-4, were applied to the supply/output lines via the capacitive clamp. During the test, the input was 50 %.

21+ Surge test

Surges of 1 kV, according to IEC 61000-4-5, were applied between output lines and enclosure and between input lines and enclosure (unsymmetrical mode). During the test, the input was 50 %.

22 Magnetic field interference

The instrument was subjected to a magnetic field of 50 Hz in accordance with IEC 61000-4-8. During the test, the input was 50 %.

23 Electrostatic discharges

Electrostatic discharges in accordance with IEC 61000-4-2 were applied to metal parts of the transmitter most likely to be touched by personnel during normal operation. During the test, the input was 50 %.

24 HF interference

24a Conducted interference:

The test was carried out as described in IEC 61000-4-6 with a field of 10 V, 0,15…80 MHz, 80 % AM.

24b Radiated interference

The test was carried out as described in IEC 61000-4-3 with a signal of 10 V, 80…1000 MHz, 80 % AM. During the test, the input was 50 %. Transient shifts of the output signal at the various frequencies were determined.

Aggravated tests

The aggravated tests are not applicable for head mounted instruments without enclosure.

25 Ambient humidity, cyclic

If this test is carried out, the standard Ambient humidity test, test 13, will be skipped.
The test was carried out according to IEC 60068-2-30: Cyclic damp heat test. The temperature limits were 25 °C and 55 °C. Six cycles of Variant 2 were carried out. The time for the temperature rise was 3 h. The time for the temperature drop was 5 h. During the test, the input was 50 %.

26 Vibration / Endurance

If this test is carried out, the standard Vibration test, test 14, will be skipped.
Vibration: The instrument was vibrated as described at the standard vibration test (see above) except for the amplitude and acceleration. They were 3,1 mm in the range 5…15 Hz and 3 g in the range 15…500 Hz, respectively.
Endurance: The instrument was subjected to endurance testing for 30 minutes in each of the three directions at the lowest main resonance frequency for that direction.

27 Enclosure / Ingress of water

The instrument was subjected to the IP x6 test of IEC 60529. The instrument was inspected for ingress of water.

28 Salt spray

The test was carried out according to IEC 60068-2-52. Severity: three spraying periods, each of 2 h at 35 °C, with a storage between 20 h and 22 h after each at 40 °C, 93 % relative humidity. After the test, the instrument was inspected for deterioration of protective coatings.

6.1.3 Test protocol

The characteristics values, A to H, in the schedule in chapter 6.1.2, were calculated from the measurements.

A. I/O characteristic

From the measured values and output values the following was determined.

Average error	The arithmetic mean of errors at each point of measurement, for rising and falling inputs separately.
Hysteresis error	The maximum deviation between the two calibration curves of the measured variable as obtained by traversing upscale and downscale over the full range.
Repeatability error	The algebraic difference between the extreme values obtained by a number of consecutive output measurements for the same value of the input under the same operating conditions, approaching from the same direction traversing the full range.

B. Zero shift/span shift during and/or after the test

The shift of the lower range value (zero shift) was determined as well as the change of the algebraic difference between the lower range value and the upper range value (span shift).

C. Steady state shift

When applying a steady state input (either 10 %, 50 % or 90 % as mentioned under the relevant test) the output shift was determined.

D. Transient effects

The amplitude, polarity and duration of the transients on the output were determined as far as possible.

E. A.C. component (ripple) on output

The peak-to-peak and the principal frequency of any a.c. ripple content of the output were determined, both with modem plus associate equipment (PC) connected and disconnected.

F. Messages on the PC

Messages at associated equipment, if applicable, were noted.

G. Qualitative observation during the test
The operational behaviour of the instrument and the software programme was observed during the test. Any irregularities caused by the tests applied were noted.

H. Qualitative observation after the test
After the test, the instrument was inspected for mechanical damage, damage to the electronics, accumulation of moisture of dust etc.

6.2 References
Standards

IEC 61298-3	Process measurement and control devices - General methods and procedures for evaluating performance - Part 3: Tests for the effects of influence quantities (IEC 770)
IEC 60068	Basic environmental testing procedures.
IEC 60068-2-1	Test A: Cold
IEC 60068-2-2	Test B: Dry heat
IEC 60068-2-6	Test Fc: Vibration
IEC 60068-2-30	Test Db: Damp heat, cyclic (12 + 12 hour cycle)
IEC 60068-2-52	Test Kb: Salt mist, cyclic
IEC 751	Industrial platinum resistance thermometer sensors + A2:1995. (ITS-90)
IEC 584-1	Thermocouples, part 1: Reference tables. (ITS-90)
IEC 61326	Annex A: Immunity test requirements for equipment intended for use in industrial locations
IEC 60902	Industrial-process measurement and control : Terms and definitions

WIB Reports

May 2003	WIB Test Programme for Temperature Transmitters
M 2563 T 92	Test Specifications for I/O circuits of process control systems
M 2654 T 97	Guideline for EMC-Immunity Testing of Instruments and Systems for Industrial Process Measurement and Control

Other reports

E+H 03960950	EMC Test report no. 03960950, prepared by the manufacturer, 30 November 2004
Senton	EMC Test report no. 50515-20709, prepared by Senton EMI/EMC Test centre, 28 November 2002

Manufacturer's documentation

TI086R/09/en	Technical information for iTEMP® HART® TMT162
BA132R/09/a3/09.04	Operating Manula for iTEMP® HART® TMT162

6.3 Definitions
Reference operating conditions (IEC 60902)
The operating conditions within which the influence on the device by the changes in environmental conditions are disregarded.

Error (IEC 60902)
The algebraic difference between the measured value and the true value of the measured variable.
Note: The error is positive when the measured value is greater than the true value.

Average error
The arithmetic mean of the errors at each point of measurement, for rising and falling inputs separately.

Linearity, Terminal-based (IEC60902)
The closeness with which the calibration curve of a device can be adjusted to approximate to the specified straight line so that the upper and lower range values of both input and output curves coincide.

Hysteresis error (IEC 60902)
The maximum deviation between the two calibration curves of the measured variable as obtained by an upscale going traverse and a downscale going traverse over the full range and subtracting the value of the dead band.

Repeatability (IEC draft standard, reference 1, IEV 301, 302, 303, Sec. 1386)
The ability of a measuring instrument to provide closely similar indications for repeated applications of the same measurand under the same conditions of measurement. (In this report Repeatability is expressed as one standard deviation of the errors from the average error at each point of measurement, for rising and falling inputs separately. The standard deviation is calculated using the "nonbiased" or "n-1" method.

Resolution (IEC 60902)
The least interval between two adjacent discrete details that can be distinguished one from the other. Note: In the case of an instrument with digital output, the term "resolution" is often understood as the smallest change in the output (display).

Dead band (IEC 60902)
Finite range of values within which variation of the input variable does not produce any noticeable change in the output variable.
Note: For a device with digital output representation, the dead band is the smallest change in the analogue of the input signal which always causes a change in the digital output.

Shift (derived from IEC 60902)
The change in output value caused by a specified influence.

Zero shift (IEC 60902)
The change of the output value, due to some influences, when the input variable is at the lower range value.

Span shift (IEC 60902)
The change in output span due to some influences.

Drift (IEC 60902)
An undesired gradual change in the input-output relationship of a device over a period of time, not caused by external influences on the device.

Range (IEC 60902)
The region of the values between the lower and upper limits of the quantity under consideration.

Span (IEC 60902)
The algebraic difference between the upper and lower limit values of a given range.

Settling time (IEC 60902)
Time interval between the step change of an input signal and the instant when the resulting variation of the output signal does not deviate more than a specified tolerance, for instance 5 %, from its final steady-state value. (A tolerance of 1 % of output span is used in this report.)

Uncertainty of measurement (BS 5233)
An estimate characterising the range of values within which the true value of a measurand lies. (The uncertainties quoted are for a confidence probability of not less than 95 %.)
Note:
The wording in brackets is not part of the standard. The terms underlined, such as repeatability, are used in the body of the report and are followed by the practical equivalent of the formal definition.

APPENDICES

I Manufacturer's QA procedures and instrument status

II Manufacturer's documentation
Technical Information iTEMP® HART® TMT162, code: TI086R/09/en

Appendix I

MANUFACTURER'S QUALITY ASSURANCE AND INSTRUMENT STATUS

Appendix for EI -WIB-EXERA (EWE) Evaluation Reports

An evaluation report describes an objective evaluation of the product in question, carried out by an independent laboratory. The report is not intended to be a detailed description of the product or the manufacturer's facilities. It is augmented by the inclusion of the manufacturer's product literature and statements of his Quality Assurance (QA) scheme and of the product availability in an Appendix.

Please provide the following information in a form suitable for inclusion verbatim in the Appendix to the SIREP-WIB-EXERA Evaluation Report.

1 Quality Assurance

If your QA System is formally accredited under a nationally established approval scheme (e.g. ISO 9000 series, EN 29000 series, BS 5750 series), it is sufficient just to state the details and scope of the accreditation. Then continue to Section 2 below.

If no such accreditation exists, then please provide a brief indication of the quality control procedures using the headings of Sections 1.1 to 1.8 as a guide. The statements should be limited to half an A4 page of typescript in total.

1.1 Has your company adopted a structured QA policy and, if so, when was this fully implemented?

1.2 On which international/national standard is your QA system based? Is it registered under any particular scheme? If so, please state which scheme.

1.3 Does your QA scheme cover all aspects of design, manufacture and installation?

1.4 If your company is part of a corporate organisation, is your QA system subject to, and controlled by, a corporate QA policy?

1.5 Does your QA system cover all activities and products in your manufacturing facility? If not, please specify where it does apply.

1.6 How many times, and by whom, has your location or company been audited by an external organisation during the last three years?

1.7 Who required the audit(s) to be carried out?

1.8 Are (corporate) products apparatus, if manufactured elsewhere organisation, also subject to an identical QA system?

Reply: See copy of the ISO-9001 certificate attached to this questionnaire.

2 Information on the product evaluated by EI -WIB-EXERA

This information is required to show if the product is likely to be commercially available for some reasonable time into the future, and to give an indication of the likely reliability in service. The statements provided should be limited to an A4 page of typescript in total, using the headings of Section 2.1 to 2.4 as a guide.

2.1 Is the product evaluated being produced elsewhere in your organisation? If so, state where. Are all/any parts of the product fully interchangeable, regardless of origin?

Reply: The product is produced at: Endress+Hauser Wetzer GmbH + Co KG, DE-87484 Nesselwang (Germany)

2.2 What is the expected product lifetime?

Reply: There can be assumed that Endress+Hauser is producing at least a compatible device as long as there are requests from customers. Since more than 50 years Endress+Hauser is a reliable partner in process automation and this will be also valid in the future.

2.3 What is the warrantee period for the hardware and software (if applicable) of the product being evaluated?

Reply: Warranty normally is 12 months, but there can be different procedures dependent of the different sales organisations in different countries worldwide and contracts with key customers of Endress+Hauser.

2.4 For how long after manufacture of the product ceases, will you provide service/maintenance facilities and spare parts?

Reply: Endress+Hauser guarantees at least 10 years support for the product.

2.5 Are installation/maintenance manuals available in both English and French? Please state their availability in any other language.

Reply: Manuals are available in English, French and German.

The Swiss Association
for Quality and Management Systems

SQS herewith certifies that the company named below has a management system
which meets the requirements of the normative bases specified below
and issues the company

Endress+Hauser Wetzer GmbH + Co KG

DE-87484 Nesselwang

Certified area

Location Nesselwang

Field of activity

Measurement and automation technology

on the basis of the audit result the

SQS Certificate ISO 9001:2000

CH-3052 Zollikofen, December 11, 2004
This SQS Certificate is valid up to and including December 10, 2007
Scope number 19
Registration number 10633

President SQS	Managing Director SQS
X. Edelmann	T. Zahner

SCES 002, 023

IQNet

Appendix-II Manufacturers specification documentation.

Level Pressure Flow Temperature Liquid Analysis Registration Systems Components Services Solutions

Technical Information

iTEMP® HART® TMT 162

Temperature Field Transmitter
Universal temperature transmitter, dual sensor input for resistance thermometers, thermocouples, resistance transmitters and voltage transmitters, adjustable via HART® protocol

HART® FIELD COMMUNICATIONS PROTOCOL

Application

- Temperature field transmitter with HART® protocol for converting various input signals to an analogue, scalable 4 to 20 mA output signal
- Input:
  Resistance thermometer (RTD)
  Thermocouples (TC)
  Resistance transmitter (Ω)
  Voltage transmitter (mV)
- HART® protocol for operating the device on site using handheld terminal (DXR 275/375) or remotely via the PC

Your benefits

- Universally programmable with HART® protocol for various input signals
- Illuminated display, rotatable
- Operation, visualisation and maintenance with PC, e.g. using COMMUWIN II, FieldCare or ReadWin® 2000 operating software
- Two-wire technology, analogue output 4 to 20 mA
- Highly accurate in entire operating temperature range
- Low voltage detection
- Sensor monitoring:
  Breakdown information, sensor backup, drift alarm, corrosion detection to NAMUR NE 89
- Breakdown information in event of sensor break or sensor short-circuit, adjustable to NAMUR NE 43
- EMC to NAMUR NE 21, CE
- Approvals:
  ATEX (EEx ia, EEx d and dust-Ex),
  FM and CSA (IS, NI, XP and DIP)
- SIL2 compliant
- Ship building approval GL
- Galvanic isolation
- Output simulation
- Min./max. process value recorded
- Customised measuring range setup or expanded SETUP, see questionnaire, page 9
- Optional: two input channels, e.g. for 2 x Pt100, 3-wire connection; stainless steel housing

TI086R/09/en
No. 510 04334

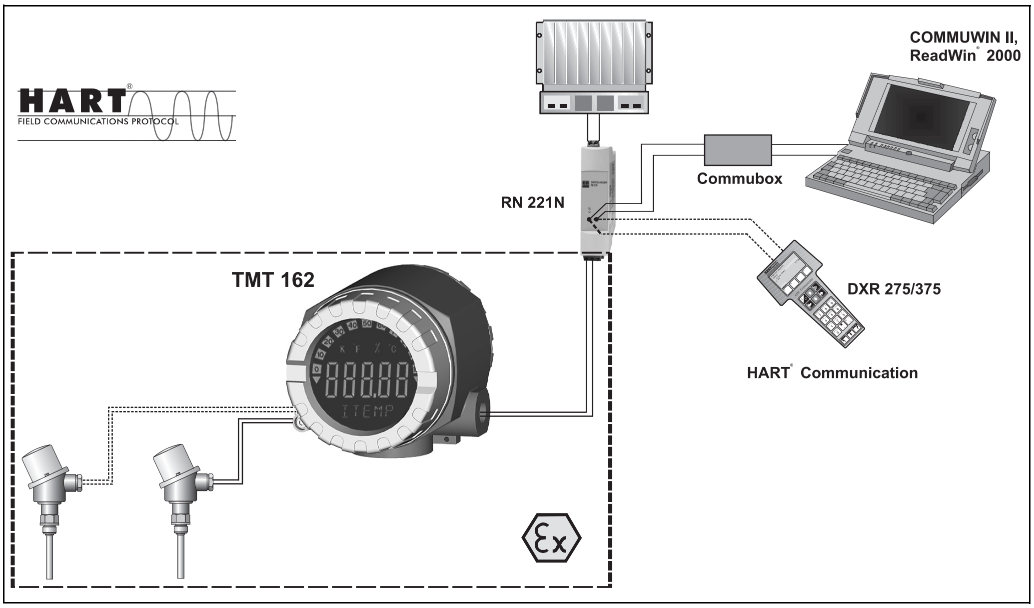
Endress+Hauser
People for Process Automation

Function and system design

Measuring principle

Electronic monitoring, conversion and display of input signals in industrial temperature measurement.

Measuring system



Example of an application of the field transmitter

The iTEMP® HART® temperature field transmitter TMT 162 is a two-wire transmitter with analog output, two (optional) measuring inputs for resistance thermometers and resistance transmitters in 2-wire, 3-wire or 4-wire connection, thermocouples and voltage transmitters. The LC display shows the current measured value digitally and as a bar graph with an indicator for limit value violation. The TMT 162 can be operated via the HART® protocol using a handheld terminal (DXR 275/375) or PC (COMMUWIN II or ReadWin® 2000 operating software).

Corrosion detection
Corrosion of the sensor connections can lead to corruption of the measured value. Our field transmitter therefore offers the option of detecting corrosion on thermocouples and resistance thermometers with a 4-wire connection before measured value corruption occurs.

Sensor backup
Sensor backup offers you maximum safety. If sensor 1 fails, the device automatically switches to sensor 2.

Input

Measured variable

Temperature (temperature linear transmission behaviour), resistance and voltage

Measuring range

The transmitter records different measuring ranges depending on the sensor connection and input signals.

Input	Designation	Measuring range limits	Min. span
Resistance thermometer (RTD) to IEC 751 (α = 0,00385)	Pt100 Pt200 Pt500 Pt1000	-200 to850 °C (-328 to 1562 °F) -200 to 850 °C (-328 to 1562 °F) -200 to 250 °C (-328 to 482 °F) -200 to 250 °C (-238 to 482 °F)	10 K 10 K 10 K 10 K
to JIS C1604-81 (α = 0,003916)	Pt100	-200 to 649 °C (-328 to 1200 °F)	10 K
to DIN 43760 (α = 0,006180)	Ni100 Ni1000	-60 to 250 °C (-76 to 482 °F) -60 to 150 °C (-76 to 302 °F)	10 K 10 K
to Edison Copper Winding No.15 (α = 0,004274)	Cu10	-100 to 260 °C (-148 to 500 °F)	10 K
to SAMA (α = 0,003923)	Pt100	-100 to 700 °C (-148 to 1292 °F)	10 K
to Edison Curve (α = 0,006720)	Ni120	-70 to 270 °C (-94 to 518 °F)	10 K
to GOST (α = 0,003911)	Pt50 Pt100	-200 to 1100 °C (-328 to 2012 °F) -200 to 850 °C (-328 to 1562 °F)	10 K 10 K
to GOST (α = 0,004278)	Cu50, Cu100	-200 to 200 °C (-328 to 392 °F)	10 K
	Polynom RTD Pt100 (Callendar - van Dusen)	-200 to 850 °C (-328 to 1562 °F) -200 to 850 °C (-328 to 1562 °F)	10 K 10 K
	■ Type of connection: 2-wire, 3-wire or 4-wire connection ■ With 2-wire circuit, compensation of wire resistance possible (0 to 30 Ω) ■ With 3-wire and 4-wire connection, sensor wire resistance to max. 50 Ω per wire ■ Sensor current: ≤ 0.3 mA		
Resistance transmitter	Resistance Ω	10 to 400 Ω 10 to 2000 Ω	10 Ω 100 Ω
Thermocouples (TC) to IEC 584 part 1	B (PtRh30-PtRh6)[1] E (NiCr-CuNi) J (Fe-CuNi) K (NiCr-Ni) N (NiCrSi-NiSi) R (PtRh13-Pt) S (PtRh10-Pt) T (Cu-CuNi)	0 to +1820 °C (32 to 3308 °F) -270 to +1000 °C (-454 to 1832 °F) -210 to +1200 °C (-346 to 2192 °F) -270 to +1372 °C (-454 to 2501 °F) -270 to +1300 °C (-454 to 2372 °F) -50 to +1768 °C (-58 to 3214 °F) -50 to +1768 °C (-58 to 3214 °F) -270 to +400 °C (-454 to 752 °F)	500 K 50 K 50 K 50 K 50 K 500 K 500 K 50 K
to ASTM E988	C (W5Re-W26Re) D (W3Re-W25Re)	0 to +2320 °C (32 to 4208 °F) 0 to +2495 °C (32 to 4523 °F)	500 K 500 K
to DIN 43710	L (Fe-CuNi) U (Cu-CuNi)	-200 to +900 °C (-328 to 1652 °F) -200 to +600 °C (-328 to 1112 °F)	50 K 50 K
	■ Internal cold junction (Pt100) ■ Accuracy of cold junction: ± 1 K ■ Max. sensor resistance 10 kΩ (if sensor resistance is greater than 10 kΩ, error message as per NAMUR NE 89)		
Voltage transmitter (mV)	Millivolt transmitter (mV)	-20 to 100 mV	5 mV

1) High measuring error increase for temperature lower than 300 °C (572 °F)

Output

Output signal

Analogue 4 to 20 mA, 20 to 4 mA

Signal on alarm

- Underranging
  Linear drop to 3.8 mA
- Overranging:
  Linear rise to 20.5 mA
- Sensor break; sensor short-circuit (not for thermocouples TC):
  ≤ 3.6 mA or ≥ 21.0 mA

Load

Max. ($V_{power\ supply}$ – 11 V) / 0.022 A (current output)

Linearisation/transmission behaviour

Temperature linear, resistance linear, voltage linear

Filter

1st order digital filter: 0 to 60 s

Galvanic isolation

U = 2 kV AC (input/output)

Min. current consumption

≤ 3.5 mA

Current limit

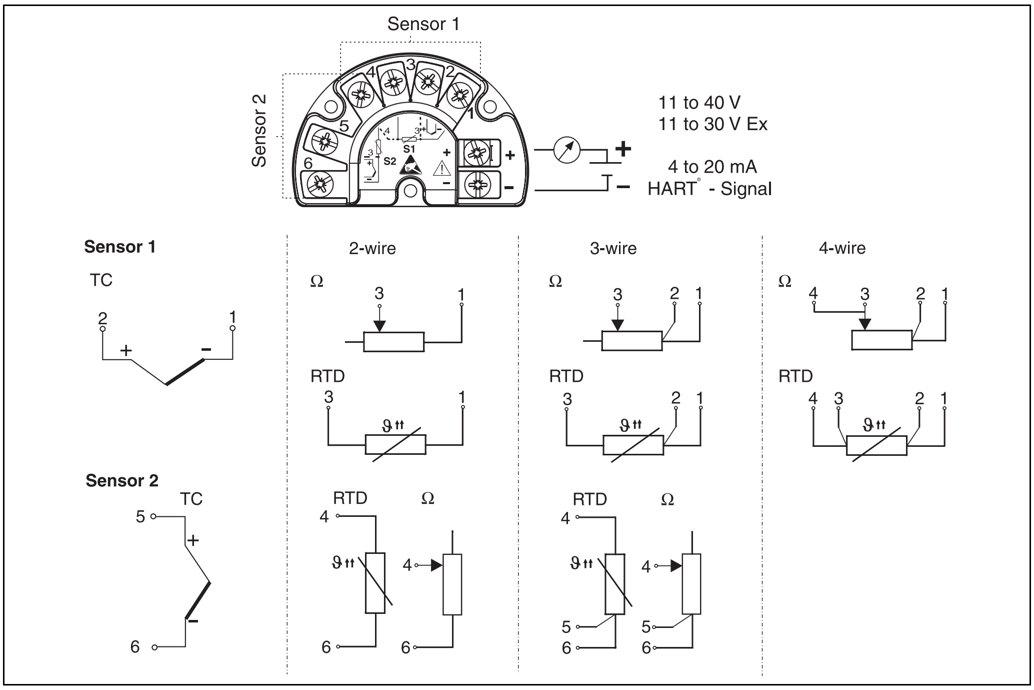
≤ 23 mA

Switch-on delay

4 s (during switch-on operation I_a ≤ 4 mA)

Power supply

Electrical connection



Supply voltage

U_b= 11 to 40 V (8 to 40 V without display), reverse polarity protection

Warning!
The TMT 162 must be powered by a 11 to 40 VDC power supply with a limited power according to NEC Class 02 (low voltage, low current) limited to 8 A and 150 VA in case of a short circuit.

Cable entry See 'Product structure'

Residual ripple Perm. residual ripple U_{ss} ≤ 3 V at U_b ≥ 13.5 V, $f_{max.}$ = 1 kHz

Performance characteristics

Response time 1 s per channel

Reference operating conditions Calibration temperature: +23 °C (73.4 °F) ± 5 K

Maximum measured error

	Designation	Accuracy	
		Digital	D/A[1]
Resistance thermometer (RTD)	Cu100, Pt100, Ni100, Ni120 Pt500 Cu50, Pt50, Pt1000, Ni1000 Cu10, Pt200	0,1 K 0,3 K 0,2 K 1 K	0,02% 0,02% 0,02% 0,02%
Thermocouples (TC)	K, J, T, E, L, U N, C, D S, B, R	typ. 0.25 K typ. 0.5 K typ. 1.0 K	0.02% 0.02% 0.02%

1) % relates to the set span. Accuracy = digital + D/A accuracy

	Measuring range	Accuracy	
		Digital	D/A[1]
Resistance transmitter (Ω)	10 to 400 Ω 10 to 2000 Ω	± 0.04 Ω ± 0.8 Ω	0.02% 0.02%
Voltage transmitter (mV)	-20 to 100 mV	± 10 µV	0.02%

1) % relates to the set span. Accuracy = digital + D/A accuracy

Physical input range of the sensors	
10 to 400 Ω	Cu10, Cu50, Cu100, Polynom RTD, Pt50, Pt100, Ni100, Ni120
10 to 2000 Ω	Pt200, Pt500, Pt1000, Ni1000
-20 to 100 mV	Thermocouple type: C, D, E, J, K, L, N
-5 to 30 mV	Thermocouple type: B, R, S, T, U

Repeatability 0.0015% of the physical input range (16 Bit)
Resolution A/D conversion: 18 Bit

Influence of supply voltage ≤ ±0.005%/V deviation from 24 V, related to the full scale value

Long-term stability ≤ 0.1 K/year or ≤ 0.05%/year
Data under reference conditions. % relates to the set span. The larger value applies.

Influence of ambient temperature (temperature drift)

Total temperature drift = input temperature drift + output temperature drift

Effect on the accuracy when ambient temperature changes by 1 K:	
Input 10 to 400 Ω	0.001% of measured value
Input 10 to 2000 Ω	0.001% of measured value
Input -20 to 100 mV	typ. 0.001% of measured value (maximum value = 1.5 x typ.)
Input -5 to 30 mV	typ. 0.001% of measured value (maximum value = 1.5 x typ.)
Output 4 to 20 mA	typ. 0.001% of span (maximum value = 1.5 x typ.)

Typical sensor resistance change when process temperature changes by 1 K:				
Cu10: 0.04 Ω	Pt200: 0.8 Ω	Ni120: 0.7 Ω	Cu50: 0.2 Ω	Pt50: 0.2 Ω
Cu100, Pt100: 0.4 Ω	Pt500: 2 Ω	Pt1000: 4 Ω	Ni100: 0.6 Ω	Ni1000: 6 Ω

Typical change in thermoelectric voltage when process temperature changes by 1 K:					
B: 10 µV	C: 20 µV	D: 20 µV	E: 75 µV	J: 55 µV	K: 40 µV
L: 55 µV	N: 35 µV	R: 12 µV	S: 12 µV	T: 50 µV	U: 60 µV

Examples for calculation of accuracy:

- **Example 1:** input temperature drift $\Delta\vartheta$ = 10 K, Pt100, span 0 to 100 °C (32 to 212 °F)
  Maximum process value: 100 °C (212 °F)
  Measured resistance value: 138.5 Ω (s. IEC751)
  Typ. influence in Ω: (0.001% of 138.5 Ω) * 10 = 0.01385 Ω
  Conversion Ω to K: 0.01385 Ω / 0.4 Ω/K = 0.03 K

- **Example 2:** input temperature drift $\Delta\vartheta$ = 10 K, thermocouple type K with span 0 to 600 °C (32 to 1112 °F)
  Maximum process value: 600 °C (1112 °F)
  Measured thermoelectric voltage: 24905 µV (s. IEC584)
  Typ. influence in µV: (0.001% of 24905 µV) * 10 = 2.5 µV
  Conversion Ω to K: 2.5 µV / 40 µV/K = 0.06 K

- **Example 3:** output temperature drift $\Delta\vartheta$= 10 K, measuring range 0 to 100 °C (32 to 212 °F)
  Span: 100 K
  Typical influence: (0.001% of 100 K) * 10 = 0.01 K

- **Example 4:** max. possible measured error $\Delta\vartheta$ = 10 K (18 °F), Pt100, measuring range 0 to 100 °C (32 to 212 °F)
  Measured error Pt100: 0.1 K
  Output measured error: 0.02 K (0.02% of 100 K)
  Input temperature drift: 0.03 K
  Output temperature drift: 0.01 K * 1.5 = 0.015 K
  Max. possible error (total of errors): 0.165 K

$\Delta\vartheta$ = deviation of ambient temperature from the reference operating condition.

Total measuring point error = max. possible measured error + temperature sensor error.

Influence of cold junction

Pt100 DIN IEC 751 Cl. B (internal cold junction with thermocouples TC)

Installation conditions

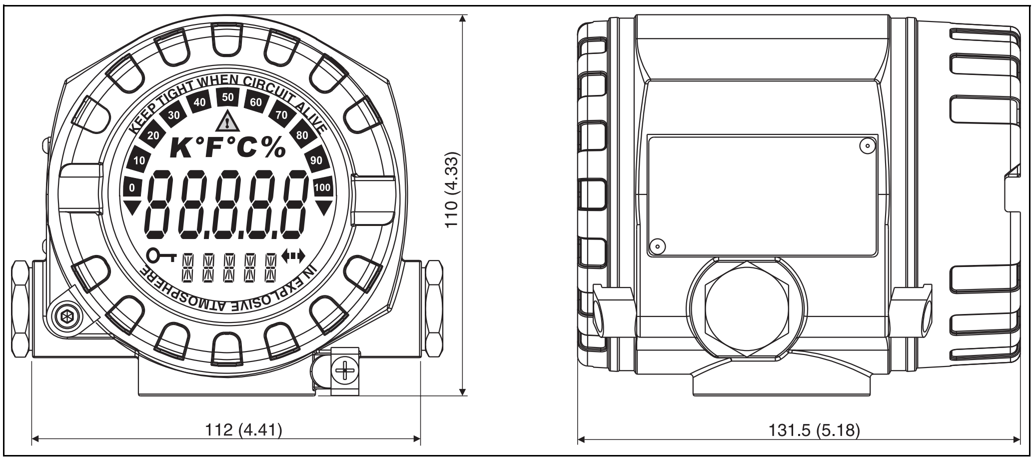
Installation instructions	**Mounting location** Direct mounting on the temperature sensor or indirect mounting using mounting bracket (see 'accessories').

Environment conditions

Ambient temperature limits	▪ Without display: -40 to +85 °C (-40 to 185 °F) ▪ With display: -40 to +70 °C (-40 to 158 °F) For use in Ex area, see Ex certificate Note! At temperatures < -20 °C (-4 °F) the display may react slowly.
Storage temperature	▪ Without display: -40 to +100 °C (-40 to 212 °F) ▪ With display: -40 to +85 °C (-40 to 185 °F)
Altitude	up to 2000 m above sea level
Climate class	As per IEC 60654-1, Class C
Degree of protection	IP 67, NEMA 4x
Shock and vibration resistance	3g / 2 to 150 Hz as per IEC 60 068-2-6
Electromagnetic compatibility (EMC)	Interference immunity and interference emission as per EN 61 326-1 (IEC 1326) and NAMUR NE 21. 0.08 to 2 GHz, 10 V/m; 1.4 to 2 GHz, 30 V/m according to IEC 61000-4-3
Condensation	Permitted
Installation category	I
Pollution degree	2

Mechanical construction

Design, dimensions



Data in mm (inch)

- Separate electronics compartment and connection compartment
- Display rotatable in 90° stages

Weight

- Approx. 1.4 kg (aluminium housing)
- Approx. 4.2 kg (stainless steel housing)

Material

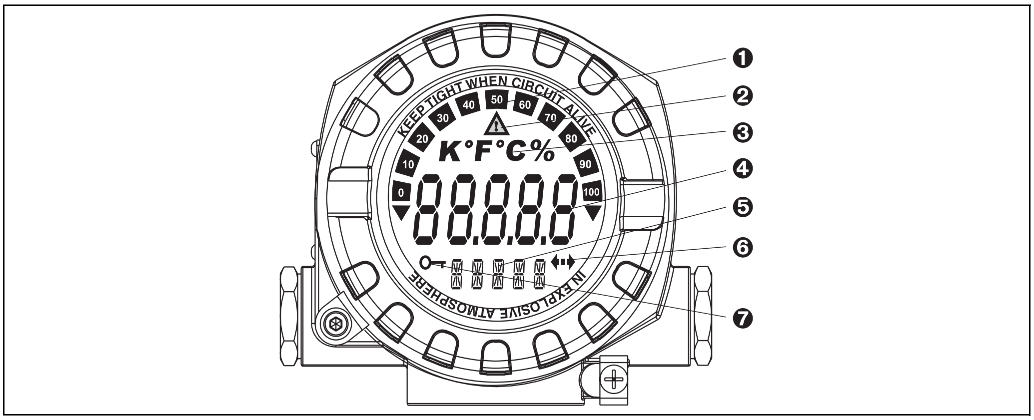
- Housing: die-cast aluminium housing AlSi10Mg with powder coating on polyester basis or stainless steel 1.4435 (AISI 316L)
- Nameplate: 1.4301 (AISI 304)

Terminals

Leads to max. 2.5 mm^2 (0.0039 in^2) plus ferrule.

Human interface

Display elements



LC display of the field transmitter (illuminated, rotable in 90° stages)

Item 1: Bar graph display in 10 % stages with indicators for overranging/underranging
Item 2: 'Caution' display
Item 3: Unit display K, °F, °C or %
Item 4: Measured value display - height of digits 20.5 mm (0.807 in)
Item 5: Status and information display
Item 6: 'Communication' display
Item 7: 'Programming disabled' display

Operating elements	No operating elements are present directly on the display. The device parameters of the field transmitter are configured using the DXR 275/375 handheld terminal or a PC with Commubox FXA 191 and operating software (e.g. COMMUWIN II, FieldCare or ReadWin® 2000)
Remote operation	**Configuration** See 'Operating elements' **Interface** HART® communication via transmitter power supply (e.g. RN 221N; see 'measuring system'). **Configurable device parameters (selection)** Sensor type and type of connection, measuring dimension (C/F), measuring ranges, internal/external cold junction, compensation of wire resistance with 2-wire connection, failure mode, output signal (4 to 20/20 to 4 mA), digital filter (damping), offset, TAG+descriptor (8+16 characters), output simulation, customised linearisation, recording of min./max. process value, analogue output: channel 1 (C1), difference measurement, averaging between C1 and C2, sensor backup Option: customised linearisation, mathematics function

Certificates and approvals

CE-Mark	The device meets the legal requirements of the EC diectives. Endress+Hauser confirms that the device has been successfully tested by applying the CE mark.
Hazardous area approvals	For further details on the available Ex versions (ATEX, CSA, FM, etc.), please contact your nearest E+H sales organisation. All relevant data for hazardous areas can be found in separate Ex documentation. If required, please request copies from us or your E+H sales organisation.
Other standards and guidelines	▪ IEC 60529: Degree of protection provided by housing (IP-Code) ▪ IEC 61010: Safety requirements for electrical measurement, control and laboratory use. ▪ IEC 1326: Electromagnetic compatibility (EMC requirements) ▪ NAMUR Standards working group for measurement and control technology in the chemical industry. (www.namur.de)
Functional safety according to IEC 61508/ IEC 61511	FMEDA including SFF determination and PFD_{AVG} calculation according to IEC 61508. See also Functional Safety manual in chapter 'Further documentation'.

Ordering information

Questionnaire

Questionnaire Endress+Hauser iTEMP temperature transmitter
Customer specific setup / Kundenspezifische Einstellung

Standard setup / Standardeinstellung

Sensor 1 (S1)	Sensor 2 (S2)
TC ( ) B ( ) C ( ) D ( ) E ( ) J ( ) K ( ) L ( ) N ( ) R ( ) S ( ) T ( ) U	TC ( ) B ( ) C ( ) D ( ) E ( ) J ( ) K ( ) L ( ) N ( ) R ( ) S ( ) T ( ) U
RTD **( ) Pt100** ( ) Pt500 ( ) Pt1000 ( ) Ni100 ( ) Ni500 ( ) Ni1000	RTD **( ) Pt100** ( ) Pt500 ( ) Pt1000 ( ) Ni100 ( ) Ni500 ( ) Ni1000
( ) mV ( ) 10...400 Ohm ( ) 10...2000 Ohm	( ) mV ( ) 10...400 Ohm ( ) 10...2000 Ohm
( ) 2 wire **( ) 3 wire** ( ) 4 wire	( ) 2 wire **( ) 3 wire**

Unit / Einheit **( ) °C** ( ) °F ( ) K ( ) °R ( ) mV ( ) Ohm

Range / Messbereich (not / nicht PROFIBUS-PA)
- Low scale / Anfang: [ ][ ][ ][ ][ ] , [ ]
- High scale / Ende: [ ][ ][ ][ ][ ] , [ ]

Bitte beachten!: Messbereich und min. Spanne (s. Techn. Daten)

Note!: Range and min. span (s. Techn. data)

Bus address / Busadresse (only / nur PROFIBUS-PA) [ ][ ][ ] **[0...126]**

Expanded setup / Erweiterte Einstellung

Reference junction / Vergleichsstelle	**( ) intern**	( ) extern [ ][ ][ ]	[0...80°C; 32...176°F]	(only / nur TC)
Compensation wire resistance / Kompensation Leitungswiderstand	S1 [ ][ ]	S2 [ ][ ]	[**0**...30 Ohm]	(only / nur RTD 2 wire)
Failure mode / Fehlerverhalten	( ) ≤ 3,6 mA	**( ) ≥ 21,0 mA**		(not / nicht PROFIBUS-PA)
Output / Ausgang	**( ) 4...20 mA**	( ) 20...4 mA		(not / nicht PROFIBUS-PA)
Filter		[ ][ ]		[**0**, 1, 2,..., 60s]
Offset	S1 [ ][ ] , [ ]	S2 [ ][ ] , [ ]		[-10... **0**...+10 K/-18...0...+18 °F]
Line voltage filter/Netzspannungsfilter	**( ) 50 Hz**	( ) 60 Hz		

TAG
- PCP / HART: [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]
- (HART: 8 char. TAG + 16 char. Descriptor , PROFIBUS-PA: 32 char.)
- PROFIBUS-PA: [ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ][ ]

Endress+Hauser
People for Process Automation

When ordering a unit with 2 input channels and 2 sensors with the same configuration, select the standard setting via the product structure and the extended setting from the questionnaire.

When ordering a unit with 2 input channels and 2 sensors with a different configuration, select "Configuration temperature sensor: Y" via the product structure and the standard and extended setting from the questionnaire.

Product structure

TMT 162	iTEMP® HART® Field transmitter TMT 162

Certification

A	Version for non hazardous areas	
B	ATEX	II1G EEx ia IIC T4/T5/T6
C	FM	IS, NI I/1+2/A-D
D	CSA	IS, NI I/1+2/A-D
E	ATEX	II2G EEx d IIC T6
F	FM	XP, DIP I,II,III/1+2/A-G
G	CSA	XP, DIP I,II,III/1+2/A-G
H	ATEX	EEx d, EEx ia
J	FM	XP, DIP, IS, NI I,II,III/1+2/A-G
K	CSA	XP, DIP, IS, NI I,II,III/1+2/A-G
L	ATEX	II3G EEx nA IIC T4/T5/T6
M	FM + CSA	XP, DIP, IS, NI, I,II,III/1+2/A-G
N	ATEX	II1/2D

Housing, display

1	Aluminium housing
2	Aluminium housing including display
3	Housing stainless steel 316
4	Housing stainless steel 316 incl. displ.

Cable entry

1	2 x NPT ½“ cable entries
2	2 x M20x1.5 cable entries
4	2 x JIS G½“ cable entries
5	M20x1.5 / M24x1.5 cable entries
6	2 x M20x1.5 cable glands

Additional equipment

1	Without accessories
2	Mounting bracket SS 316L wall/tube 2“
3	Mounting bracket SS 316L tube 2“

Configuration transmitter connection

A	Standard factory configuration 3-wire
3	Configuration connection RTD 3-wire
4	Configuration connection RTD 4-wire
2	Configuration connection RTD 2-wire
1	Configuration connection TC

Configuration temperature sensor

A	Standard factory configuration Pt100
1	Config. Pt100 (-200 to 850 °C, -328 to 1562 °F, min. sp. 10 K) accord. to IEC 751 (a = 0,00385)
9	Config. Pt100 (-200 to 649°C, -328 to 1200 °F, min. sp. 10 K) accord. to JIS C1604-81 (a = 0,003916)
2	Config. Ni100 (-60 to 250 °C, -76 to 482 °F, min. sp. 10 K)
3	Config. Pt500 (-200 to 250 °C, -328 to 482 °F, min. sp. 10 K)
5	Config. Pt1000 (-200 to 250 °C, -328 to 482 °F, min. sp. 10 K)
6	Config. Ni1000 (-60 to 150 °C, -76 to 302 °F, min. sp. 10 K)
7	Config. resistance transm. (10 to 400 Ω, min. span 10 Ω)
8	Config. resistance transm. (10 to 2000 Ω, min. span 100 Ω)
B	Config. Type B (0 to 1820 °C, 32 to 3308 °F, min. sp. 500 K)
C	Config. Type C (0 to 2320 °C, 32 to 4208 °F, min. sp. 500 K)
D	Config. Type D (0 to 2495 °C, 32 to 4523 °F, min. sp. 500 K)
E	Config. Type E (-270 to 1000 °C, -454 to 1832 °F, min. sp. 50 K)
J	Config. Type J (-210 to 1200 °C, -346 to 2192 °F, min. sp. 50 K)
K	Config. Type K (-270 to 1372 °C, -454 to 2501 °F, min. sp. 50 K)
L	Config. Type L (-200 to 900 °C, -328 to 1652 °F, min. sp. 50 K)
N	Config. Type N (-270 to 1300 °C, -454 to 2372 °F, min. sp. 50 K)
R	Config. Type R (-50 to 1768 °C, -58 to 2314.4 °F, min. sp. 500 K)
S	Config. Type S (-50 to 1768 °C, -58 to 2314.4 °F, min. sp. 500 K)
T	Config. Type T (-270 to 400 °C, -454 to 752 °F, min. sp. 50 K)
U	Config. Type U (-200 to 600 °C, -328 to 1112 °F, min. sp. 50 K)
V	Config. voltage transmitter (-20 to 100 mV, min. span 5 mV)
Y	Other

TMT162-							⇐ order code (part 1)

							Configuration			
							A	Stand. fact. conf. Pt100/3-wire/0 to 100 °C (32 to 212 °F)		
							B	Customised measurement range		
							C	Customised expanded config. for TC, (see questionnaire)		
							D	Customised expanded config. for RTD, (see questionnaire)		
								Model		
								A	Standard model	
								B	Works calibration certificate	
									Version	
									A	Single sensor input
									B	config. output sensor 1, dual sensor input
									C	config. differential, dual sensor input
									D	config. average, dual sensor input
									E	config. sensor backup, dual sensor input
TMT162-										**⇐ order code (complete)**

Customised options

51003527	TAG print/configuration 8 char
51003546	Descriptor print/configuration 16 char

Accessories

Cable gland for connection of 2 sensors

- NPT ½" cable gland 2xD0.5 cable for 2 sensors
  Order number: 51004654
- M20x1.5 cable gland 2xD0.5 cable for 2 sensors
  Order number: 51004653
- M20x1.5 cable gland for 2 sensors (Y-Form)
  Order number: 51007474

Wall and pipe mounting bracket

- Mounting bracket stainless steel wall/tube 2"
  Order number: 51004823
- Mounting bracket stainless steel tube 2"
  Order number: 51006412

Documentation

❑ 'iTEMP® HART® TMT 162' Operating Instructions (BA 132R/09/a3)
❑ Functional safety manual (SD005R/09/en)
❑ Ex supplementary documentation:
ATEX II2(1)G: XA 020R/09/a3
ATEX II2G, EEx d: XA 031R/09/a3
ATEX II2D: XA 032R/09/a3
ATEX II1G: XA 033R/09/a3

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