Deutsche Akkreditierungsstelle GmbH

# Annex to the Accreditation Certificate D-K-17616-01-00 according to DIN EN ISO/IEC 17025:2005

Period of validity: 09.11.2017 to 08.11.2022 Date of issue: 04.12.2017

Holder of certificate:

**Thermo Electron LED GmbH**
**Robert-Bosch-Straße 1. 63505 Langenselbold**

| | |
|---|---|
| Head: | Harald Gutknecht |
| Deputy head: | Matthias Goschier |

Accredited as calibration laboratory since: 12.12.2003

Calibration in the fields:

**Thermodynamic quantities**
**Temperature quantities**
- **Climatic chambers (temperature) #)**
- **Resistance thermometers**
- **Direct reading thermometers**
- **Temperature transmitters, data loggers**
- **Temperature indicators and simulators**

**Chemical analysis, reference materials**
- **Volume of liquids**

**Electrical quantities**
**DC and low frequency quantities**
- **DC resistance**
- **DC current**
- **DC voltage**
- **AC current**
- **AC voltage**

**Time and frequency**
- **Frequency**

**#) also on-site calibration**

**Within the measurands/calibration items marked with *), the calibration laboratory is permitted, without being required to inform and obtain prior approval from DAkkS, to use calibration standards or equivalent calibration procedures listed here with different issue dates.**

**The calibration laboratory maintains a current list of all calibration standards / equivalent calibration procedures within the flexible scope of accreditation.**

## Permanent Laboratory

| Measurement quantity / Calibration item | Range | Measurement conditions / procedure | Best measurement capability [1)] | Remarks |
|---|---|---|---|---|
| Temperature<br>Heated, climatic and cooling chambers in empty or defined loaded useful volume [*)] | -90 °C to 0 °C | Measurement in air<br>DAkkS-DKD-R 5-7:2010<br>Calibration methods A and B | 0.8 K | Comparison with standard resistance thermometers<br>If loaded, type and arrangement of the load are to be precisely stated in the calibration certificate. |
| | > 0 °C to 100 °C | | 0.5 K | |
| | > 100 °C to 200 °C | | 0.8 K | |
| | > 200 °C to 350 °C | | 1.2 K | |
| Measuring locations in heated, climatic and cooling chambers in empty or defined loaded useful volume [*)] | -90 °C to 0 °C | Measurement in air<br>DAkkS-DKD-R 5-7:2010<br>Calibration method C | 0.5 K | |
| | > 0 °C to 100 °C | | 0.3 K | |
| | > 100 °C to 200 °C | | 0.5 K | |
| | > 200 °C to 350 °C | | 0.8 K | |
| Resistance thermometers; Indicating thermometers [a)], temperature sensors with transmitter [b)] and combined temperature-humidity sensors [*)] | 0 °C | Ice point of Water | 5 mK | |
| | -196 °C | Comparative measurement in liquid nitrogen ($LN_2$) | 0.06 K | With aluminum or brass compensation block |
| | -92 °C to -80 °C | DAkkS-DKD-R 5-1:2010<br>Comparative measurement in cryogenic chamber | 0.15 K | |
| | > -80 °C to -50 °C | | 0.25 K | |
| | -90 °C to -62 °C | DAkkS-DKD-R 5-1:2010<br>Comparative measurement in dry block calibrator | 0.15 K | |
| | > -62 °C to -2 °C | | 0.1 K | |
| | > -2 °C to 125 °C | | 0.05 K | |
| | > 125 °C to 200 °C | | 0.1 K | |
| | > 200 °C to 300 °C | | 0.15 K | |
| | > 300 °C to 400 °C | | 0.2 K | |
| | 10 °C to 70 °C | DAkkS-DKD-R 5-1:2010<br>Comparative measurement in climatic chamber<br>Measurement in air | 0.08 K | |
| | -30 °C to 200 °C | DAkkS-DKD-R 5-1:2010<br>Comparative measurement in stirred liquid bath<br>Measurement in glycol/water mix, water or oil | 0.08 K | |

[a)] semiconductor sensors as measurement chain or combined temperature-humidity sensors,

[b)] with direct indicator and/or signal transmitter as measuring chain (e.g. 4 mA to 20 mA)

[1)] The best measurement capabilities are stated according to EA-4/02. These are expanded uncertainties of measurement with a coverage probability of 95% and have a coverage factor of k = 2 unless stated otherwise. Uncertainties without unit are relative uncertainties referring to the measurement value unless stated otherwise.

| Measurement quantity / Calibration item | Range | Measurement conditions / procedure | Best measurement capability [1)] | Remarks |
|---|---|---|---|---|
| Indicating thermometers, measuring chains with thermocouple sensor*) | 0 °C | Ice point of water | 0.25 K | |
| | -196 °C | Comparative measurement in liquid nitrogen ($LN_2$) | 0.3 K | With aluminum or brass compensation block |
| | -92 °C to -80 °C | DAkkS-DKD-R 5-3:2010 Comparative measurement in cryogenic chamber | 0.35 K | |
| | > -80 °C to -50 °C | | 0.45 K | |
| | -90 °C to -62 °C | DAkkS-DKD-R 5-3:2010 Comparative measurement in block calibrator | 0.35 K | |
| | > -62 °C to -2 °C | | 0.3 K | |
| | > -2 °C to 125 °C | | 0.25 K | |
| | > 125 °C to 200 °C | | 0.3 K | |
| | 10 °C to 70 °C | DAkkS-DKD-R 5-3:2010 Comparative measurement in climatic chamber Measurement in air | 0.3 K | |
| | -30 °C to 200 °C | DAkkS-DKD-R 5-3:2010) Comparative measurement in stirred liquid bath Measurement in glycol/water mix, water or oil | 0.3 K | |
| Temperature indicators and simulators for resistance thermometers*) | -200 °C to 200 °C | DAkkS-DKD-R 5-5:2010 | 0.02 K | Characteristic curve according to DIN EN 60751:2009 |
| | > 200 °C to 650 °C | | 0.03 K | |
| | > 650 °C to 850 °C | | 35 mK | |
| Temperature indicators and simulators for noble metal thermocouples*) | 0 °C to 1760 °C | DAkkS-DKD-R 5-5:2010. without internal reference junction | 0.2 K | Characteristic curve according to DIN EN 60584:2014 Type S |
| | 0 °C to 1760 °C | DAkkS-DKD-R 5-5:2010 with internal reference junction | 0.3 K | |
| Temperature indicators and simulators for base metal thermocouples*) | -200 °C to 1300 °C | DAkkS-DKD-R 5-5:2010. without internal reference junction | 0.1 K | Characteristic curve according to DIN EN 60584:2014 Type K |
| | -200 °C to 1300 °C | DAkkS-DKD-R 5-5:2010 with internal reference junction | 0.3 K | |

[1)] The best measurement capabilities are stated according to EA-4/02. These are expanded uncertainties of measurement with a coverage probability of 95% and have a coverage factor of k = 2 unless stated otherwise. Uncertainties without unit are relative uncertainties referring to the measurement value unless stated otherwise.

| Measurement quantity / Calibration item | Range | Measurement conditions / procedure | Best measurement capability [1)] | Remarks |
|---|---|---|---|---|
| Volume of liquids<br>Piston-operated volumetric apparatus: piston pipettes [*)], dispensers[*)], positive displacement pipettes [*)] | 0.1 µL to < 10 µL | Gravimetric method<br>DKD-R 8-1:2011<br>together with<br>DIN EN ISO 8655-6:2002 | 0.75 % | The best measurement capability refers to the nominal volume.<br>To state these uncertainty values the reference temperature shall be set equal to the temperature of the test liquid |
| | 10 µL to < 100 µL | | 0.30 % | |
| | 100 µL to 10 mL | | 0.12 % | |
| Piston-operated volumetric apparatus (with variable volume): piston pipettes [*)], dispensers[*)], positive displacement pipettes [*)] | 0.1 µL to < 10 µL | Gravimetric method<br>DKD-R 8-1:2011<br>together with<br>DIN EN ISO 8655-6:2002 | 0.80 %; 0.60 %; 0.40 % | First uncertainty: upper test volume.<br>Second uncertainty: medium test volume.<br>Third uncertainty: lower test volume.<br>To state these uncertainty values the reference temperature shall be set equal to the temperature of the test liquid |
| | 10 µL to < 100 µL | | 0.30 %; 0.23 %; 0.15 % | |
| | 100 µL to 10 mL | | 0.15 %; 0.11 %; 0.075 % | |
| Multichannel piston pipettes [*)], Multichannel - dispensers [*)] | 0.1 µL to < 10 µL | Gravimetric method<br>DKD-R 8-1:2011<br>together with<br>DIN EN ISO 8655-6:2002 | 0.80 %; 0.60 %; 0.40 % | First uncertainty: upper test volume.<br>Second uncertainty: medium test volume.<br>Third uncertainty: lower test volume.<br>To state these uncertainty values the reference temperature shall be set equal to the temperature of the test liquid |
| | 10 µL to < 100 µL | | 0.35 %; 0.27 %; 0.18 % | |
| | 100 µL to 1.25 mL | | 0.18 %; 0.14 %; 0.09 % | |

[1)] The best measurement capabilities are stated according to EA-4/02. These are expanded uncertainties of measurement with a coverage probability of 95% and have a coverage factor of k = 2 unless stated otherwise. Uncertainties without unit are relative uncertainties referring to the measurement value unless stated otherwise.

| Measurement quantity / Calibration item | Range | Measurement conditions / procedure | Best measurement capability [1)] | Remarks |
|---|---|---|---|---|
| DC voltage | 0V | | 2µV | $U$ = set value |
| | 0.001 V to < 0.33 V | | $27 \cdot 10^{-6} \cdot U + 2$ µV | Fluke 5522A |
| | 0.33 V to < 3.3 V | | $15 \cdot 10^{-6} \cdot U + 3$ µV | |
| | 3.3 V to < 33 V | | $17 \cdot 10^{-6} \cdot U + 25$ µV | |
| | 33V to < 330 V | | $22 \cdot 10^{-6} \cdot U + 0.1$ mV | |
| | 330 V to < 1000 V | | $22 \cdot 10^{-6} \cdot U + 1.7$ mV | |
| | 0 V | | 2 µV | $U$ = measured value |
| | > 0 V to < 0.2 V | | $5 \cdot 10^{-6} \cdot U + 2$ µV | Fluke 8508A |
| | 0.2 V to < 2 V | | $5 \cdot 10^{-6} \cdot U + 1$ µV | |
| | 2 V To < 20 V | | $5 \cdot 10^{-6} \cdot U + 5$ µV | |
| | 20 V to < 200 V | | $7 \cdot 10^{-6} \cdot U + 50$ µV | |
| | 200 V to < 1000 V | | $7 \cdot 10^{-6} \cdot U + 0.6$ mV | |
| DC current | 0 A | | 2 µA | $I$ = set value |
| | 100 µA to < 330 µA | | $10 \cdot 10^{-6} \cdot I + 2$ µA | Fluke 5522A |
| | 330 µA to < 3.3 mA | | $30 \cdot 10^{-6} \cdot I + 2$ µA | |
| | 3.3 mA to < 33 mA | | $0.10 \cdot 10^{-3} \cdot I + 2$ µA | |
| | 33 mA to < 330 mA | | $0.12 \cdot 10^{-3} \cdot I + 5$ µA | |
| | 330 mA to < 1.1 A | | $0.25 \cdot 10^{-3} \cdot I + 50$ µA | |
| | 1.1 A To < 3 A | | $0.45 \cdot 10^{-3} \cdot I + 50$ µA | |
| | 3 A to < 11 A | | $0.6 \cdot 10^{-3} \cdot I + 0.6$ mA | |
| | 11 A to 20.5 A | | $1.2 \cdot 10^{-3} \cdot I + 1.7$ mA | |
| | 0 A | | 2 µA | $I$ = measured value |
| | 0.1m A to < 2 mA | | $1 \cdot 10^{-6} \cdot I + 2$ µA | Fluke 8508A |
| | 2 mA to < 20 mA | | $4 \cdot 10^{-6} \cdot I + 2$ µA | |
| | 20 mA to < 200 mA | | $45 \cdot 10^{-6} \cdot I + 2$ µA | |
| | 0.2A to < 2 A | | $0.21 \cdot 10^{-3} \cdot I + 20$ µA | |
| | 2A to < 20 A | | $0.47 \cdot 10^{-3} \cdot I + 0.47$ mA | |
| DC resistance | 0 Ω | | 0.5 mΩ | $R$ = set value |
| | 0.01 Ω to < 11 Ω | | $50 \cdot 10^{-6} \cdot R + 1.2$ mΩ | Fluke 5522A |
| | 11 Ω to < 110 Ω | | $35 \cdot 10^{-6} \cdot R + 1.7$ mΩ | |
| | 110 Ω to < 1.1 kΩ | | $35 \cdot 10^{-6} \cdot R + 2.5$ mΩ | |
| | 1.1 kΩ to < 11 kΩ | | $35 \cdot 10^{-6} \cdot R + 25$ mΩ | |
| | 11 kΩ to < 110 kΩ | | $35 \cdot 10^{-6} \cdot R + 0.25$ Ω | |
| | 110 kΩ to < 1.1 MΩ | | $40 \cdot 10^{-6} \cdot R + 2.5$ Ω | |
| | 1.1 MΩ to < 3.3 MΩ | | $70 \cdot 10^{-6} \cdot R + 35$ Ω | |
| | 3.3 MΩ to < 11 MΩ | | $0.16 \cdot 10^{-3} \cdot R + 60$ Ω | |
| | 11 MΩ to < 33 MΩ | | $0.3 \cdot 10^{-3} \cdot R + 3$ kΩ | |
| | 33 MΩ to < 110 MΩ | | $0.6 \cdot 10^{-3} \cdot R + 3.5$ kΩ | |
| | 110 MΩ to < 330 MΩ | | $3.5 \cdot 10^{-3} \cdot R + 0.15$ MΩ | |
| | 330 MΩ to < 1.1 GΩ | | $17 \cdot 10^{-3} \cdot R + 0.6$ MΩ | |

[1)] The best measurement capabilities are stated according to EA-4/02. These are expanded uncertainties of measurement with a coverage probability of 95% and have a coverage factor of k = 2 unless stated otherwise. Uncertainties without unit are relative uncertainties referring to the measurement value unless stated otherwise.

| Measurement quantity / Calibration item | Range | Measurement conditions / procedure | Best measurement capability [1] | Remarks |
|---|---|---|---|---|
| DC resistance | 0 Ω | | 0.5 mΩ | $R$ = measured value |
| | 0.1 mΩ to < 2 Ω | | $20 \cdot 10^{-6} \cdot R + 0.015$ mΩ | Fluke 8508A |
| | 2 Ω to < 20 Ω | | $15 \cdot 10^{-6} \cdot R + 0.02$ mΩ | |
| | 20 Ω to < 200 Ω | | $10 \cdot 10^{-6} \cdot R + 0.06$ mΩ | |
| | 200 Ω to < 2 kΩ | | $10 \cdot 10^{-6} \cdot R + 0.6$ mΩ | |
| | 2 kΩ to < 20 kΩ | | $10 \cdot 10^{-6} \cdot R + 6$ mΩ | |
| | 20 kΩ to < 200 kΩ | | $10 \cdot 10^{-6} \cdot R + 60$ mΩ | |
| | 200 kΩ to < 2 MΩ | | $12 \cdot 10^{-6} \cdot R + 1.2$ Ω | |
| | 2 MΩ to < 20 MΩ | | $25 \cdot 10^{-6} \cdot R + 0.12$ kΩ | |
| | 20 MΩ to < 200 MΩ | | $0.15 \cdot 10^{-3} \cdot R + 12$ kΩ | |
| | 200 MΩ to < 2 GΩ | | $1.7 \cdot 10^{-3} \cdot R + 1.2$ MΩ | |
| | 2 GΩ to < 20 GΩ | | $1.7 \cdot 10^{-3} \cdot R + 12$ MΩ | |
| AC voltage | 0.001 V to < 0.033 V | 10 Hz to 45 Hz | $0.95 \cdot 10^{-3} \cdot U + 8$ µV | $U$ = set value |
| | | > 45 Hz to 10 kHz | $0.20 \cdot 10^{-3} \cdot U + 8$ µV | Fluke 5522A |
| | | > 10 kHz to 20 kHz | $0.25 \cdot 10^{-3} \cdot U + 8$ µV | |
| | | > 20 kHz to 50 kHz | $1.2 \cdot 10^{-3} \cdot U + 8$ µV | |
| | | > 50 kHz to 100 kHz | $4.2 \cdot 10^{-3} \cdot U + 15$ µV | |
| | | > 100 kHz to 500 kHz | $9.5 \cdot 10^{-3} \cdot U + 65$ µV | |
| | 0.033 V to < 0.33 V | 10 Hz to 45 Hz | $0.40 \cdot 10^{-3} \cdot U + 10$ µV | |
| | | > 45 Hz to 10 kHz | $0.17 \cdot 10^{-3} \cdot U + 10$ µV | |
| | | > 10 kHz to 20 kHz | $0.20 \cdot 10^{-3} \cdot U + 10$ µV | |
| | | > 20 kHz to 50 kHz | $0.42 \cdot 10^{-3} \cdot U + 10$ µV | |
| | | > 50 kHz to 100 kHz | $0.95 \cdot 10^{-3} \cdot U + 40$ µV | |
| | | > 100 kHz to 500 kHz | $2.5 \cdot 10^{-3} \cdot U + 85$ µV | |
| | 0.33 V to < 3.3 V | 10 Hz to 45 Hz | $0.37 \cdot 10^{-3} \cdot U + 60$ µV | |
| | | > 45 Hz to 10 kHz | $0.17 \cdot 10^{-3} \cdot U + 75$ µV | |
| | | > 10 kHz to 20 kHz | $0.22 \cdot 10^{-3} \cdot U + 75$ µV | |
| | | > 20 kHz to 50 kHz | $0.35 \cdot 10^{-3} \cdot U + 60$ µV | |
| | | > 50 kHz to 100 kHz | $0.85 \cdot 10^{-3} \cdot U + 0.15$ mV | |
| | | > 100 kHz to 500 kHz | $3.0 \cdot 10^{-3} \cdot U + 0.70$ mV | |
| | 3.3 V to < 33 V | 10 Hz to 45 Hz | $0.37 \cdot 10^{-3} \cdot U + 0.73$ mV | |
| | | > 45 Hz to 10 kHz | $0.17 \cdot 10^{-3} \cdot U + 0.70$ mV | |
| | | > 10 kHz to 20 kHz | $0.28 \cdot 10^{-3} \cdot U + 0.70$ mV | |
| | | > 20 kHz to 50 kHz | $0.41 \cdot 10^{-3} \cdot U + 0.70$ mV | |
| | | > 50 kHz to 100 kHz | $1.1 \cdot 10^{-3} \cdot U + 1.8$ mV | |
| | 33 V to < 330 V | 45 Hz to 1 kHz | $0.22 \cdot 10^{-3} \cdot U + 2.3$ mV | |
| | | > 1 kHz to 10 kHz | $0.25 \cdot 10^{-3} \cdot U + 7$ mV | |
| | | > 10 kHz to 20 kHz | $0.30 \cdot 10^{-3} \cdot U + 7$ mV | |
| | | > 20 kHz to 50 kHz | $0.37 \cdot 10^{-3} \cdot U + 7$ mV | |
| | | > 50 kHz to 100 kHz | $2.4 \cdot 10^{-3} \cdot U + 57$ mV | |
| | 330 V to < 1000 V | 45 Hz to 1 kHz | $0.35 \cdot 10^{-3} \cdot U + 12$ mV | |
| | | > 1 kHz to 5 kHz | $0.30 \cdot 10^{-6} \cdot U + 12$ mV | |
| | | > 5 kHz to 10 kHz | $0.35 \cdot 10^{-3} \cdot U + 12$ mV | |

[1] The best measurement capabilities are stated according to EA-4/02. These are expanded uncertainties of measurement with a coverage probability of 95% and have a coverage factor of k = 2 unless stated otherwise. Uncertainties without unit are relative uncertainties referring to the measurement value unless stated otherwise.

| Measurement quantity / Calibration item | Range | Measurement conditions / procedure | Best measurement capability [1] | Remarks |
|---|---|---|---|---|
| AC voltage | 0.001 V to < 0.2 V | 10 Hz to 40 Hz | $0.18 \cdot 10^{-3} \cdot U + 5\ \mu V$ | $U$ = measured value<br>Fluke 8508A |
| | | > 40 Hz to 100 Hz | $0.13 \cdot 10^{-3} \cdot U + 5\ \mu V$ | |
| | | > 100 Hz to 2 kHz | $0.13 \cdot 10^{-3} \cdot U + 5\ \mu V$ | |
| | | > 2 kHz to 10 kHz | $0.15 \cdot 10^{-3} \cdot U + 5\ \mu V$ | |
| | | > 10 kHz to 30 kHz | $0.37 \cdot 10^{-3} \cdot U + 10\ \mu V$ | |
| | | > 30 kHz to 100 kHz | $0.85 \cdot 10^{-3} \cdot U + 25\ \mu V$ | |
| | 0.2 V to < 2 V | 10 Hz to 40 Hz | $0.14 \cdot 10^{-3} \cdot U + 25\ \mu V$ | |
| | | > 40 Hz to 100 Hz | $0.11 \cdot 10^{-3} \cdot U + 25\ \mu V$ | |
| | | > 100 Hz to 2 kHz | $90 \cdot 10^{-6} \cdot U + 25\ \mu V$ | |
| | | > 2 kHz to 10 kHz | $0.13 \cdot 10^{-3} \cdot U + 25\ \mu V$ | |
| | | > 10 kHz to 30 kHz | $0.26 \cdot 10^{-3} \cdot U + 50\ \mu V$ | |
| | | > 30 kHz to 100 kHz | $0.66 \cdot 10^{-3} \cdot U + 0.25\ mV$ | |
| | | > 100 kHz to 300 kHz | $3.5 \cdot 10^{-3} \cdot U + 2.5\ mV$ | |
| | | > 300 kHz to 1 MHz | $12 \cdot 10^{-3} \cdot U + 24\ mV$ | |
| | 2 V to < 20 V | 10 Hz to 40 Hz | $0.14 \cdot 10^{-3} \cdot U + 0.25\ mV$ | |
| | | > 40 Hz to 100 Hz | $0.11 \cdot 10^{-3} \cdot U + 0.25\ mV$ | |
| | | > 100 Hz to 2 kHz | $90 \cdot 10^{-6} \cdot U + 0.25\ mV$ | |
| | | > 2 kHz to 10 kHz | $0.13 \cdot 10^{-3} \cdot U + 0.25\ mV$ | |
| | | > 10 kHz to 30 kHz | $0.26 \cdot 10^{-3} \cdot U + 0.50\ mV$ | |
| | | > 30 kHz to 100 kHz | $0.66 \cdot 10^{-3} \cdot U + 2.5\ mV$ | |
| | | > 100 kHz to 300 kHz | $3.5 \cdot 10^{-3} \cdot U + 25\ mV$ | |
| | | > 300 kHz to 1 MHz | $12 \cdot 10^{-3} \cdot U + 0.25\ V$ | |
| | 20 V to < 200 V | 10 Hz to 40 Hz | $0.14 \cdot 10^{-3} \cdot U + 2.3\ mV$ | |
| | | > 40 Hz to 100 Hz | $0.11 \cdot 10^{-3} \cdot U + 2.3\ mV$ | |
| | | > 100 Hz to 2 kHz | $95 \cdot 10^{-6} \cdot U + 2.3\ mV$ | |
| | | > 2 kHz to 10 kHz | $0.13 \cdot 10^{-3} \cdot U + 2.3\ mV$ | |
| | | > 10 kHz to 30 kHz | $0.26 \cdot 10^{-3} \cdot U + 5.0\ mV$ | |
| | | > 30 kHz to 100 kHz | $0.67 \cdot 10^{-3} \cdot U + 25\ mV$ | |
| | 200 V to < 1000 V | > 40 Hz to 10 kHz | $0.15 \cdot 10^{-3} \cdot U + 25\ mV$ | |
| | | > 10 kHz to 30 kHz | $0.25 \cdot 10^{-3} \cdot U + 50\ mV$ | |
| AC current | 0.029 mA to < 0.33 mA | 10 Hz to 20 Hz | $1 \cdot 10^{-3} \cdot I + 1.5\ \mu A$ | $I$ = measured value<br>Fluke 5522A |
| | | > 20 Hz to 45 Hz | $0.6 \cdot 10^{-3} \cdot I + 1.5\ \mu A$ | |
| | | > 45 Hz to 1 kHz | $0.45 \cdot 10^{-3} \cdot I + 1.5\ \mu A$ | |
| | | > 1 kHz to 5 kHz | $1.9 \cdot 10^{-3} \cdot I + 1.5\ \mu A$ | |
| | | > 5 kHz to 10 kHz | $7.5 \cdot 10^{-3} \cdot I + 1.5\ \mu A$ | |
| | 0.33 mA to < 3.3 mA | 10 Hz to 20 Hz | $2.2 \cdot 10^{-3} \cdot I + 1\ \mu A$ | |
| | | > 20 Hz to 45 Hz | $1.3 \cdot 10^{-3} \cdot I + 1\ \mu A$ | |
| | | > 45 Hz to 1 kHz | $1 \cdot 10^{-3} \cdot I + 1\ \mu A$ | |
| | | > 1 kHz to 5 kHz | $2.2 \cdot 10^{-3} \cdot I + 1\ \mu A$ | |
| | | > 5 kHz to 10 kHz | $6 \cdot 10^{-3} \cdot I + 1\ \mu A$ | |
| | 3.3 mA to < 33 mA | 10 Hz to 20 Hz | $2.1 \cdot 10^{-3} \cdot I + 2.5\ \mu A$ | |
| | | > 20 Hz to 45 Hz | $1.1 \cdot 10^{-3} \cdot I + 2.5\ \mu A$ | |
| | | > 45 Hz to 1 kHz | $0.5 \cdot 10^{-3} \cdot I + 2.5\ \mu A$ | |
| | | > 1 kHz to 5 kHz | $1.0 \cdot 10^{-3} \cdot I + 2.4\ \mu A$ | |
| | | > 5 kHz to 10 kHz | $2.5 \cdot 10^{-3} \cdot I + 3.5\ \mu A$ | |
| | 33 mA to < 330 mA | 10 Hz to 20 Hz | $2.1 \cdot 10^{-3} \cdot I + 25\ \mu A$ | |
| | | > 20 Hz to 45 Hz | $1.1 \cdot 10^{-3} \cdot I + 25\ \mu A$ | |
| | | > 45 Hz to 1 kHz | $0.5 \cdot 10^{-3} \cdot I + 25\ \mu A$ | |
| | | > 1 kHz to 5 kHz | $1.2 \cdot 10^{-3} \cdot I + 60\ \mu A$ | |
| | | > 5 kHz to 10 kHz | $2.4 \cdot 10^{-3} \cdot I + 0.12\ mA$ | |

[1] The best measurement capabilities are stated according to EA-4/02. These are expanded uncertainties of measurement with a coverage probability of 95% and have a coverage factor of k = 2 unless stated otherwise. Uncertainties without unit are relative uncertainties referring to the measurement value unless stated otherwise.

| Measurement quantity / Calibration item | Range | Measurement conditions / procedure | Best measurement capability [1)] | Remarks |
|---|---|---|---|---|
| AC current | 0.33 A to < 1.1 A | 10 Hz to 45 Hz | $2.1 \cdot 10^{-3} \cdot I + 0.12$ mA | $I$ = measured value<br>Fluke 5522A |
| | | > 45 Hz to 1 kHz | $0.6 \cdot 10^{-3} \cdot I + 0.12$ mA | |
| | | > 1 kHz to 5 kHz | $7 \cdot 10^{-3} \cdot I + 1.2$ mA | |
| | | > 5 kHz to 10 kHz | $30 \cdot 10^{-3} \cdot I + 6$ mA | |
| | 1.1 A to < 3 A | 10 Hz to 45 Hz | $2.1 \cdot 10^{-3} \cdot I + 0.12$ mA | |
| | | > 45 Hz to 1 kHz | $0.7 \cdot 10^{-3} \cdot I + 0.13$ mA | |
| | | > 1 kHz to 5 kHz | $7 \cdot 10^{-3} \cdot I + 1.2$ mA | |
| | | > 5 kHz to 10 kHz | $29 \cdot 10^{-3} \cdot I + 5.9$ mA | |
| | 3 A to < 11 A | 45 Hz to 100 Hz | $0.72 \cdot 10^{-3} \cdot I + 2.5$ mA | |
| | | > 100 Hz to 1 kHz | $1.2 \cdot 10^{-3} \cdot I + 2.5$ mA | |
| | | > 1 kHz to 5 kHz | $35 \cdot 10^{-3} \cdot I + 2.5$ mA | |
| | 11 A to < 20.5 A | 45 Hz to 100 Hz | $1.5 \cdot 10^{-3} \cdot I + 6$ mA | |
| | | > 100 Hz to 1 kHz | $1.8 \cdot 10^{-3} \cdot I + 6$ mA | |
| | | > 1 kHz to 5 kHz | $35 \cdot 10^{-3} \cdot I + 6$ mA | |
| AC current | 0.1 mA to < 0.2 mA | 10 Hz to 10 kHz | $55 \cdot 10^{-6} \cdot I + 1.5$ µA | $I$ = measured value<br>Fluke 8508A |
| | 0.2 mA to < 2 mA | 10 Hz to 10 kHz | $0.2 \cdot 10^{-3} \cdot I + 1.5$ µA | |
| | 2 mA to < 20 mA | 10 Hz to 10 kHz | $0.4 \cdot 10^{-3} \cdot I + 2.5$ µA | |
| | 20 mA to < 200 mA | 10 Hz to 10 kHz | $0.4 \cdot 10^{-3} \cdot I + 25$ µA | |
| | 200 mA to < 2 A | 10 Hz to 10 kHz | $0.9 \cdot 10^{-3} \cdot I + 0.25$ mA | |
| | 2 A to < 20 A | 10 Hz to 2 kHz | $3 \cdot 10^{-3} \cdot I + 2.5$ mA | |
| Frequency | 1 Hz to 2 MHz | | $4 \cdot 10^{-6} \cdot f + 10$ µHz + $U_{tf}$ | $f$ = measured value<br>$U_{tf}$ = trigger-uncertainty<br>Fluke 5522A |

## On-site calibration

| Measurement quantity / Calibration item | Range | Measurement conditions / procedure | Best measurement capability [1)] | Remarks |
|---|---|---|---|---|
| Temperature<br>Heated, climatic and cooling chambers in empty or defined loaded useful volume [*)] | -90 °C to 0 °C | Measurement in air<br>DAkkS-DKD-R 5-7:2010 Calibration methods A and B | 0.8 K | Comparison with standard resistance thermometers<br>If loaded, type and arrangement of the load are to be precisely stated in the calibration certificate. |
| | > 0 °C to 100 °C | | 0.5 K | |
| | > 100 °C to 200 °C | | 0.8 K | |
| | > 200 °C to 350 °C | | 1.2 K | |
| Measuring locations in heated, climatic and cooling chambers in empty or defined loaded useful volume [*)] | -90 °C to 0 °C | Measurement in air<br>DAkkS-DKD-R 5-7:2010 Calibration method C | 0.5 K | |
| | > 0 °C to 100 °C | | 0.3 K | |
| | > 100 °C to 200 °C | | 0.5 K | |
| | > 200 °C to 350 °C | | 0.8 K | |

**Abbreviations used:**

DAkkS-DKD-R Calibration Guideline of Deutsche Akkreditierungsstelle GmbH
DKD-R Calibration Guideline of Deutscher Kalibrierdienst

[1)] The best measurement capabilities are stated according to EA-4/02. These are expanded uncertainties of measurement with a coverage probability of 95% and have a coverage factor of k = 2 unless stated otherwise. Uncertainties without unit are relative uncertainties referring to the measurement value unless stated otherwise.