Organisme belge d'Accréditation
Belgische Accreditatieinstelling
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Bijlage bij accreditatie-certificaat
Annexe au certificat d'accréditation
Annex to the accreditation certificate
Beilage zur Akkreditierungszertifikat

# 001-CAL

**EN ISO/IEC 17025:2017**

| | |
|---|---|
| **Versie / Version / Version / Fassung** | 22 |
| **Geldigheidsperiode / Validité / Validity / Gültigkeitsdauer** | 2023-12-08 - 2026-06-01 |

**Maureen Logghe**
Voorzitster van het Accreditatiebureau
La Présidente du Bureau d'Accréditation
Chair of the Accreditation Board
Vorsitzende des Akkreditierungsbüro

**De accreditatie werd uitgereikt aan / L'accréditation est délivrée à / The accreditation is granted to / Die akkreditierung wurde erteilt für:**

## TRESCAL nv
## Vosstraat, 200
## 2600 Antwerpen

**Activiteitencentra / Sites d'activités / Sites of activities / Standorte mit aktivitäten:**

| | |
|---|---|
| Locatie 1 - WOMMELGEM | Nijverheidsstraat, 70<br>2160 Wommelgem |
| Locatie 2 - WELLIN | Rue Jean Meunier, 2<br>6922 Wellin |
| Locatie 3 - LOUVAIN-LA-NEUVE | Rue du Bosquet, 7<br>1348 Ottignies-Louvain-la-Neuve |

## DCLF Electricity Wommelgem (In House or Onsite)

## Calibration and Measurement Capabilities

Direct voltage
Measure

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | Location |
|---|---|---|---|---|---|
| ± 100 mV | DC | $5{,}0 \times 10^{-6} \times U$ | • Transfer standard in "30 day" loop<br>• Fixed points<br>• positive /negative<br>• measuring | P2-02-E.006 | AN, OS |
| ± 1 V | DC | $2{,}7 \times 10^{-6} \times U$ | | | |
| ± 10 V | DC | $2{,}1 \times 10^{-6} \times U$ | | | |
| ± 19 V | DC | $2{,}3 \times 10^{-6} \times U$ | | | |
| ± 100 V | DC | $3{,}0 \times 10^{-6} \times U$ | | | |
| ± 1000 V | DC | $3{,}0 \times 10^{-6} \times U$ | | | |

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| 0 mV to 200 mV | DC | $7{,}0 \times 10^{-6} \times U$ or 0,1 µV[1] | • measure<br>• positive / negative | P2-02-E.019 | AN , OS |
| 0,2 V to 2 V | DC | $5{,}0 \times 10^{-6} \times U$ | | | |
| 2 V to 20 V | DC | $4{,}5 \times 10^{-6} \times U$ | | | |
| 20 V to 200 V | DC | $5{,}5 \times 10^{-6} \times U$ | | | |
| 200 V to 1000 V | DC | $5{,}5 \times 10^{-6} \times U$ | | | |
| 1 kV to 75 kV | DC | $3{,}0 \times 10^{-4} \times U$ | Measure | P2-02-E.016 | |
| 0,2 V to 11 V | DC | $1{,}0 \times 10^{-4} \times U$ | Loop calibration | P2-02-E.019 | OS |

[1] Whichever is greater

| Direct voltage<br>Generate | | | | | |
|---|---|---|---|---|---|
| **Generating range or point** | **Frequency** | **expanded uncertainty (*)** | **Remark** | **Calibration procedure** | |
| 100 mV | DC | $1{,}5 \times 10^{-6} \times U$ | • generate / measure<br>• Fixed points with Zener | PZ2-02-E.001 | AN |
| 1 V, 10 V, 100 V | DC | $1 \times 10^{-6} \times U$ | | | |
| 1000 V | DC | $1{,}2 \times 10^{-6} \times U$ | | | |
| | | | | | |
| **Generating range or point** | **Frequency** | **expanded uncertainty (*)** | **Remark** | **Calibration procedure** | |
| 0 mV to 200 mV | DC | $18 \times 10^{-6} \times U$ or 0,5 µV[1] | • generate<br>• positive / negative | P2-02-E.005 | AN, OS |
| 0,2 V to 2 V | DC | $8{,}0 \times 10^{-6} \times U$ | | | |
| 2 V to 20 V | DC | $4{,}5 \times 10^{-6} \times U$ | | | |
| 20 V to 200 V | DC | $7{,}0 \times 10^{-6} \times U$ | | | |
| 200 V to 1100 V | DC | $10 \times 10^{-6} \times U$ | | | |
| 1,1 kV to 40 kV | DC | $3{,}0 \times 10^{-4} \times U$ | Generate | P2-02-E.016 | |
| 0,2 V to 11 V | DC | $1{,}0 \times 10^{-4} \times U$ | Loop calibration | P2-02-E.005 | OS |

[1] Whichever is greater

Direct current
Measure

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| ±100 µA | DC | $24 \times 10^{-6} \times I$ | • Transfer standard in "30 day" loop<br>• Fixed points<br>• positive / negative<br>• Measurement | P2-02-E.006 | AN, OS |
| ±1 mA | DC | $16 \times 10^{-6} \times I$ | | | |
| ±10 mA | DC | $16 \times 10^{-6} \times I$ | | | |
| ±100 mA | DC | $19 \times 10^{-6} \times I$ | | | |
| ±1 A | DC | $31 \times 10^{-6} \times I$ | | | |
| ±10 A | DC | $60 \times 10^{-6} \times I$ | | | |
| | | | | | |
| **Measuring range or point** | **Frequency** | **expanded uncertainty (*)** | **Remark** | **Calibration procedure** | |
| 1 A to 10 A | DC | $2 \times 10^{-5} \times I$ | • measure / generate<br>• positive / negative<br>• with standard resistances | P2-02-E.022 | AN |
| 100 mA to 1 A | DC | $1 \times 10^{-5} \times I$ | | | |
| 100 nA to 100 mA | DC | $5 \times 10^{-6} \times I$ | | | |
| 100 nA to 10 nA | DC | $6 \times 10^{-5} \times I$ | | | |
| 10 nA to 1 nA | DC | $1 \times 10^{-4} \times I$ | | | |
| 1 nA to 100 pA | DC | $3 \times 10^{-4} \times I$ | | | |
| 100 pA to 10 pA | DC | $1 \times 10^{-3} \times I$ | | | |
| 10 pA to 1 pA | DC | $2 \times 10^{-3} \times I$ | | | |
| | | | | | |
| **Measuring range or point** | **Frequency** | **expanded uncertainty (*)** | **Remark** | **Calibration procedure** | |
| 0 µA to 200 µA | DC | $12 \times 10^{-6} \times I$ or 0,5 nA[1] | • measure<br>• in the lowest possible range<br>• positive / negative | P2-02-E.019 | AN, OS |
| 0,2 mA to 2 mA | DC | $11 \times 10^{-6} \times I$ | | | |
| 2 mA to 20 mA | DC | $9{,}0 \times 10^{-6} \times I$ | | | |
| 20 mA to 200 mA | DC | $16 \times 10^{-6} \times I$ | | | |
| 0,2 A to 2 A | DC | $90 \times 10^{-6} \times I$ | | | |
| 2 A to 20 A | DC | $90 \times 10^{-6} \times I$ | | | |
| 0,2 mA to 24 mA | DC | $1{,}0 \times 10^{-4} \times I$ | Loop calibration | P2-02-E.019 | OS |

[1] Whichever is greater

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| 20 A to 3000 A | DC | $2{,}0 \times 10^{-4} \times I$ | measure/generate | P2-02-E.030 | AN, OS |

Calibration of current clamps

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| 20 A to 1000 A | DC | $5{,}0 \times 10^{-3} \times I$ | • with current coils | P2-02-E.021 | AN, OS |

Generate

| Generating range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| 0 µA to 20 µA | DC | 1,5 nA | • generate<br>• positive / negative | P2-02-E.005 | AN, OS |
| 20 µA to 200 µA | DC | $1{,}7 \times 10^{-4} \times I$ | | | |
| 0,2 mA to 200 mA | DC | $0{,}70 \times 10^{-4} \times I$ | | | |
| 0,2 A to 2 A | DC | $1{,}9 \times 10^{-4} \times I$ | | | |
| 2 A to 11 A | DC | $2{,}7 \times 10^{-4} \times I$ | | | |
| 11 A to 20 A | DC | $6{,}0 \times 10^{-4} \times I$ | | | |
| 0,2 mA to 24 mA | DC | $1{,}0 \times 10^{-4} \times I$ | Loop calibration | P2-02-E.005 | OS |

Alternating voltage

Measure

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| 1 mV | 20 Hz to 20 kHz | $3{,}0 \times 10^{-4} \times U + 2\ \mu V$ | • Transfer standard in "30 day" loop<br>• Fixed points<br>• measuring | P2-02-E.006 | AN, OS |
| | 30 kHz & 50 kHz | $4{,}0 \times 10^{-4} \times U + 2\ \mu V$ | | | |
| | 100 kHz | $6{,}5 \times 10^{-4} \times U + 2\ \mu V$ | | | |
| 10 mV | 20 Hz to 20 kHz | $1{,}7 \times 10^{-4} \times U + 2\ \mu V$ | | | |
| | 30 kHz & 50 kHz | $2{,}5 \times 10^{-4} \times U + 2\ \mu V$ | | | |
| | 100 kHz | $4{,}5 \times 10^{-4} \times U + 2\ \mu V$ | | | |
| 100 mV | 20 Hz to 20 kHz | $1{,}2 \times 10^{-4} \times U + 2\ \mu V$ | | | |
| | 30 kHz & 50 kHz | $2{,}0 \times 10^{-4} \times U + 2\ \mu V$ | | | |
| | 100 kHz | $4{,}0 \times 10^{-4} \times U + 2\ \mu V$ | | | |
| 1 V | 10 Hz to 30 Hz | $4{,}0 \times 10^{-5} \times U$ | | | |
| | 40 Hz to 30 kHz | $3{,}0 \times 10^{-5} \times U$ | | | |
| | 50 kHz | $4{,}0 \times 10^{-5} \times U$ | | | |
| | 100 kHz | $5{,}0 \times 10^{-5} \times U$ | | | |
| | 300 kHz | $12 \times 10^{-5} \times U$ | | | |
| | 500 kHz | $25 \times 10^{-5} \times U$ | | | |
| | 1 MHz | $60 \times 10^{-5} \times U$ | | | |
| 10 V | 10 Hz to 30 Hz | $4{,}0 \times 10^{-5} \times U$ | • Transfer standard in "30 day" loop<br>• Fixed points<br>• measuring | P2-02-E.006 | AN, OS |
| | 40 Hz to 30 kHz | $3{,}0 \times 10^{-5} \times U$ | | | |
| | 50 kHz | $3{,}5 \times 10^{-5} \times U$ | | | |
| | 100 kHz | $4{,}0 \times 10^{-5} \times U$ | | | |
| | 300 kHz | $11 \times 10^{-5} \times U$ | | | |
| | 500 kHz | $22 \times 10^{-5} \times U$ | | | |
| | 1 MHz | $60 \times 10^{-5} \times U$ | | | |
| 19 V | 1 kHz | $4{,}0 \times 10^{-5} \times U$ | | | |
| 100 V | 10 Hz to 30 Hz | $4{,}5 \times 10^{-5} \times U$ | | | |
| | 40 Hz & 55 Hz | $4{,}0 \times 10^{-5} \times U$ | | | |
| | 300 Hz to 20 kHz | $3{,}0 \times 10^{-5} \times U$ | | | |
| | 30 kHz | $3{,}5 \times 10^{-5} \times U$ | | | |
| | 50 kHz | $4{,}5 \times 10^{-5} \times U$ | | | |
| | 100 kHz | $7{,}4 \times 10^{-5} \times U$ | | | |
| 1000 V | 40 Hz to 1 kHz | $4{,}0 \times 10^{-5} \times U$ | | | |
| | 10 kHz | $4{,}5 \times 10^{-5} \times U$ | | | |
| | 20 kHz | $5{,}0 \times 10^{-5} \times U$ | | | |
| | 30 kHz | $7{,}5 \times 10^{-5} \times U$ | | | |
| 700 V | 50 kHz | $13 \times 10^{-5} \times U$ | | | |
| | 100 kHz | $35 \times 10^{-5} \times U$ | | | |

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| 0,7 mV to 2,2 mV | 10 Hz to 20 Hz | $17 \times 10^{-4} \times U + 1{,}3\ \mu V$ | • measure | P2-02-E.019 | AN, OS |
| | 20 Hz to 40 Hz | $7{,}4 \times 10^{-4} \times U + 1{,}3\ \mu V$ | | | |
| | 40 Hz to 20 kHz | $4{,}2 \times 10^{-4} \times U + 1{,}3\ \mu V$ | | | |
| | 20 kHz to 50 kHz | $8{,}2 \times 10^{-4} \times U + 2{,}0\ \mu V$ | | | |
| | 50 kHz to 100 kHz | $12 \times 10^{-4} \times U + 2{,}5\ \mu V$ | | | |
| | 100 kHz to 300 kHz | $23 \times 10^{-4} \times U + 4{,}0\ \mu V$ | | | |
| | 300 kHz to 500 kHz | $26 \times 10^{-4} \times U + 8{,}0\ \mu V$ | | | |
| | 500 kHz to 1 MHz | $50 \times 10^{-4} \times U + 8{,}0\ \mu V$ | | | |
| 2 mV to 7 mV | 10 Hz to 20 Hz | $8{,}5 \times 10^{-4} \times U + 1{,}3\ \mu V$ | • measure | P2-02-E.019 | AN, OS |
| | 20 Hz to 40 Hz | $3{,}7 \times 10^{-4} \times U + 1{,}3\ \mu V$ | | | |
| | 40 Hz to 20 kHz | $2{,}1 \times 10^{-4} \times U + 1{,}3\ \mu V$ | | | |
| | 20 kHz to 50 kHz | $4{,}1 \times 10^{-4} \times U + 2{,}0\ \mu V$ | | | |
| | 50 kHz to 100 kHz | $6{,}1 \times 10^{-4} \times U + 2{,}5\ \mu V$ | | | |
| | 100 kHz to 300 kHz | $12 \times 10^{-4} \times U + 4{,}0\ \mu V$ | | | |
| | 300 kHz to 500 kHz | $14 \times 10^{-4} \times U + 8{,}0\ \mu V$ | | | |
| | 500 kHz to 1 MHz | $36 \times 10^{-4} \times U + 8{,}0\ \mu V$ | | | |
| 7 mV to 22 mV | 10 Hz to 20 Hz | $2{,}9 \times 10^{-4} \times U + 1{,}3\ \mu V$ | • measure | P2-02-E.019 | AN, OS |
| | 20 Hz to 40 Hz | $1{,}9 \times 10^{-4} \times U + 1{,}3\ \mu V$ | | | |
| | 40 Hz to 20 kHz | $1{,}1 \times 10^{-4} \times U + 1{,}3\ \mu V$ | | | |
| | 20 kHz to 50 kHz | $2{,}1 \times 10^{-4} \times U + 2{,}0\ \mu V$ | | | |
| | 50 kHz to 100 kHz | $3{,}1 \times 10^{-4} \times U + 2{,}5\ \mu V$ | | | |
| | 100 kHz to 300 kHz | $8{,}2 \times 10^{-4} \times U + 4{,}0\ \mu V$ | | | |
| | 300 kHz to 500 kHz | $10 \times 10^{-4} \times U + 8{,}0\ \mu V$ | | | |
| | 500 kHz to 1 MHz | $26 \times 10^{-4} \times U + 8{,}0\ \mu V$ | | | |
| 22 mV to 70 mV | 10 Hz to 20 Hz | $2{,}4 \times 10^{-4} \times U + 1{,}5\ \mu V$ | • measure | P2-02-E.019 | AN, OS |
| | 20 Hz to 40 Hz | $1{,}3 \times 10^{-4} \times U + 1{,}5\ \mu V$ | | | |
| | 40 Hz to 20 kHz | $0{,}69 \times 10^{-4} \times U + 1{,}5\ \mu V$ | | | |
| | 20 kHz to 50 kHz | $1{,}3 \times 10^{-4} \times U + 2{,}0\ \mu V$ | | | |
| | 50 kHz to 100 kHz | $2{,}6 \times 10^{-4} \times U + 2{,}5\ \mu V$ | | | |
| | 100 kHz to 300 kHz | $5{,}3 \times 10^{-4} \times U + 4{,}0\ \mu V$ | | | |
| | 300 kHz to 500 kHz | $6{,}8 \times 10^{-4} \times U + 8{,}0\ \mu V$ | | | |
| | 500 kHz to 1 MHz | $13 \times 10^{-4} \times U + 8{,}0\ \mu V$ | | | |
| 70 mV to 220 mV | 10 Hz to 20 Hz | $21 \times 10^{-5} \times U + 1{,}5\ \mu V$ | • measure | P2-02-E.019 | AN, OS |
| | 20 Hz to 40 Hz | $8{,}7 \times 10^{-5} \times U + 1{,}5\ \mu V$ | | | |
| | 40 Hz to 20 kHz | $4{,}3 \times 10^{-5} \times U + 1{,}5\ \mu V$ | | | |
| | 20 kHz to 50 kHz | $7{,}3 \times 10^{-5} \times U + 2{,}0\ \mu V$ | | | |
| | 50 kHz to 100 kHz | $16 \times 10^{-5} \times U + 2{,}5\ \mu V$ | | | |
| | 100 kHz to 300 kHz | $28 \times 10^{-5} \times U + 4{,}0\ \mu V$ | | | |
| | 300 kHz to 500 kHz | $40 \times 10^{-5} \times U + 8{,}0\ \mu V$ | | | |
| | 500 kHz to 1 MHz | $120 \times 10^{-5} \times U + 8{,}0\ \mu V$ | | | |
| 220 mV to 700 mV | 10 Hz to 20 Hz | $21 \times 10^{-5} \times U + 1{,}5\ \mu V$ | • measure | P2-02-E.019 | AN, OS |
| | 20 Hz to 40 Hz | $8{,}7 \times 10^{-5} \times U + 1{,}5\ \mu V$ | | | |
| | 40 Hz to 20 kHz | $3{,}8 \times 10^{-5} \times U + 1{,}5\ \mu V$ | | | |
| | 20 kHz to 50 kHz | $5{,}6 \times 10^{-5} \times U + 2{,}0\ \mu V$ | | | |
| | 50 kHz to 100 kHz | $8{,}4 \times 10^{-5} \times U + 2{,}5\ \mu V$ | | | |
| | 100 kHz to 300 kHz | $21 \times 10^{-5} \times U + 4{,}0\ \mu V$ | | | |
| | 300 kHz to 500 kHz | $34 \times 10^{-5} \times U + 8{,}0\ \mu V$ | | | |
| | 500 kHz to 1 MHz | $120 \times 10^{-5} \times U + 8{,}0\ \mu V$ | | | |
| 0,7 V to 2,2 V | 10 Hz to 20 Hz | $7 \times 10^{-5} \times U$ | • measure | P2-02-E.019 | AN, OS |
| | 20 Hz to 40 Hz | $6{,}9 \times 10^{-5} \times U$ | | | |
| | 40 Hz to 20 kHz | $2{,}9 \times 10^{-5} \times U$ | | | |
| | 20 kHz to 50 kHz | $5{,}2 \times 10^{-5} \times U$ | | | |
| | 50 kHz to 100 kHz | $7{,}6 \times 10^{-5} \times U$ | | | |
| | 100 kHz to 300 kHz | $20 \times 10^{-5} \times U$ | | | |
| | 300 kHz to 500 kHz | $31 \times 10^{-5} \times U$ | | | |
| | 500 kHz to 1 MHz | $120 \times 10^{-5} \times U$ | | | |

| | | | | | |
|---|---|---|---|---|---|
| 2,2 V to 7 V | 10 Hz to 20 Hz | $7 \times 10^{-5} \times U$ | • measure | P2-02-E.019 | AN, OS |
| | 20 Hz to 40 Hz | $7{,}0 \times 10^{-5} \times U$ | | | |
| | 40 Hz to 20 kHz | $2{,}9 \times 10^{-5} \times U$ | | | |
| | 20 kHz to 50 kHz | $5{,}3 \times 10^{-5} \times U$ | | | |
| | 50 kHz to 100 kHz | $8{,}8 \times 10^{-5} \times U$ | | | |
| | 100 kHz to 300 kHz | $22 \times 10^{-5} \times U$ | | | |
| | 300 kHz to 500 kHz | $47 \times 10^{-5} \times U$ | | | |
| | 500 kHz to 1 MHz | $150 \times 10^{-5} \times U$ | | | |
| 7 V to 22 V | 10 Hz to 20 Hz | $7 \times 10^{-5} \times U$ | • measure | P2-02-E.019 | AN, OS |
| | 20 Hz to 40 Hz | $7{,}0 \times 10^{-5} \times U$ | | | |
| | 40 Hz to 20 kHz | $3{,}1 \times 10^{-5} \times U$ | | | |
| | 20 kHz to 50 kHz | $5{,}3 \times 10^{-5} \times U$ | | | |
| | 50 kHz to 100 kHz | $8{,}5 \times 10^{-5} \times U$ | | | |
| | 100 kHz to 300 kHz | $22 \times 10^{-5} \times U$ | | | |
| | 300 kHz to 500 kHz | $47 \times 10^{-5} \times U$ | | | |
| | 500 kHz to 1 MHz | $150 \times 10^{-5} \times U$ | | | |
| 22 V to 70 V | 10 Hz to 20 Hz | $7 \times 10^{-5} \times U$ | • measure | P2-02-E.019 | AN, OS |
| | 20 Hz to 40 Hz | $7{,}2 \times 10^{-5} \times U$ | | | |
| | 40 Hz to 20 kHz | $3{,}9 \times 10^{-5} \times U$ | | | |
| | 20 kHz to 50 kHz | $6{,}3 \times 10^{-5} \times U$ | | | |
| | 50 kHz to 100 kHz | $11 \times 10^{-5} \times U$ | | | |
| | 100 kHz to 300 kHz | $22 \times 10^{-5} \times U$ | | | |
| | 300 kHz to 500 kHz | $51 \times 10^{-5} \times U$ | | | |
| | 500 kHz to 1 MHz | $150 \times 10^{-5} \times U$ | | | |
| 70 V to 220 V | 10 Hz to 20 Hz | $7 \times 10^{-5} \times U$ | • measure | P2-02-E.019 | AN, OS |
| | 20 Hz to 40 Hz | $7{,}2 \times 10^{-5} \times U$ | | | |
| | 40 Hz to 20 kHz | $3{,}8 \times 10^{-5} \times U$ | | | |
| | 20 kHz to 50 kHz | $7{,}7 \times 10^{-5} \times U$ | | | |
| | 50 kHz to 100 kHz | $11 \times 10^{-5} \times U$ | | | |
| | 100 kHz to 300 kHz | $26 \times 10^{-5} \times U$ | | | |
| | 300 kHz to 500 kHz | $70 \times 10^{-5} \times U$ | | | |
| 220 V to 700 V | 10 Hz to 20 Hz | $7 \times 10^{-5} \times U$ | • measure | P2-02-E.019 | AN, OS |
| | 20 Hz to 40 Hz | $11 \times 10^{-5} \times U$ | | | |
| | 40 Hz to 20 kHz | $4{,}7 \times 10^{-5} \times U$ | | | |
| | 20 kHz to 50 kHz | $15 \times 10^{-5} \times U$ | | | |
| | 50 kHz to 100 kHz | $85 \times 10^{-5} \times U$ | | | |
| 700 V to 1000 V | 10 Hz to 20 Hz | $7 \times 10^{-5} \times U$ | • measure | P2-02-E.019 | AN, OS |
| | 20 Hz to 40 Hz | $11 \times 10^{-5} \times U$ | | | |
| | 40 Hz to 20 kHz | $4{,}4 \times 10^{-5} \times U$ | | | |
| | 20 kHz to 50 kHz | $15 \times 10^{-5} \times U$ | | | |
| | 50 kHz to 100 kHz | $85 \times 10^{-5} \times U$ | | | |
| 1 kV to 53 kV | 50 / 60 Hz | $3{,}0 \times 10^{-3} \times U$ | • measure | P2-02-E.016 | AN, OS |

Generate

| Generating range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| 2 mV to 20 mV | 1 kHz to10 kHz | $7{,}0 \times 10^{-4} \times U$ | • generate | P2-02-E.005 | AN, OS |
| | 10 kHz to100 kHz | $11 \times 10^{-4} \times U$ | | | |
| 20 mV to 200 mV | 10 Hz to 300 Hz | $2{,}1 \times 10^{-4} \times U$ | • generate | P2-02-E.005 | AN, OS |
| | 300 Hz to 10 kHz | $1{,}8 \times 10^{-4} \times U$ | | | |
| | 10 kHz to 30 kHz | $2{,}8 \times 10^{-4} \times U$ | | | |
| | 30 kHz to 100 kHz | $6{,}1 \times 10^{-4} \times U$ | | | |
| 0,2 V to 2 V | 10 Hz to 300 Hz | $1{,}6 \times 10^{-4} \times U$ | • generate | P2-02-E.005 | AN, OS |
| | 300 Hz to 1 kHz | $1{,}1 \times 10^{-4} \times U$ | | | |
| | 1 kHz to 30 kHz | $0{,}70 \times 10^{-4} \times U$ | | | |
| | 30 kHz to 100 kHz | $1{,}6 \times 10^{-4} \times U$ | | | |
| | 100 kHz to 300 kHz | $6{,}0 \times 10^{-4} \times U$ | | | |
| | 300 kHz to 1 MHz | $30 \times 10^{-4} \times U$ | | | |
| 2 V to 20 V | 10 Hz to 300 Hz | $1{,}6 \times 10^{-4} \times U$ | • generate | P2-02-E.005 | AN, OS |
| | 300 Hz to 1 kHz | $1{,}0 \times 10^{-4} \times U$ | | | |
| | 1 kHz to 10 kHz | $0{,}80 \times 10^{-4} \times U$ | | | |
| | 10 kHz to 30 kHz | $0{,}70 \times 10^{-4} \times U$ | | | |
| | 30 kHz to 100 kHz | $1{,}7 \times 10^{-4} \times U$ | | | |
| | 100 kHz to 300 kHz | $6{,}0 \times 10^{-4} \times U$ | | | |
| | 300 kHz to 1 MHz | $30 \times 10^{-4} \times U$ | | | |
| 20 V to 200 V | 10 Hz to 300 Hz | $1{,}6 \times 10^{-4} \times U$ | • generate | P2-02-E.005 | AN, OS |
| | 300 Hz to 1 kHz | $1{,}2 \times 10^{-4} \times U$ | | | |
| | 1 kHz to 10 kHz | $1{,}0 \times 10^{-4} \times U$ | | | |
| | 10 kHz to 30 kHz | $1{,}1 \times 10^{-4} \times U$ | | | |
| | 30 kHz to 100 kHz | $2{,}1 \times 10^{-4} \times U$ | | | |
| 200 V to 1000 V | 40 Hz to 300 Hz | $2{,}3 \times 10^{-4} \times U$ | • generate | P2-02-E.005 | AN, OS |
| | 300 Hz to 1 kHz | $2{,}3 \times 10^{-4} \times U$ | | | |
| | 1 kHz to 10 kHz | $1{,}7 \times 10^{-4} \times U$ | | | |
| | 10 kHz to 30 kHz | $2{,}2 \times 10^{-4} \times U$ | | | |
| 200 V to 750 V | 30 kHz to 100 kHz | $15 \times 10^{-4} \times U$ | • generate | P2-02-E.005 | AN, OS |
| 1 kV to 45 kV | 50 / 60 Hz | $3{,}0 \times 10^{-3} \times U$ | • generate | P2-02-E.016 | AN, OS |

Alternating current
Measure

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| 100 µA | 10 Hz to 30 Hz | $1{,}4 \times 10^{-4} \times I$ | • Transfer standard in "30 day" loop<br>• Fixed points<br>• Measurement | P2-02-E.006 | AN, OS |
| | 40 Hz to 1 kHz | $1{,}1 \times 10^{-4} \times I$ | | | |
| | 5 kHz | $1{,}7 \times 10^{-4} \times I$ | | | |
| 1 mA | 10 Hz to 30 Hz | $1{,}3 \times 10^{-4} \times I$ | | | |
| | 40 Hz to 1 kHz | $1{,}0 \times 10^{-4} \times I$ | | | |
| | 5 kHz | $1{,}5 \times 10^{-4} \times I$ | | | |
| 10 mA | 10 Hz to 30 Hz | $1{,}3 \times 10^{-4} \times I$ | | | |
| | 40 Hz to 1 kHz | $1{,}0 \times 10^{-4} \times I$ | | | |
| | 5 kHz | $1{,}5 \times 10^{-4} \times I$ | | | |
| 100 mA | 10 Hz to 30 Hz | $1{,}3 \times 10^{-4} \times I$ | | | |
| | 40 Hz to 1 kHz | $1{,}0 \times 10^{-4} \times I$ | | | |
| | 5 kHz | $1{,}5 \times 10^{-4} \times I$ | | | |
| 1 A | 10 Hz to 30 Hz | $1{,}8 \times 10^{-4} \times I$ | | | |
| | 40 Hz to 1 kHz | $1{,}2 \times 10^{-4} \times I$ | | | |
| | 5 kHz | $2{,}3 \times 10^{-4} \times I$ | | | |
| 10 A | 40 Hz | $3{,}0 \times 10^{-4} \times I$ | | | |
| | 50 Hz to 1 kHz | $2{,}9 \times 10^{-4} \times I$ | | | |
| | 5 kHz | $4{,}0 \times 10^{-4} \times I$ | | | |
| | 10 kHz | $7{,}0 \times 10^{-4} \times I$ | | | |
| | | | | | |
| **Measuring range or point** | **Frequency** | **expanded uncertainty (*)** | **Remark** | **Calibration procedure** | |
| 10 mA | 10 Hz to 300 Hz | $61 \times 10^{-6} \times I$ | • measure / generate<br>• AC/DC difference | P2-02-E.022 | AN |
| | 300 Hz to 5 kHz | $35 \times 10^{-6} \times I$ | | | |
| | 5 kHz to 10 kHz | $41 \times 10^{-6} \times I$ | | | |
| | 10 kHz to 30 kHz | $45 \times 10^{-6} \times I$ | | | |
| 100 mA | 10 Hz to 300 Hz | $66 \times 10^{-6} \times I$ | | | |
| | 300 Hz to 5 kHz | $37 \times 10^{-6} \times I$ | | | |
| | 5 kHz to 10 kHz | $41 \times 10^{-6} \times I$ | | | |
| | 10 kHz to 30 kHz | $45 \times 10^{-6} \times I$ | | | |
| 1A | 10 Hz to 300 Hz | $70 \times 10^{-6} \times I$ | | | |
| | 300 Hz to 5 kHz | $49 \times 10^{-6} \times I$ | | | |
| | 5 kHz to 10 kHz | $51 \times 10^{-6} \times I$ | | | |
| | 10 kHz to 30 kHz | $55 \times 10^{-6} \times I$ | | | |
| 10A | 10 Hz to 300 Hz | $101 \times 10^{-6} \times I$ | | | |
| | 300 Hz to 5 kHz | $88 \times 10^{-6} \times I$ | | | |
| | 5 kHz to 10 kHz | $90 \times 10^{-6} \times I$ | | | |
| | 10 kHz to 30 kHz | $95 \times 10^{-6} \times I$ | | | |
| | | | | | |
| **Measuring range or point** | **Frequency** | **expanded uncertainty (*)** | **Remark** | **Calibration procedure** | |
| 5 µA to 200 µA | 10 Hz to 5 kHz | $1{,}6 \times 10^{-4} \times I$ | • measure | P2-02-E.019 | AN, OS |
| | 5 kHz to 10 kHz | $5{,}0 \times 10^{-4} \times I$ | | | |
| 0,2 mA to 2 mA | 10 Hz to 5 kHz | $0{,}60 \times 10^{-4} \times I$ | | | |
| | 5 kHz to 10 kHz | $1{,}3 \times 10^{-4} \times I$ | | | |
| 2 mA to 20 mA | 10 Hz to 5 kHz | $1{,}0 \times 10^{-4} \times I$ | | | |
| | 5 kHz to 10 kHz | $5{,}0 \times 10^{-4} \times I$ | | | |
| 20 mA to 200 mA | 10 Hz to 1 kHz | $1{,}0 \times 10^{-4} \times I$ | | | |
| | 1 kHz to 10 kHz | $26 \times 10^{-4} \times I$ | | | |
| 0,2 A to 2 A | 10 Hz to 1 kHz | $1{,}0 \times 10^{-4} \times I$ | | | |
| | 1 kHz to 10 kHz | $4{,}0 \times 10^{-4} \times I$ | | | |
| 2 A to 20 A | 10 Hz to 1 kHz | $1{,}0 \times 10^{-4} \times I$ | | | |
| | 1 kHz to 5 kHz | $3{,}0 \times 10^{-4} \times I$ | | | |
| | 5 kHz to 10 kHz | $10 \times 10^{-4} \times I$ | | | |

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| 20 A to 6000 A | 50 / 60 Hz | $5{,}0 \times 10^{-4} \times I$ | measure | P2-02-E.030 | AN, OS |
| 20 A to 4000 A | 50 / 60 Hz | $5{,}0 \times 10^{-4} \times I$ | generate | P2-02-E.030 | AN, OS |

Calibration of current clamps

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| 20 A to 1000 A | 45 Hz to 440 Hz | $5{,}0 \times 10^{-3} \times I$ | • with current coils | P2-02-E.022 | AN, OS |

Generate

| Generating range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| 20 µA to 200 µA | 10 Hz to 1 kHz | $4{,}0 \times 10^{-4} \times I$ | • generate<br>• in the lowest range possible | P2-02-E.005 | AN, OS |
| | 1 kHz to 5 kHz | $6{,}0 \times 10^{-4} \times I$ | | | |
| 0,2 mA to 2 mA | 10 Hz to 1 kHz | $3{,}2 \times 10^{-4} \times I$ | | | |
| | 1 kHz to 5 kHz | $4{,}0 \times 10^{-4} \times I$ | | | |
| 2 mA to 20 mA | 10 Hz to 1 kHz | $3{,}1 \times 10^{-4} \times I$ | | | |
| | 1 kHz to 5 kHz | $4{,}1 \times 10^{-4} \times I$ | | | |
| 20 mA to 200 mA | 10 Hz to 1 kHz | $3{,}1 \times 10^{-4} \times I$ | | | |
| | 1 kHz to 5 kHz | $4{,}0 \times 10^{-4} \times I$ | | | |
| 0,2 A to 2 A | 10 Hz to 1 kHz | $6{,}0 \times 10^{-4} \times I$ | | | |
| | 1 kHz to 5 kHz | $7{,}1 \times 10^{-4} \times I$ | | | |
| 2 A to 10 A | 10 Hz to 1 kHz | $6{,}1 \times 10^{-4} \times I$ | | | |
| | 1 kHz to 5 kHz | $12 \times 10^{-4} \times I$ | | | |
| | 5 kHz to 10 kHz | $34 \times 10^{-4} \times I$ | | | |
| 10 A to 20 A | 45 Hz to 100 Hz | $17 \times 10^{-4} \times I$ | | | |
| | 100 Hz to 1 kHz | $20 \times 10^{-4} \times I$ | | | |

Power and Energy

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| Mono phase , direct without measuring clamps | | | | | |
| 33 mV to 1000 V / 0,33 mA to 330 mA | DC | $3{,}0 \times 10^{-4} \times P$ | 11 µW to 330 W generate | P2-02-E.013 | AN, OS |
| 33 mV to 1000 V / 0,33 A to 3,3 A | DC | $5{,}0 \times 10^{-4} \times P$ | 3,3 kW generate | | |
| 33 mV to 1000 V / 3,3 A to 10,5 A | DC | $6{,}0 \times 10^{-4} \times P$ | 10,5 kW generate | | |
| 33 mV to 1000 V / 10,5 A to 20,5 A | DC | $11 \times 10^{-4} \times P$ | 20,5 kW generate | | |
| 33 mV to 1000 V / 0,1 mA to 20,5A | 45 Hz to 1 kHz | $15 \times 10^{-4} \times P$ | 3,3 µW to 20,5 kW / kVA(r) generate cosphi/sinphi > 0,5 | | |
| 33 mV to 1000 V / 0,1 mA to 20,5A | 45 Hz to 1 kHz | $40 \times 10^{-4} \times P$ | 3,3 µW to 20,5 kW / kVA(r) generate cosphi/sinphi > 0,25 | | |
| Mono phase , direct with measuring clamps | | | | | |
| 33 mV to 1000 V / 20 A to 500 A | DC | $10 \times 10^{-3} \times P$ | 0,66 W to 500 kW / kVA(r) generate | P2-02-E.013<br>P2-02-E.022 | AN, OS |
| 33 mV to 1000 V / 20 A to 500 A | 45 Hz to 100 Hz | $11 \times 10^{-3} \times P$ | 0,66 W to 500 kW / kVA(r) generate cosphi/sinphi > 0,25 | | |
| 33 mV to 1000 V / 20 A to 500 A | 100 Hz to 440 Hz | $16 \times 10^{-3} \times P$ | 0,66 W to 500 kW / kVA(r) generate cosphi/sinphi > 0,25 | | AN, OS |

| | | | | | |
|---|---|---|---|---|---|
| 3-phase, direct without measuring clamps | | | | | |
| 1 V to 300 V / 0,3 A to 100 A | 50 Hz & 60 Hz | $2{,}0 \times 10^{-3} \times P$ | 0,3 W to 30 kW / kVA(r) generate cosphi/sinphi > 0,5 | P2-02-E.018 | AN |
| 1 V to 300 V / 0,3 A to 100 A | 50 Hz & 60 Hz | $4{,}0 \times 10^{-3} \times P$ | 0,3 W to 30 kW / kVA(r) generate cosphi/sinphi > 0,25 | | |
| 1 V to 1000 V / 0,3 A to 100 A | 10 Hz to 1 kHz | $2{,}0 \times 10^{-3} \times P$ | 0,3 W to 100 kW / kVA(r) measure cosphi/sinphi > 0,5 | | |
| 1 V to 1000 V / 0,3 A to 100 A | 10 Hz to 1 kHz | $4{,}0 \times 10^{-3} \times P$ | 0,3 W to 100 kW / kVA(r) measure cosphi/sinphi > 0,25 | | |
| 3-phase, direct with measuring clamps | | | | | |
| 1 V to 300 V / 20 A to 500 A | 50 Hz & 60 Hz | $11 \times 10^{-3} \times P$ | 20 W to 150 kW / kVA(r) generate cosphi/sinphi > 0,25 | P2-02-E.013 P2-02-E.022 | AN, OS |
| 1 V to 1000 V / 20 A to 100 A | 15 Hz to 440 Hz | $16 \times 10^{-3} \times P$ | 20 W to 100 kW / kVA(r) measure cosphi/sinphi > 0,25 | | |
| Phase / phase angle | | | | | |
| Cosphi/sinphi -1 to 1 | 10 Hz to 1 kHz | 0,000 40 | measure / generate | P2-02-E.018 | AN, OS |
| Phase angle -180 to 180 ° | 10 Hz to 1 kHz | 0,02° | measure / generate | | |

P indicates active,reactive as well as apparent power.

RF Power

| Range amplitude | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| -67 dBm to -19 dBm | 20 kHz to 100 MHz | 0,056 dB | • measure | P2-02-E.036 | AN |
| | 100 MHz to 4 GHz | 0,047 dB | | | |
| -19 dBm to 1 dBm | 20 kHz to 100 MHz | 0,066 dB | • measure | P2-02-E.036 | AN |
| | 100 MHz to 4 GHz | 0,058 dB | | | |
| 1 dBm to 23 dBm | 20 kHz to 100 MHz | 0,083 dB | • measure | P2-02-E.036 | AN |
| | 100 MHz to 4 GHz | 0,072 dB | | | |
| 24 dBm to 20 dBm | 10 Hz to 20 kHz | 0,050 dB | • generate | P2-02-E.035 | AN |
| | 20 kHz to 100 kHz | 0,050 dB | | | |
| | 100 kHz to 10 MHz | 0,050 dB | | | |
| | 10 MHz to 125 MHz | 0,050 dB | | | |
| 20 dBm to 14 dBm | 10 Hz to 20 kHz | 0,050 dB | • generate | P2-02-E.035 | AN |
| | 20 kHz to 100 kHz | 0,050 dB | | | |
| | 100 kHz to 10 MHz | 0,050 dB | | | |
| | 10 MHz to 125 MHz | 0,050 dB | | | |
| | 125 MHz to 300 MHz | 0,10 dB | | | |
| | 300 MHz to 1,4 GHz | 0,25 dB | | | |
| 14 dBm to -17 dBm | 10 Hz to 20 kHz | 0,050 dB | • generate | P2-02-E.035 | AN |
| | 20 kHz to 100 kHz | 0,050 dB | | | |
| | 100 kHz to 10 MHz | 0,050 dB | | | |
| | 10 MHz to 125 MHz | 0,050 dB | | | |
| | 125 MHz to 300 MHz | 0,10 dB | | | |
| | 300 MHz to 1,4 GHz | 0,25 dB | | | |
| | 1,4 GHz to 3 GHz | 0,30 dB | | | |
| | 3 GHz to 4 GHz | 0,50 dB | | | |

| | | | | | |
|---|---|---|---|---|---|
| -17 dBm to -48 dBm | 10 Hz to 20 kHz | 0,050 dB | • generate | P2-02-E.035 | AN |
| | 20 kHz to 100 kHz | 0,050 dB | | | |
| | 100 kHz to 10 MHz | 0,050 dB | | | |
| | 10 MHz to 125 MHz | 0,050 dB | | | |
| | 125 MHz to 300 MHz | 0,10 dB | | | |
| | 300 MHz to 1,4 GHz | 0,50 dB | | | |
| | 1,4 GHz to 3 GHz | 0,50 dB | | | |
| | 3 GHz to 4 GHz | 0,50 dB | | | |
| -48 dBm to -74 dBm | 100 kHz to 10 MHz | 0,20 dB | • generate | P2-02-E.035 | AN |
| | 10 MHz to 125 MHz | 0,20 dB | | | |
| | 125 MHz to 300 MHz | 0,20 dB | | | |
| | 300 MHz to 1,4 GHz | 0,50 dB | | | |
| | 1,4 GHz to 3 GHz | 0,50 dB | | | |
| | 3 GHz to 4 GHz | 0,50 dB | | | |
| -74 dBm to -84 dBm | 100 kHz to 10 MHz | 0,50 dB | • generate | P2-02-E.035 | AN |
| | 10 MHz to 125 MHz | 0,50 dB | | | |
| | 125 MHz to 300 MHz | 0,50 dB | | | |
| | 300 MHz to 1,4 GHz | 1,0 dB | | | |
| | 1,4 GHz to 3 GHz | 1,0 dB | | | |
| | 3 GHz to 4 GHz | 1,0 dB | | | |
| -84 dBm to -94 dBm | 100 kHz to 10 MHz | 0,50 dB | • generate | P2-02-E.035 | AN |
| | 10 MHz to 125 MHz | 0,50 dB | | | |
| | 125 MHz to 300 MHz | 0,50 dB | | | |
| | 300 MHz to 1,4 GHz | 1,0 dB | | | |
| | 1,4 GHz to 3 GHz | 1,0 dB | | | |
| -94 dBm to -124 dBm | 100 kHz to 10 MHz | 1,5 dB | • generate | P2-02-E.035 | AN |
| | 10 MHz to 125 MHz | 1,5 dB | | | |
| | 125 MHz to 300 MHz | 1,5 dB | | | |
| | 300 MHz to 1,4 GHz | 1,5 dB | | | |
| | 1,4 GHz to 3 GHz | 1,5 dB | | | |

Impedance (DC/LF)

Measure

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| 1 Ω | DC | $11 \times 10^{-6} \times R$ | • Transfer standard in "30 day" loop<br>• Fixed points<br>• Measuring<br>• 4-wire resistance measurement<br>• Negligible dissipated power | P2-02-E.006 | AN, OS |
| 10 Ω | DC | $9{,}5 \times 10^{-6} \times R$ | | | |
| 100 Ω | DC | $6{,}5 \times 10^{-6} \times R$ | | | |
| 1 kΩ | DC | $4{,}5 \times 10^{-6} \times R$ | | | |
| 10 kΩ | DC | $4{,}5 \times 10^{-6} \times R$ | | | |
| 100 kΩ | DC | $7{,}5 \times 10^{-6} \times R$ | | | |
| 1 MΩ | DC | $1{,}4 \times 10^{-5} \times R$ | | | |
| 10 MΩ | DC | $2{,}5 \times 10^{-5} \times R$ | | | |
| 100 MΩ | DC | $2{,}0 \times 10^{-4} \times R$ | | | |
| **Measuring range or point** | **Frequency** | **expanded uncertainty (*)** | **Remark** | **Calibration procedure** | |
| 0 Ω to 2 Ω | DC | $18 \times 10^{-6} \times R$ or 20 μΩ[1] | • measure<br>• 4-wire resistance measurement<br>• negligible dissipated power | P2-02-E.019 | AN, OS |
| 2 Ω to 20 Ω | DC | $3{,}1 \times 10^{-6} \times R$ | | | |
| 20 Ω to 200 Ω | DC | $5{,}5 \times 10^{-6} \times R$ | | | |
| 0,2 kΩ to 2 kΩ | DC | $2{,}6 \times 10^{-6} \times R$ | | | |
| 2 kΩ to 20 kΩ | DC | $5{,}0 \times 10^{-6} \times R$ | | | |
| 20 kΩ to 200 kΩ | DC | $6{,}3 \times 10^{-6} \times R$ | | | |
| 0,2 MΩ to 2 MΩ | DC | $6{,}0 \times 10^{-6} \times R$ | | | |
| 2 MΩ to 20 MΩ | DC | $11 \times 10^{-6} \times R$ | | | |
| 20 MΩ to 200 MΩ | DC | $60 \times 10^{-6} \times R$ | | | |
| 0,2 GΩ to 2 GΩ | DC | $1{,}2 \times 10^{-3} \times R$ | | | |

[1] Whichever is greater

Generate

| Generating range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| 0 Ω | DC | 100 μΩ | | | |
| 1 mΩ | DC | $12 \times 10^{-6} \times R$ | • generate<br>• standard resistors<br>• also combinations of these resistors1<br>• 4-wire resistance<br>• maximum dissipated power 10 mW[1,2] | P2-02-E.020 | AN |
| 10 mΩ | DC | $12 \times 10^{-7} \times R$ | | | |
| 100 mΩ | DC | $3 \times 10^{-6} \times R$ | | | |
| 1 Ω | DC | $12 \times 10^{-7} \times R$ | | | |
| 10 Ω, 25 Ω, 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ | DC | $5 \times 10^{-7} \times R$ | | | |
| 1 MΩ | DC | $15 \times 10^{-7} \times R$ | | | |
| 10 MΩ | DC | $8 \times 10^{-6} \times R$ | | | |
| 100 MΩ | DC | $2 \times 10^{-5} \times R$ | | | |
| 1 GΩ | DC | $7 \times 10^{-5} \times R$ | | | |
| 10 GΩ | DC | $3 \times 10^{-4} \times R$ | | | |
| 100 GΩ | DC | $1 \times 10^{-3} \times R$ | | | |
| 1 TΩ | DC | $2 \times 10^{-3} \times R$ | | | |
| 10 TΩ | DC | $6 \times 10^{-3} \times R$ | | | |
| 100 TΩ | DC | $2 \times 10^{-2} \times R$ | | | |
| 378 Ω | DC | $4 \times 10^{-6} \times R$ | | | |
| 10 Ω | 75 Hz | $3{,}0 \times 10^{-6} \times R$ | • generate<br>• standard resistors<br>• also combinations of these resistors[1]<br>• 4- wire resistance | P2-02-E.020 | AN |
| 25 Ω | 75 Hz | $1{,}5 \times 10^{-6} \times R$ | | | |
| 100 Ω | 75 Hz | $1{,}5 \times 10^{-6} \times R$ | | | |
| 378 Ω | 75 Hz | $3{,}0 \times 10^{-6} \times R$ | | | |

[1] The uncertainty varies as the combinations and the dissipated power are different.

[2] these resistors can be used to generate/measure currents from 10pA up to 10A with decreased uncertainties.

Calibration of resistor / insulation meters

| Measuring range or point | @Voltage range | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| 10 kΩ to 40 MΩ | 50 V to 250 V | $1{,}0 \times 10^{-4} \times R$ | | RP/02/KC/E.17 | AN, OS |
| 40 MΩ to 200 MΩ | | $5{,}0 \times 10^{-4} \times R$ | | | |
| 100 kΩ to 200 MΩ | 250 V to 1000 V | $1{,}0 \times 10^{-4} \times R$ | | | |
| 200 MΩ to 1000 MΩ | | $3{,}0 \times 10^{-4} \times R$ | | | |
| 1 MΩ to 10 GΩ | 1 kV to 10 kV | $60 \times 10^{-4} \times R$ | | | |

Capacity

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| 10 pF to 100 pF | 1 kHz | $15 \times 10^{-4} \times C$ | Measure / generate | P2-02-E.010 | AN |
| 100 pF to 1000 nF | 1 kHz | $10 \times 10^{-4} \times C$ | Measure / generate | | |
| 1000 nF to 10 µF | 100 Hz & 1 kHz | $6 \times 10^{-4} \times C$ | Measure / generate | | |
| 10 µF tot 100 µF | 100 Hz & 1 kHz | $7 \times 10^{-4} \times C$ | Measure / generate | | |
| 10 pF, 100 pF, 1 nF, 10 nF | 1 kHz | $1{,}0 \times 10^{-4} \times C$ | Generate | P2-02-E.040 | AN |
| 100 nF, 1 µF | 1 kHz | $1{,}5 \times 10^{-4} \times C$ | | | |
| 10 µF | 1 kHz | $3{,}0 \times 10^{-4} \times C$ | | | |
| 100 µF | 1 kHz | $5{,}0 \times 10^{-4} \times C$ | | | |
| 1 µF | 100 Hz | $2{,}0 \times 10^{-4} \times C$ | | | |
| 10 µF | 100 Hz | $3{,}0 \times 10^{-4} \times C$ | | | |
| 100 µF | 100 Hz | $5{,}0 \times 10^{-4} \times C$ | | | |

Inductance

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | calibration/procedure | |
|---|---|---|---|---|---|
| 100 µH to 1 H | 1 kHz | $10 \times 10^{-4} \times L$ | Measure / generate | P2-02-E.010 | AN |
| 1 H to 10 H | 1 kHz | $20 \times 10^{-4} \times L$ | Measure / generate | | |
| 100 µH, 1 mH, 10 mH, 100 mH, 1H | 1 kHz | $5{,}0 \times 10^{-4} \times L$ | Generate | P2-02-E.040 | AN |
| 10 H | 100 Hz, 1 kHz | $7{,}0 \times 10^{-4} \times L$ | | | |

Oscilloscopes (on screen) – input impedance 50 Ω and 1 MΩ

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| ± 1 mV to 200 V | DC | $2{,}5 \times 10^{-4} \times U + 25\ \mu V$ | 50 Ω to 5,56 V | P2-02-E.007 | AN, OS |
| 1 mVpp to 21 mVpp | 10 Hz to 10 kHz | $25 \times 10^{-4} \times U + 10\ \mu V$ | Square wave | | |
| 21 mVpp to 556 mVpp | 10 Hz to 10 kHz | $10 \times 10^{-4} \times U + 10\ \mu V$ | Square wave | | |
| 556 mVpp to 210 Vpp | 10 Hz to 10 kHz | $5{,}0 \times 10^{-4} \times U + 10\ \mu V$ | Square wave 50 Ω to 5,56 V | | |
| 4,44 mVpp to 5,56 Vpp | 100 mHz to 100 MHz | $1{,}5 \times 10^{-2} \times U$ | Sine wave | | |
| 4,44 mVpp to 5,56 Vpp | 100 MHz to 550 MHz | $3{,}0 \times 10^{-2} \times U$ | Sine wave | | |
| 4,44 mVpp to 3,35 Vpp | 550 MHz to 1 GHz | $4{,}0 \times 10^{-2} \times U$ | Sine wave | | |
| 4,44 mVpp to 3,54 Vpp | 1 GHz to 4 GHz | $6{,}0 \times 10^{-2} \times U$ | Sine wave | | |
| 500 ps | - | 40 ps | Rise/ falltime (max. 3 V) | | |
| 250 ps to 10 ks | - | $5{,}0 \times 10^{-9} \times t$ | Time base | | |
| 40 Ω to 90 Ω | 1 kHz | $1{,}0 \times 10^{-3} \times Z$ | Input impedance | | |
| 0,8 MΩ to 1,2 MΩ | | | | | |
| 10 Ω to 150 Ω | 1 kHz | $5{,}0 \times 10^{-3} \times Z$ | Input impedance | | |
| 50 kΩ to 12 MΩ | | | | | |
| | 0,1 Hz to 100 MHz | 0,15 dB | Attenuation at bandwidth | | |
| | 100 MHz to 550 MHz | 0,30 dB | Attenuation at bandwidth | | |
| | 550 MHz to 1 GHz | 0,40 dB | Attenuation at bandwidth | | |
| | 1 GHz to 4 GHz | 0,50 dB | Attenuation at bandwidth | P2-02-E.035 | AN, OS |

Bridge calibration

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure | |
|---|---|---|---|---|---|
| -2,5 mV / V to 2,5 mV / V | 225 Hz | $50 \times 10^{-6}$ mV / V | 5 V supply / 350 Ω bridges | | AN, OS |

(*) the smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**DCLF Electricity Wellin**

**Calibration and Measurement Capabilities**

Direct voltage

Measure

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure |
|---|---|---|---|---|
| 0 mV to 200 mV | DC | $5{,}0 \times 10^{-6} \times U + 2{,}0\ \mu V$ | • measure<br>• positive / negative | P2-02-E.019.C |
| 0,2 V to 2 V | DC | $5{,}0 \times 10^{-6} \times U + 2{,}0\ \mu V$ | | |
| 2 V to 20 V | DC | $5{,}0 \times 10^{-6} \times U + 5{,}0\ \mu V$ | | |
| 20 V to 200 V | DC | $5{,}5 \times 10^{-6} \times U + 60\ \mu V$ | | |
| 200 V to 1000 V | DC | $10{,}0 \times 10^{-6} \times U + 550\ \mu V$ | | |

Generate

| Generating range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure |
|---|---|---|---|---|
| 0 mV to 220 mV | DC | $8{,}0 \times 10^{-6} \times U + 2{,}0\ \mu V$ | • generate<br>• positive / negative | P2-02-E.039.C |
| 220 mV to 2,2 V | DC | $8{,}0 \times 10^{-6} \times U + 2{,}0\ \mu V$ | | |
| 2,2 V to 22 V | DC | $8{,}0 \times 10^{-6} \times U + 6{,}5\ \mu V$ | | |
| 22 V to 220 V | DC | $9{,}0 \times 10^{-6} \times U + 80\ \mu V$ | | |
| 220 V to 1100 V | DC | $11 \times 10^{-6} \times U + 500\ \mu V$ | | |

Direct current

Measure

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure |
|---|---|---|---|---|
| 0 µA to 200 µA | DC | $12 \times 10^{-6} \times I + 1{,}0\ nA$ | • measure<br>• in the lowest possible range<br>• positive / negative | P2-02-E.019.C |
| 0,2 mA to 2,0 mA | DC | $12 \times 10^{-6} \times I + 6{,}0\ nA$ | | |
| 2,0 mA to 20 mA | DC | $15 \times 10^{-6} \times I + 50\ nA$ | | |
| 20 mA to 200 mA | DC | $55 \times 10^{-6} \times I + 2{,}5\ \mu A$ | | |
| 0,2 A to 2 A | DC | $20 \times 10^{-5} \times I + 20\ \mu A$ | | |
| 2 A to 20 A | DC | $41 \times 10^{-5} \times I + 450\ \mu A$ | | |
| 10 A to 100 A | DC | $2 \times 10^{-5} \times I + 2\ mA$ | | P2-02-E.058 |

Calibration of current clamps

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure |
|---|---|---|---|---|
| 20 A to 1000 A | DC | $5{,}0 \times 10^{-3} \times I$ | • with current coils | P2-02-E.021 |

Generate

| Generating range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure |
|---|---|---|---|---|
| 0 µA to 2,2 mA | DC | $55 \times 10^{-6} \times I + 8{,}0\ nA$ | • generate<br>• positive / negative | P2-02-E.039.C |
| 2,2 mA to 22 mA | DC | $55 \times 10^{-6} \times I + 80\ nA$ | | |
| 22 mA to 220 mA | DC | $90 \times 10^{-6} \times I + 1{,}0\ \mu A$ | | |
| 220 mA to 2,2 A | DC | $12 \times 10^{-5} \times I + 30\ \mu A$ | | |
| 2,2 A to 11 A | DC | $38 \times 10^{-5} \times I + 490\ \mu A$ | | |
| 2 A to 20 A | DC | $1 \times 10^{-5} \times I + 0{,}3\ mA$ | | P2-02-E.058 |
| 20 A to 100 A | DC | $2 \times 10^{-5} \times I + 2\ mA$ | | |

Alternating voltage

Measure

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure |
|---|---|---|---|---|
| 10 mV to 200 mV | 20 Hz to 10 kHz | $14 \times 10^{-5} \times U + 5{,}0\ \mu V$ | • measure | P2-02-E.019.C |
| | 10 kHz to 30 kHz | $35 \times 10^{-5} \times U + 10\ \mu V$ | | |
| | 30 kHz to 100 kHz | $77 \times 10^{-5} \times U + 22\ \mu V$ | | |
| 200 mV to 2 V | 20 Hz to 10 kHz | $12 \times 10^{-5} \times U + 25\ \mu V$ | • measure | P2-02-E.019.C |
| | 10 kHz to 30 kHz | $25 \times 10^{-5} \times U + 50\ \mu V$ | | |
| | 30 kHz to 100 kHz | $57 \times 10^{-5} \times U + 210\ \mu V$ | | |
| 2 V to 20 V | 20 Hz to 10 kHz | $12 \times 10^{-5} \times U + 200\ \mu V$ | • measure | P2-02-E.019.C |
| | 10 kHz to 30 kHz | $25 \times 10^{-5} \times U + 400\ \mu V$ | | |
| | 30 kHz to 100 kHz | $58 \times 10^{-5} \times U + 2000\ \mu V$ | | |
| 20 V to 200 V | 20 Hz to 10 kHz | $12 \times 10^{-5} \times U + 2{,}0\ mV$ | • measure | P2-02-E.019.C |
| | 10 kHz to 30 kHz | $22 \times 10^{-5} \times U + 5{,}0\ mV$ | | |
| | 30 kHz to 100 kHz | $57 \times 10^{-5} \times U + 22\ mV$ | | |
| 200 V to 1000 V | 50 Hz to 10 kHz | $30 \times 10^{-5} \times U + 50\ mV$ | • measure | P2-02-E.019.C |
| | 10 kHz to 30 kHz | $15 \times 10^{-4} \times U + 50\ mV$ | | |

Generate

| Generating range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure |
|---|---|---|---|---|
| 2,2 mV to 22 mV | 20 Hz to 20 kHz | $13 \times 10^{-5} \times U + 6{,}0\ \mu V$ | • generate | P2-02-E.039.C |
| | 20 kHz to 100 kHz | $87 \times 10^{-5} \times U + 30\ \mu V$ | | |
| 22 mV to 220 mV | 20 Hz to 20 kHz | $13 \times 10^{-5} \times U + 9{,}0\ \mu V$ | • generate | |
| | 20 kHz to 100 kHz | $88 \times 10^{-5} \times U + 30\ \mu V$ | | |
| 0,22 V to 2,2 V | 20 Hz to 20 kHz | $10 \times 10^{-5} \times U + 10\ \mu V$ | • generate | |
| | 20 kHz to 100 kHz | $26 \times 10^{-5} \times U + 90\ \mu V$ | | |
| 2,2 V to 22 V | 40 Hz to 20 kHz | $11 \times 10^{-5} \times U + 70\ \mu V$ | • generate | |
| | 20 kHz to 100 kHz | $28 \times 10^{-5} \times U + 360\ \mu V$ | | |
| 22 V to 220 V | 40 Hz to 20 kHz | $11 \times 10^{-5} \times U + 1{,}0\ mV$ | • generate | |
| | 20 kHz to 100 kHz | $52 \times 10^{-5} \times U + 10\ mV$ | | |
| 220 V to 1100 V | 50 Hz to 1 kHz | $11 \times 10^{-5} \times U + 5{,}0\ mV$ | • generate | |
| | 1 kHz to 20 kHz | $18 \times 10^{-5} \times U + 8{,}0\ mV$ | | |

Alternating current

Measure

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure |
|---|---|---|---|---|
| 10 µA to 200 µA | 55 Hz to 5 kHz | $31 \times 10^{-5} \times I + 40\ nA$ | • measure | P2-02-E.019.C |
| 0,2 mA to 2 mA | 50 Hz to 5 kHz | $31 \times 10^{-5} \times I + 400\ nA$ | | |
| 2 mA to 20 mA | 50 Hz to 5 kHz | $31 \times 10^{-5} \times I + 2{,}5\ \mu A$ | | |
| 20 mA to 200 mA | 50 Hz to 5 kHz | $30 \times 10^{-5} \times I + 25\ \mu A$ | | |
| 0,2 A to 2 A | 50 Hz to 1 kHz | $63 \times 10^{-5} \times I + 25\ \mu A$ | | |
| | 1 kHz to 5 kHz | $73 \times 10^{-5} \times I + 25\ \mu A$ | | |
| 2 A to 20 A | 50 Hz to 1 kHz | $85 \times 10^{-5} \times I + 250\ \mu A$ | | |

Calibration of current clamps

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure |
|---|---|---|---|---|
| 20 A to 1000 A | 45 Hz to 440 Hz | $5{,}0 \times 10^{-3} \times I$ | • with current coils | P2-02-E.021 |

Generate

| Generating range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure |
|---|---|---|---|---|
| 10 µA to 220 µA | 40 Hz to 1 kHz | $14 \times 10^{-5} \times I$ + 35 nA | • generate | P2-02-E.039.C |
| 220 µA to 2,2 mA | 40 Hz to 1 kHz | $20 \times 10^{-5} \times I$ + 35 nA | | |
| 2,2 mA to 22 mA | 40 Hz to 1 kHz | $20 \times 10^{-5} \times I$ + 350 nA | | |
| 22 mA to 220 mA | 40 Hz to 1 kHz | $20 \times 10^{-5} \times I$ + 3,5 µA | | |
| 220 mA to 2,2 A | 40 Hz to 1 kHz | $70 \times 10^{-5} \times I$ + 35 µA | | |
| 2,2 A to 11 A | 40 Hz to 1 kHz | $65 \times 10^{-5} \times I$ + 200 µA | | |

Impedance (DC/LF)

Measure

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure |
|---|---|---|---|---|
| 0 Ω to 2 Ω | DC | $(18 \times 10^{-6} \times R + 5{,}0\ \mu\Omega)$ or 20 μΩ[1] | • measure<br>• 4-wire resistance measurement<br>• negligible dissipated power | P2-02-E.019.C |
| 2 Ω to 20 Ω | DC | $10 \times 10^{-6} \times R$ + 15 μΩ | | |
| 20 Ω to 200 Ω | DC | $10 \times 10^{-6} \times R$ + 50 μΩ | | |
| 200 Ω to 2 kΩ | DC | $10 \times 10^{-6} \times R$ + 500 μΩ | | |
| 2 kΩ to 20 kΩ | DC | $10 \times 10^{-6} \times R$ + 5 mΩ | | |
| 20 kΩ to 200 kΩ | DC | $10 \times 10^{-6} \times R$ + 50 mΩ | | |
| 0,2 MΩ to 2 MΩ | DC | $11 \times 10^{-6} \times R$ + 1,2 Ω | | |
| 2 MΩ to 20 MΩ | DC | $25 \times 10^{-6} \times R$ + 120 Ω | | |
| 20 MΩ to 200 MΩ | DC | $13 \times 10^{-5} \times R$ + 12 kΩ | | |
| 200 MΩ to 2 GΩ | DC | $16 \times 10^{-4} \times R$ + 1,2 MΩ | | |

[1] Whichever is greater

Generate

| Generating range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure |
|---|---|---|---|---|
| 0 Ω | DC | 100 μΩ | • generate<br>• fixed points<br>• 4-wire resistance<br>• lowest possible power dissipation<br>• * 2-wire resistance | P2-02-E.039.C |
| 1 Ω, 1,9 Ω | DC | $12 \times 10^{-5} \times R$ | | |
| 10 Ω, 19 Ω | DC | $35 \times 10^{-6} \times R$ | | |
| 100 Ω, 190 Ω | DC | $20 \times 10^{-6} \times R$ | | |
| 1 kΩ, 1,9 kΩ, 10 kΩ, 19 kΩ, 100 kΩ, 190 kΩ | DC | $17 \times 10^{-6} \times R$ | | |
| 1 MΩ, 1,9 MΩ | DC | $30 \times 10^{-6} \times R$ | | |
| 10 MΩ, 19 MΩ | DC | $60 \times 10^{-6} \times R$ | | |
| 100 MΩ* | DC | $15 \times 10^{-5} \times R$ | | |

Calibration of resistor / insulation meters

| Measuring range or point | Resistance | expanded uncertainty (*) | Remark | Calibration procedure |
|---|---|---|---|---|
| 50 V to 250 V | 10 kΩ to 40 MΩ | $1{,}0 \times 10^{-4} \times R$ | | P2-02-E.017 |
| | 40 MΩ to 200 MΩ | $5{,}0 \times 10^{-4} \times R$ | | |
| 250 V to 1000 V | 100 kΩ to 200 MΩ | $1{,}0 \times 10^{-4} \times R$ | | |
| | 200 MΩ to 1000 MΩ | $3{,}0 \times 10^{-4} \times R$ | | |

Capacity

| Measuring range or point | Frequency | expanded uncertainty (*) | Remark | Calibration procedure |
|---|---|---|---|---|
| 1 μF | From 20Hz to 1 kHz | 0,50% | Capacitance generation on all DUTs with a "capacitance measurement" function with a sinusoidal measurement signal | P2-02-E.053 |
| 10 μF | | | | |

(*) the smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Time and Frequency Wommelgem**

**Calibration and Measurement Capabilities**

Relative time

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Tachometers, stroboscopes (optical) | 1,2 rpm to 100 000 rpm | $3{,}0 \times 10^{-7} \times n$ | | P2-02-E.041 |
| Mechanical tachometers | 10 rpm to 17 000 rpm | $0{,}050 \text{ rpm} + 10 \times 10^{-5} \times n$ | | P2-02-E.046 |

n: number of rotations in rpm

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Frequencymeters, frequencygenerators, counters | 1 Hz | $5{,}0 \times 10^{-11} \times f$ | • generate<br>• fixed points | P2-02-E.004 |
| | 1 MHz | $5{,}0 \times 10^{-11} \times f$ | | |
| | 5 MHz | $5{,}0 \times 10^{-11} \times f$ | | |
| | 10 MHz | $5{,}0 \times 10^{-11} \times f$ | | |
| | 0,002 Hz to 3 GHz | $6{,}0 \times 10^{-11} \times f$ | • meassure | P2-02-E008 |
| | 0,002 Hz to 4 GHz | $5{,}0 \times 10^{-9} \times f$ | • generate | RP/02/KC/E.01<br>P2-02-E.007<br>P2-02-E035 |

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Electronic chronometers | n.a. | 0,10 s / 24 h | direct measurement | P2-02-E.014 |
| Mechanic chronometers | n.a. | 5,0 s / 24 h | direct measurement | |
| Electronic & mechanic chronometers | Standard 0 h to 72 h | 0,50 s / 24 h with a minimum van 0,30 s | By comparison with a standard chronometer via a digital-optical recorder | P1-02-E.003 |
| Signal-triggered chronometers | Standard 0 h to 72 h | 0,15 s / 24 h with a minimum van 0,060 s | By comparison with a standard chronometer via a digital-optical recorder | |

(*) the smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Time and Frequency Wellin**
**Calibration and Measurement Capabilities**

Relative time

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Tachometers, stroboscopes (optical) | 6 rpm to 100 000 rpm | $3{,}0 \times 10^{-7} \times n$ | | P2-02-E.041 |

$n$ : number of rotations in rpm

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Frequency meter, Reference oscillator | 1 Hz | $5 \times 10^{-11} \times f$ | Frequency generated by a Rubidium controlled by GPS. Calibration made by generation or comparison. | P2-02-E.031D |
| | 1 MHz | | | P2-02-E.031D |
| | 5 MHz | | | P2-02-E.031D |
| | 10 MHz | | | P2-02-E.031D |
| | 0,1 Hz to 10 MHz | $1 \times 10^{-10} \times f$ + 0,1 µHz | Frequency generation | P2-02-E.054 |
| | 10 MHz to 45 GHz | 2 Hz | | P2-02-E.056 |
| Frequency generator | 0,1 Hz to 10 MHz | $6 \times 10^{-11} \times f$ + 0,1 µHz | Frequency measurement (Square wave) | P2-02-E.055 |
| | 10 Hz to 3 GHz | $6 \times 10^{-11} \times f$ + 0,1 mHz | Frequency measurement (Sine wave) | P2-02-E.055 |
| | 3 GHz to 45 GHz | $6 \times 10^{-11} \times f$ + 2 Hz | Frequency measurement | P2-02-E.057 |

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Electronic chronometers | n.a. | 0,10 s / 24 h | direct measurement | P2-02-E.014 |
| Mechanic chronometers | n.a. | 5,0 s / 24 h | direct measurement | |

(*) the smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Dimensional Quantities Wommelgem**

**Calibration and Measurement Capabilities**

Length gauges

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Central length steel | 0,5 mm to 100 mm<br>0,02 inch to 4 inch | $0{,}060\ \mu m + 0{,}90 \times 10^{-6} \times l$ | fixed sizes | P2-02-G.001 |
| Central length tungsten carbide | | $0{,}060\ \mu m + 0{,}70 \times 10^{-6} \times l$ | | |
| Central length ceramic | | $0{,}060\ \mu m + 0{,}80 \times 10^{-6} \times l$ | | |
| | | $0{,}060\ \mu m + 1{,}2 \times 10^{-6} \times l$ | reference steel | |
| Central length steel, tungsten carbide, ceramic | 0,05 mm to 500 mm<br>0,005 inch to 20 inch | $0{,}10\ \mu m + 2{,}0 \times 10^{-6} \times l$ | all sizes | P2-02-G.003 |
| Lengthvariation steel, tungsten carbide, ceramic | 0,5 mm to 100 mm<br>0,02 inch to 4 inch | 0,050 µm | | P2-02-G.002 |
| Step gauge | to 1200 mm | $0{,}80\ \mu m + 3{,}0 \times 10^{-6} \times l$ | | P2-02-G.011 |

Clinometers
See 1.5.13

Line scales, distances

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Ruler (all models) | to 200 mm | $1{,}5\ \mu m + 3{,}0 \times 10^{-6} \times l$ | e.g. spring rule | P2-02-G.094<br>P2-02-G.100 |
| | to 400 mm | $2{,}0\ \mu m + 3{,}0 \times 10^{-6} \times l$ | | |
| | to 3000 mm | $12\ \mu m + 3{,}0 \times 10^{-6} \times l$ | | |
| | to 100 m | $6{,}0\ \mu m + 5{,}0 \times 10^{-6} \times l$ | | P2-02-G.143 |
| Feeler gauges | to 5 mm | $0{,}50\ \mu m + 2{,}0 \times 10^{-6} \times l$ | | P2-02-G.011<br>P2-02-G.041<br>P2-02-G.068<br>P2-02-G.070<br>P2-02-G.127 |
| Setting standard for external micrometers | to 300 mm | $0{,}50\ \mu m + 2{,}0 \times 10^{-6} \times l$ | | P2-02-G.011<br>P2-02-G.012<br>P2-02-G.041<br>P2-02-G.068<br>P2-02-G.070<br>P2-02-G.127 |
| | 300 to 500 mm | $0{,}90\ \mu m + 0{,}60 \times 10^{-6} \times l$ | | |
| | 500 to 3000 mm | $3{,}0\ \mu m + 3{,}0 \times 10^{-6} \times l$ | | |
| Other distance of 2 parallel planes | to 300 mm | $0{,}50\ \mu m + 2{,}0 \times 10^{-6} \times l$ | | P2-02-G.011<br>P2-02-G.012<br>P2-02-G.041<br>P2-02-G.068<br>P2-02-G.070<br>P2-02-G.127 |
| | 300 to 500 mm | $0{,}90\ \mu m + 0{,}60 \times 10^{-6} \times l$ | | |
| | 500 to 3000 mm | $3{,}0\ \mu m + 3{,}0 \times 10^{-6} \times l$ | | |

Length measuring instruments

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Hand held tools for external measurements | 0 mm to 200 mm | $0{,}45\ \mu m + 0{,}50 \times R + 25 \times 10^{-6} \times l$ | (1) e.g. vernier, micrometer, … | P2-02-G.050 |
| | 200 mm to 3000 mm | $4{,}0\ \mu m + 0{,}50 \times R + 5{,}0 \times 10^{-6} \times l$ | | P2-02-G.050 |
| Hand held tools for internal measurements | | | (1) e.g. internal micrometers | |
| 2-point | 0 mm to 200 mm | $0{,}70\ \mu m + 0{,}50 \times R + 25 \times 10^{-6} \times l$ | | P2-02-G.051 P2-02-G.055 |
| | 200 mm to 400 mm | $5{,}0\ \mu m + 0{,}50 \times R + 4{,}0 \times 10^{-6} \times l$ | | |
| 2- and 3-point | 0 mm to 250 mm | $1{,}5\ \mu m + 0{,}50 \times R + 25 \times 10^{-6} \times l$ | | P2-02-G.055 |
| Hand held tools for height and depth measurements | 0 mm to 500 mm | $0{,}70\ \mu m + 0{,}50 \times R + 25 \times 10^{-6} \times l$ | (1) | P2-02-G.052 P2-02-G.097 |
| Linear displacement sensor | to 200 mm | $0{,}050\ \mu m + 2{,}5 \times 10^{-6} \times l + 0{,}80 \times R$ | to 50 mm (1) | P2-02-G.042 P2-02-G.050 |
| Height gauge | to 1500 mm | $0{,}80\ \mu m + 0{,}70 \times R + 2{,}5 \times 10^{-6} \times l$ | (1) | P2-02-G.052 P2-02-G.098 |
| Film thickness gauge | to 2 mm | $1{,}0\ \mu m + 2{,}0 \times 10^{-3} \times l$ | (1) | P2-02-G.099 |
| Laser distance meter | to 25 m | $0{,}50\ mm + 40 \times 10^{-6} \times l + 0{,}60 \times R$ | | P2-02-G.045 P2-02-G.126 |

Diameter

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Setting rings and ring gauges | Ø 1 mm to Ø 250 mm | $0{,}50\ \mu m + 2{,}0 \times 10^{-6} \times l$ | | P2-02-G.039 P2-02-G.043 P2-02-G.121 |
| Cylindrical setting pins | to 200 mm | $0{,}50\ \mu m + 1{,}5 \times 10^{-6} \times l$ | | P2-02-G.041 P2-02-G.071 P2-02-G.121 P2-02-G.127 |
| Plain plug gauges | to 200 mm | $0{,}50\ \mu m + 1{,}5 \times 10^{-6} \times l$ | | |
| Thread wires | to 20 mm | $0{,}50\ \mu m + 1{,}5 \times 10^{-6} \times l$ | | P2-02-G.041 P2-02-G.071 P2-02-G.121 P2-02-G.127 |
| Radius gauge | to Ø 200 mm | $3{,}0\ \mu m + 5{,}0 \times 10^{-6} \times l$ | | P2-02-G.121 P2-02-G.136 |
| Other internal diameters | Ø 1 mm to Ø 250 mm | $0{,}50\ \mu m + 2{,}0 \times 10^{-6} \times l$ | | P2-02-G.039 P2-02-G.043 P2-02-G.121 |
| Other external diameters | Ø 0,05 mm to Ø 300 mm | $0{,}50\ \mu m + 1{,}5 \times 10^{-6} \times l$ | | P2-02-G.041 P2-02-G.071 P2-02-G.121 P2-02-G.127 |
| | Ø 300 mm to Ø 500 mm | $0{,}90\ \mu m + 0{,}60 \times 10^{-6} \times l$ | | P2-02-G.041 P2-02-G.071 P2-02-G.121 P2-02-G.127 |

Form error

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Knife edge straight edge | to 300 mm | 0,30 µm | | P2-02-G.028<br>P2-02-G.101<br>P2-02-G.111<br>P2-02-G.113<br>P2-02-G.128<br>P2-02-G.133 |
| Straight edge | to 6000 mm | $0{,}50\ \mu m + 0{,}50 \times 10^{-6} \times l$ | (1) | P2-02-G.028<br>P2-02-G.101<br>P2-02-G.113<br>P2-02-G.128<br>P2-02-G.133 |
| Surface plate | to 6 000 mm x 10 000 mm | $0{,}30\ \mu m + 1{,}6 \times 10^{-6} \times l$ | (1)<br>$l$ = longest side of the surface plate | P2-02-G.038 |
| Roundness tester | to 300 µm | 0,050 µm + 0,50 × R | (1) | P2-02-G.056 |
| Roundness standard | to Ø 300 mm | 0,050 µm + 0,020 × A | A = measured roundness | P2-02-G.027 |
| Flick standard (roundness standard) | to 1 mm | 0,25 µm | | P2-02-G.074 |

Roughness

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Surface texture measuring instruments | Ra: 0,05 µm to 5 µm | 0,040 × A + 0,50 × R (minimum 0,030 µm) | (1) A = Ra-value of reference | P2-02-G.059 |
| | Rz: 0,1 µm to 10 µm | 0,060 × A + 0,50 × R (minimum 0,050 µm) | (1) A = Rz-value of reference | |
| | Rmax: 0,1 µm to 10 µm | 0,060 × A + 0,50 × R (minimum 0,050 µm) | (1) A = Rmax-value of reference | |
| Roughness standards | Ra: to 10 µm | 0,025 µm + 0,060 × A | A = measured Ra-value | P2-02-G.025 |
| | Rz: to 15 µm | 0,030 µm + 0,090 × A | A = measured Rz-value | |
| | Rmax: to 15 µm | 0,030 µm + 0,090 × A | A = measured Rmax-value | |

Thread quantities

| **Thread external** | | | | |
|---|---|---|---|---|
| **Measured quantity, instrument or gauge** | **Range** | **expanded uncertainty (*)** | **Remarks** | **Calibration procedure** |
| Pitch | to 10 mm | 2 µm | | P2-02-G.011<br>P2-02-G.045 |
| Profile angle | to 180° | (0,50 + 12/$l$) bgmin | $l$ = leg length in mm | P2-02-G.040 |
| Simple pitch diameter | Ø 1 mm to Ø 300 mm | α = 30°: (6,0 µm to 9,7 µm) | Acc. to Euramet/CG-10, method 1a or 1b | P2-02-G.102 |
| | | α = 60°: (3,2 µm to 5,9 µm) | | |
| | | α = 90°: (2,6 µm to 5,5 µm) | | |
| Pitch diameter | Ø 3 mm to Ø 90 mm | $2{,}5\ \mu m + 5 \times 10^{-6} \times l$ | Acc. to Euramet/CG-10, method 2b, α ≥ 27° | PM2-02-G.002 |
| | | $4{,}5\ \mu m + 10 \times 10^{-6} \times l$ | Acc. to Euramet/CG-10, method 2b, α < 27° | PM2-02-G.002 |
| Outside, core diameter | Ø 3 mm to Ø 90 mm | $1{,}5\ \mu m + 10 \times 10^{-6} \times l$ | Acc. to Euramet/CG-10, method 2b | PM2-02-G.002 |

| Thread internal | | | | |
|---|---|---|---|---|
| **Measured quantity, instrument or gauge** | **Range** | **expanded uncertainty (*)** | **Remarks** | **Calibration procedure** |
| Pitch | to 10 mm | 2 µm | | P2-02-G.011<br>P2-02-G.045 |
| Profile angle | to 180° | (0,50 + 12//) bgmin | *l* = leg length in mm | P2-02-G.040 |
| Simple pitch diameter | Ø 4 mm to Ø 300 mm | α = 30°: (9,0 µm to 14 µm) | Acc. to Euramet/CG-10, method 1a or 1b | P2-02-G.106 |
| | | α = 60°: (3,6 µm to 7,0 µm) | | |
| | | α = 90°: (3,1 µm to 6,2 µm) | | |
| Pitch diameter | Ø 3 mm to Ø 90 mm | 2,5 µm + 10 × $10^{-6}$ × *l* | Acc. to Euramet/CG-10, method 2b, α ≥ 27° | PM2-02-G.002 |
| | | 4,5 µm + 10 × $10^{-6}$ × *l* | Acc. to Euramet/CG-10, method 2b, α < 27° | PM2-02-G.002 |
| Outside, core diameter | Ø 3 mm to Ø 90 mm | 1,5 µm + 10 × $10^{-6}$ × *l* | Acc. to Euramet/CG-10, method 2b | PM2-02-G.002 |

Coordinate measuring machines

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Deviation of nominal displacement | to 20 m | | e.g. 1D/2D/3D Measuring machine with: | |
| | | $0{,}15\ \mu m + 0{,}70 \times R + 1{,}0 \times 10^{-6} \times l$ | Zerodur scales; (1) | P2-02-G.046 |
| | | $0{,}15\ \mu m + 0{,}70 \times R + 1{,}3 \times 10^{-6} \times l$ | Glass scales; (1) | P2-02-G.046 |
| | | $0{,}15\ \mu m + 0{,}70 \times R + 1{,}6 \times 10^{-6} \times l$ | Steel scales; (1) | P2-02-G.046 |
| | to 400 mm | $0{,}30\ \mu m + 2{,}3 \times 10^{-6} \times l$ | using reference glass scale; (1) | P2-02-G.073 |
| Deviations transverse to the translation directions | to 0,5 mm | $0{,}30\ \mu m + 3{,}0 \times 10^{-6} \times l + 5{,}0 \times 10^{-3} \times A$ | A = measured deviation Measuring length to 3000 mm; (1) | P2-02-G.047 |
| Rotational deviations around the translation direction | to 400 as | $0{,}50\ as + 3{,}5 \times 10^{-3} \times A$ | A = measured angle; horizontal translation only; (1) | P2-02-G.048 P2-02-G.069 P2-02-G.124 |
| Other rotational deviations | to 7200 as | $0{,}50\ as + 1{,}6 \times 10^{-3} \times A$ | A = measured angle; measured length to 4500 mm; (1) | P2-02-G.048 P2-02-G.124 |

as = arcsecond

Angle gauges

| Measured quantity, instrument or gauge | Range | | Remarks | Calibration procedure |
|---|---|---|---|---|
| Angle gauge block | to 180° | $0{,}000\ 28° + 10 \times 10^{-6} \times A$ | A = measured angle | P2-02-G.120 P2-02-G.125 |
| | | $1{,}0” + 10 \times 10^{-6} \times A$ | | |
| Cylindrical square | to Ø 300 mm to height 300 mm | $0{,}30\ \mu m + 2{,}0 \times 10^{-6} \times l$ | Squareness | P2-02-G.032 P2-02-G.122 |
| Square | to 300 mm leg length | $0{,}30\ \mu m + 2{,}0 \times 10^{-6} \times l$ | Squareness | P2-02-G.032 P2-02-G.122 |
| Angle plate | 90° | 0,50 as | | P2-02-G.122 |
| Polygon | to 360 ° | 0,50 as | | P2-02-G.072 |
| Pentagonprism | 90 ° | 0,50 as | | P2-02-G.075 |

as = arcsecond

Angle (measuring instruments)

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Spirit level | to 12,5 mm/m | 0,50 µm/m + 1,0 × $10^{-3}$ × A + 0,7 × R | A = set angle | P2-02-G.091 |
| | to 2600 as | 0,10 as + 1,0 × $10^{-3}$ × A + 0,70 × R | | |
| Autocollimator | to 12,5 mm/m | 0,50 µm/m + 1,0 × $10^{-3}$ × A + 0,70 × R | A = set angle | P2-02-G.091 |
| | to 2600 as | 0,10 as + 1,0 × $10^{-3}$ × A + 0,70 × R | | |
| Angle meters | 0° - 360° | 0,50 amin | e.g. protractor; (1) | P2-02-G.120<br>P2-02-G.040 |
| Angle sensor | 0° - 360° | 2,0 as | e.g. protractor; (1) | P2-02-G.064 |
| Clinometers | 0° - 360° | 2,0 as | | P2-02-G.084 |
| Theodolites | 180° | 3,0 as | Rotation around vertical axis | P2-02-G.089 |
| | 180° | 1,5 as | Defining horizontal plane | P2-02-G.138 |
| | 180° | 1,8 as | Deviation of crosshairs to rotations | P2-02-G.090 |

as = arcsecond
amin = arcminute

Product measurement

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| **Form** | | | | |
| Surface profile | to 10 mm × 100 mm | 1,0 µm + 0,010 × A | A = measured profile height | P2-02-G.112 |
| Roughness value | Ra: to 10 µm | 0,025 µm + 0,060 × A | A = measured Ra-value | P2-02-G.025 |
| | Rz: to 15 µm | 0,030 µm + 0,090 × A | A = measured Rz-value | P2-02-G.025 |
| | Rmax: to 15 µm | 0,030 µm + 0,090 × A | A = measured Rmax-value | P2-02-G.025 |
| Straightness | to 10 mm × 100 mm | 1,0 µm + 0,010 × A | A = measured profile height | P2-02-G.112 |
| | to 300 mm | 0,30 µm | | P2-02-G.028<br>P2-02-G.101<br>P2-02-G.111<br>P2-02-G.113<br>P2-02-G.128<br>P2-02-G.133 |
| | to 6000 mm | 0,50 µm + 0,50 × $10^{-6}$ × L | (1) | P2-02-G.037 |
| **Roundness** | | | | |
| Roundness external | to Ø 300 mm | 0,050 µm + 0,020 × A | A = measured roundness | P2-02-G.027 |
| Roundness internal | Ø 0,7 mm to Ø 300 mm | 0,050 µm + 0,020 × A | A = measured roundness | P2-02-G.027 |
| **Cilindricity** | | | | |
| Cilindricity external | to Ø 300 mm<br>to height 300 mm | 0,40 µm + 0,040 × A | A = measured cilindricity | P2-02-G.030<br>P2-02-G.114 |
| Cilindricity internal | Ø 0,7 mm to Ø 300 mm<br>to height 300 mm | 0,40 µm + 0,040 × A | A = measured cilindricity | P2-02-G.030<br>P2-02-G.114 |
| Coaxiality and concentricity | Ø 0,7 mm to Ø300 mm<br>to height 300 mm | 0,10 µm + 0,040 × A | A = measured coaxiality / concentricity | P2-02-G.031<br>P2-02-G.115 |

| | | | | |
|---|---|---|---|---|
| **Planes or sides** | | | | |
| Flatness | to Ø 55 mm | 0,050 µm | | P2-02-G.038<br>P2-02-G.060<br>P2-02-G.116 |
| | to Ø 150 mm | 0,060 µm | | |
| | to Ø 290 mm | 0,15 µm | | |
| | to 6 000 mm × 10 000 mm | 0,50 µm + 1,5 × $10^{-6}$ × *l* | *l* = longest side of surface plate; (1) | P2-02-G.060 |
| Angle between sides or planes | to 180° | (0,50 + 12/*l*) amin | *l* = leg length in mm; leg length to 200 mm | P2-02-G.040<br>P2-02-G.049<br>P2-02-G.120 |
| | | 3,0 as | optical surfaces | |
| Squareness | to 1200 x 550 mm | 2,1 µm + 4,0 × $10^{-6}$ × *l* | *l* = leg length<br>ratio leg length : reference length = 1 : 1 | P2-02-G.082<br>P2-02-G.122<br>P2-02-G.131 |
| Parallelism | to 1200 mm | 1,0 µm + 2,0 × $10^{-6}$ × *l* | *l* = leg length | P2-02-G.132<br>P2-02-G.135 |
| **Diameter** | | | | |
| External | Ø 0,05 mm to Ø 300 mm | 0,50 µm + 1,5 × $10^{-6}$ × *l* | | P2-02-G.041<br>P2-02-G.071<br>P2-02-G.121<br>P2-02-G.127<br>P2-02-G.136 |
| | Ø 300 mm to Ø 500 mm | 0,90 µm + 0,60 × $10^{-6}$ × *l* | | |
| | Ø 500 mm to Ø 3000 mm | 0,40 µm + 2,0 × $10^{-6}$ × *l* | | |
| Internal | Ø 1 mm to Ø 250 mm | 0,50 µm + 2,0 × $10^{-6}$ × *l* | | P2-02-G.039<br>P2-02-G.043 |
| **Distance of 2 parallel surfaces** | | | | |
| External | to 200 mm | 0,50 µm + 2,0 × $10^{-6}$ × *l* | | P2-02-G.011<br>P2-02-G.012<br>P2-02-G.041<br>P2-02-G.045<br>P2-02-G.068<br>P2-02-G.070<br>P2-02-G.127 |
| | to 3000 mm | 0,40 µm + 4,0 × $10^{-6}$ × *l* | | |
| Internal | to 1200 mm | 1,2 µm + 4,0 × $10^{-6}$ × *l* | | P2-02-G.011<br>P2-02-G.012<br>P2-02-G.039 |
| **Thread external** | | | | |
| Pitch | to 10 mm | 2,0 µm | | P2-02-G.011<br>P2-02-G.045 |
| Profile angle | to 180° | (0,50 + 12 / *l*) bgmin | *l* = leg length in mm | P2-02-G.040 |
| Simple pitch diameter | Ø 1 mm to Ø 300 mm | α = 30°: (6,0 µm to 9,7 µm) | Acc. to Euramet/CG-10, method 1a or 1b | P2-02-G.102 |
| | | α = 60°: (3,2 µm to 5,9 µm) | | P2-02-G.102 |
| | | α = 90°: (2,6 µm to 5,5 µm) | | P2-02-G.102 |
| Pitch diameter | Ø 3 mm to Ø 90 mm | 2,5 µm + 5 × $10^{-6}$ × *l* | Acc. to Euramet/CG-10, method 2b, α ≥ 27° | PM2-02-G.002 |
| | | 4,5 µm + 10 × $10^{-6}$ × *l* | Acc. to Euramet/CG-10, method 2b, α < 27° | PM2-02-G.002 |
| Outside, core diameter | Ø 3 mm to Ø 90 mm | 1,5 µm + 10 × $10^{-6}$ × *l* | Acc. to Euramet/CG-10, method 2b | PM2-02-G.002 |

| **Thread internal** | | | | |
|---|---|---|---|---|
| Pitch | to 10 mm | 2,0 µm | | P2-02-G.011<br>P2-02-G.045 |
| Profile angle | to 180° | (0,50 + 12 / *l* ) bgmin | *l* = leg length in mm | P2-02-G.040 |
| Simple pitch diameter | Ø 4 mm to Ø 300 mm | α = 30°: (9,0 µm to 14 µm) | Acc. to Euramet/CG-10, method 1a or 1b | P2-02-G.106 |
| | | α = 60°: (3,6 µm to 7,0 µm) | | P2-02-G.106 |
| | | α = 90°: (3,1 µm to 6,2 µm) | | P2-02-G.106 |
| Pitch diameter | Ø 3 mm to Ø 90 mm | 2,5 µm + 10 × $10^{-6}$ × *l* | Acc. to Euramet/CG-10, method 2b, α ≥ 27° | PM2-02-G.002 |
| | | 4,5 µm + 10 × $10^{-6}$ × *l* | Acc. to Euramet/CG-10, method 2b, α < 27° | PM2-02-G.002 |
| Outside, core diameter | Ø 3 mm to Ø 90 mm | 1,5 µm + 10 × $10^{-6}$ × *l* | Acc. to Euramet/CG-10, method 2b | PM2-02-G.002 |

(1): also on site, the CMC can be bigger on site

R: resolution of the instrument ; *l* : measured length

(*) the smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Force and Torque Wommelgem**

**Calibration and Measurement Capabilities**

Force

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Push pull force measuring devices in tension and compression | 0,20 N to 5 000 N | $1{,}0 \times 10^{-4} \times F$ | dead weights, f.i. ISO376 and ISO7500-1[3] | P1-02-M.009<br>P1-02-M.010<br>P1-02-M.019 |
| | 2 kN to 200 kN | $8{,}0 \times 10^{-4} \times F$ | Generation and measurement by comparison with standard load cells, f.i. ISO376 and ISO7500-1[3] | |
| | 200 kN to 500 kN | $10 \times 10^{-4} \times F$ | Generation and measurement by comparison with standard load cells, f.i. ISO376 and ISO7500-1[3] | |
| | 500 kN to 1,0 MN | $10 \times 10^{-4} \times F$ | Measurement only by comparison with standard load cells, f.i. ISO376 and ISO7500-1[3] | |
| Gram force gauges | 0,050 N to 500 N | $0{,}030 \times F$ | | |

Torque

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Torque tools | 0,1 Nm to 2700 Nm | $8{,}0 \times 10^{-3} \times M$ | Accuracy acc. to ISO 6789[3] | P2-02-M.011 |
| Torque measuring devices | 0,1 Nm to 1 Nm | $1 \times 10^{-3} \times M$ | With torque arms and weights | P1-02-M.004 |
| | 1 Nm to 200 Nm | $1{,}0 \times 10^{-3} \times M$ | | |
| | 200 Nm to 4000 Nm | $0{,}5 \times 10^{-3} \times M$ | | |

[3] onsite calibration also

(*) the smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Torque Wellin**

**Calibration and Measurement Capabilities**

Torque

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Torque tools | 0,5 Nm to 1350 Nm | 8,0 × 10-3 × M | Accuracy acc. to ISO 6789 | P2-02-M.011 |

(*) the smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Mass Wommelgem**

**Calibration and Measurement Capabilities**

Mass standards

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Weights and masses | 1 mg | 0,001 0 mg | For example mass pieces up to grade E1 according to OIML R111-1 | KI/02/KC/W.02<br>KI/02/KC/W.03<br>KI/02/KC/W.04<br>KI/02/KC/W.05 |
| | 2 mg | 0,001 0 mg | | |
| | 5 mg | 0,001 0 mg | | |
| | 10 mg | 0,001 0 mg | | |
| | 20 mg | 0,001 0 mg | | |
| | 50 mg | 0,001 2 mg | | |
| | 100 mg | 0,001 6 mg | | |
| | 200 mg | 0,002 0 mg | | |
| | 500 mg | 0,002 5 mg | | |
| | 1 g | 0,003 0 mg | | |
| | 2 g | 0,004 0 mg | | |
| | 5 g | 0,005 0 mg | | |
| | 10 g | 0,007 0 mg | | |
| | 20 g | 0,008 0 mg | | |
| | 50 g | 0,010 mg | | |
| | 100 g | 0,017 mg | | |
| | 200 g | 0,033 mg | | |
| | 500 g | 0,080 mg | | |
| | 1 kg | 0,16 mg | | |
| | 2 kg | 0,33 mg | | |
| | 5 kg | 0,80 mg | | |
| | 10 kg | 1,7 mg | | |
| | 20 kg | 10 mg | For example mass pieces up to grade E2 according to OIML R111-1 | KI/02/KC/W.02<br>KI/02/KC/W.03<br>KI/02/KC/W.04<br>KI/02/KC/W.05 |
| | 50 kg | 600 mg | For example mass pieces up to grade M1 according to OIML R111-1 | KI/02/KC/W.05 |
| | 100 kg | 1 000 mg | | |
| | 150 kg | 1 600 mg | | |

Weighing instruments

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Non automatic weighing machines | | | Available weights:<br>grade E1: 1 mg to 1 kg<br>grade E2: 1 mg to 10 kg<br>grade F1: 1 g to 20 kg<br>grade M1: 1 g to 500 kg | P2-02-W.001 |
| | 1 mg to 1 kg | $5{,}0 \times 10^{-6} \times m$<br>*minimal 0,002 mg* | | |
| | > 1 kg to 10 kg | $2{,}0 \times 10^{-6} \times m$ | | |
| | > 10 kg to 240 kg | $3{,}0 \times 10^{-6} \times m$ | | |
| | > 240 kg to 10 000 kg | $1{,}1 \times 10^{-4} \times m$ | | |

(*) the smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Mass Wellin**

**Calibration and Measurement Capabilities**

Mass standards

| Measured quantity, instrument | Range | expanded measurement uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Weights and masses | 1 g | 0,3 mg | OIML R111 defined Class M1, M2 and M3 weights or equivalent, using traceable calibrated F1 reference standards while applying the direct comparison method sush as defined and elaborated in OIML R111-1 Annex C. | P1-02-W.010 |
| | 2 g | 0,4 mg | | |
| | 5 g | 0,5 mg | | |
| | 10 g | 0,6 mg | | |
| | 20 g | 0,8 mg | | |
| | 50 g | 1,0 mg | | |
| | 100 g | 1,6 mg | | |
| | 200 g | 3,0 mg | | |
| | 500 g | 8 mg | | |
| | 1 kg | 16 mg | | |
| | 2 kg | 30 mg | | |
| | 5 kg | 80 mg | | |
| | 10 kg | 0,16 g | | P1-02-W.008 |
| | 20 kg | 0,3 g | | |
| | 50 kg | 0,8 g | | |

(*) the smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Pressure and Vacuum Wommelgem**

**Calibration and Measurement Capabilities**

Gas pressure

| **Measured quantity, instrument or gauge** | **Range** | **expanded uncertainty (*)** | **Remarks** | **Calibration procedure** |
|---|---|---|---|---|
| Gauges, digital indicators, plotters, calibrators, liquid column, transmitters, transducers and pressure balances for relative and absolute[1] pressures | 0 Pa to 4800 Pa | $1 \times 10^{-4} \times p$ minimum 0,03 Pa | By comparison with a low pressure standard | P2-02-P.002 |
| | -100 kPa to -5 kPa | $25 \times 10^{-6} \times p$ | By comparison with a gas pressure balance | P2-02-P.001 P2-02-P.007 |
| | -5 kPa to -1,5 kPa | $80 \times 10^{-6} \times p$ | | |
| | 1,5 kPa to 5,0 kPa | $80 \times 10^{-6} \times p$ | | |
| | 5,0 kPa to 350 kPa | $20 \times 10^{-6} \times p$ | | |
| | 5,0 kPa to 1,9 MPa | $26 \times 10^{-6} \times p$ | | |
| | 1,9 MPa to 7,6 MPa | $30 \times 10^{-6} \times p$ | | |
| | 7,6 MPa to 12 MPa | $70 \times 10^{-6} \times p$ | | |
| Barometers | 5,0 kPa to 350 kPa abs | $20 \times 10^{-6} \times p$ | By comparison with a gas pressure balance | |
| Piston/cilinder combination (effective area)[2] | 5,0 kPa to 350 kPa | $20 \times 10^{-6} \times p$ | By comparison with a gas pressure balance | |
| | 350 kPa to 1,9 MPa | $25 \times 10^{-6} \times p$ | | |
| | 1,9 MPa to 7,6 MPa | $30 \times 10^{-6} \times p$ | | |
| | 7,6 MPa to 12 MPa | $70 \times 10^{-6} \times p$ | | |

1 For absolute pressures the uncertainty of the atmospheric pressure is added to the uncertainty (except when working with an absolute pressure balance)
2 The masses can be calibrated in our mass laboratory

Liquid pressure

| **Measured quantity, instrument or gauge** | **Range** | **expanded uncertainty (*)** | **Remarks** | **Calibration procedure** |
|---|---|---|---|---|
| Gauges, digital indicators, plotters, calibrators, liquid column, transmitters, transducers and pressure balances for relative and absolute[1] pressures | 0,5 MPa to 100 MPa | $3{,}0 \times 10^{-5} \times p$ | By comparison with a liquid pressure balance | P2-02-P.001 P2-02-P.007 |
| | 100 MPa to 120 MPa | $7{,}0 \times 10^{-5} \times p$ | | |
| | 120 MPa to 400 MPa | $2{,}5 \times 10^{-4} \times p$ | | |
| Piston/cilinder combination (effective area)[2] | 0,5 MPa to 100 MPa | $3{,}0 \times 10^{-5} \times p$ | By comparison with a liquid pressure balance | |
| | 100 MPa to 120 MPa | $7{,}0 \times 10^{-5} \times p$ | | |
| | 120 MPa to 400 MPa | $2{,}5 \times 10^{-4} \times p$ | | |

1 For absolute pressures the uncertainty of the atmospheric pressure is added to the uncertainty (except when working with an absolute pressure balance)
2 The masses can be calibrated in our mass laboratory

Vacuum quantities

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Absolute pressure | 1 Pa to 30 Pa | $2 \times 10^{-2} \times p$ | By comparison with capacitive pressure indicators | RP/02/KC/P.05<br>RP/02/KC/P.06 |
| | 30 Pa to 5 kPa | $5{,}0 \times 10^{-3} \times p$ | | |
| | 1 mPa to 1 Pa | $2{,}5 \times 10^{-2} \times p + 5$ mPa | | |

Onsite

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Relative pressures | 20 kPa to 60 MPa | $1 \times 10^{-3} \times p$ | By comparison with digital pressure indicators | RP/02/KC/S.01 |
| Absolute pressures | 20 kPa to 60 MPa abs. | $1 \times 10^{-3} \times p$ | | |

(*) the smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Flow of Gas Wommelgem**

**Calibration and Measurement Capabilities**

Velocity of gases

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Windspeed | 0,1 m/s to 35 m/s | 0,60 % + 0,020 m/s | By comparison with an LDV in a windtunnel | P2-02-P.010 |

(*) the smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Temperature Wommelgem**

**Calibration and Measurement Capabilities**

| Resistance thermometers | | | | |
|---|---|---|---|---|
| **Measured quantity, instrument or gauge** | **Range** | **expanded uncertainty (*)** | **Remarks** | **Calibration procedure** |
| Resistance thermometers | | | Fixed points | |
| | -38,8344 °C | 0,004 °C | triple point of mercury | P1-02-T.020 |
| | 0,01 °C | 0,004 °C | triple point of water | |
| | 29,7646 °C | 0,004 °C | melting point of gallium | |
| | 156,5985 °C | 0,005 °C | freeze point of indium | |
| | 231,928 °C | 0,005 °C | freeze point of tin | |
| | 419,527 °C | 0,006 °C | freeze point of zinc | |
| | 660,323 °C | 0,015 °C | freeze point of aluminum | |
| | -196 °C | 0,025 °C | By comparison with reference standards in liquid nitrogen at atmospheric pressure | P1-02-T.004 |
| | -100 °C to -40 °C | 0,05 °C | By comparison with reference standards | |
| | -40 °C to 0 °C | 0,025 °C | | |
| | 0 °C to 280 °C | 0,015 °C | | |
| | 280 °C to 350 °C | 0,04 °C | | |
| | 350 °C to 660 °C | 0,04 °C | | |

Standard Pt resistance thermometers

| **Measured quantity, instrument or gauge** | **Range** | **expanded uncertainty (*)** | **Remarks** | **Calibration procedure** |
|---|---|---|---|---|
| Platinum resistance thermometers which meet the specifications of the ITS-90 or close to these specifications | | | Fixed points | |
| | -38,8344 °C | 0,004 °C | triple point of mercury | P1-02-T.020 |
| | 0,01 °C | 0,004 °C | triple point of water | |
| | 29,7646 °C | 0,004 °C | melting point of gallium | |
| | 156,5985 °C | 0,005 °C | freeze point of indium | |
| | 231,928 °C | 0,005 °C | freeze point of tin | |
| | 419,527 °C | 0,006 °C | freeze point of zinc | |
| | 660,323 °C | 0,015 °C | freeze point of aluminum | |

Thermocouples

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Thermocouples B, R & S | 0 °C to 280 °C | 0,40 °C | By comparison with reference standards | P1-02-T.014 |
| | 280 °C to 660 °C | 0,70 °C | | |
| | 660 °C to 1100 °C | 1,7 °C | | |
| | 1100 °C to 1300 °C | 2,3 °C | | |
| Thermocouples | -196 °C | 0,20 °C | By comparison with reference standards in liquid nitrogen at atmospheric pressure | P1-02-T.014 |
| | -100 °C to 280 °C | 0,20 °C | By comparison with reference standards | |
| | 280 °C to 660 °C | 0,50 °C | | |
| | 660 °C to 1100 °C | 1,7 °C | | |
| | 1100 °C to 1300 °C | 2,3 °C | | |

Self indicating thermometers

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Temperature indicators with resistance probe | | | Fixed points | P1-02-T.020 |
| | -38,8344 °C | 0,004 °C | triple point of mercury | |
| | 0,01 °C | 0,004 °C | triple point of water | |
| | 29,7646 °C | 0,004 °C | melting point of gallium | |
| | 156,5985 °C | 0,005 °C | freeze point of indium | |
| | 231,928 °C | 0,005 °C | freeze point of tin | |
| | 419,527 °C | 0,006 °C | freeze point of zinc | |
| | 660,323 °C | 0,015 °C | freeze point of aluminum | |
| | -196 °C | 0,025 °C | By comparison with reference standards in liquid nitrogen at atmospheric pressure | P1-02-T.001 |
| | -100 °C to -40 °C | 0,025 °C | By comparison with reference standards | |
| | -40 °C to 0 °C | 0,020 °C | | |
| | 0 °C to 280 °C | 0,015 °C | | |
| | 280 °C to 350 °C | 0,04 °C | | |
| | 350 °C to 660 °C | 0,040 °C | | |
| Temperature indicators with thermocouple probes B, R & S | 0 °C to 280 °C | 0,40 °C | By comparison with reference standards | P1-02-T.001 |
| | 280 °C to 660 °C | 0,70 °C | | |
| | 660 °C to 1100 °C | 1,7 °C | | |
| | 1100 °C to 1300 °C | 2,3 °C | | |
| Temperature indicators with thermocouple probes | -196 °C | 0,20 °C | By comparison with reference standards in liquid nitrogen at atmospheric pressure | P1-02-T.001 |
| | -100 °C to 280 °C | 0,20 °C | By comparison with reference standards | |
| | 280 °C to 660 °C | 0,50 °C | | |
| | 660 °C to 1100 °C | 1,7 °C | | |
| | 1100 °C to 1300 °C | 2,3 °C | | |

| | | | | |
|---|---|---|---|---|
| Analogue thermometers | -100 °C to 0 °C | 0,60 °C | By comparison with reference standards | P1-02-T.007 |
| | 0 °C to 280 °C | 0,20 °C | | |
| Liquid in glass thermometers with a resolution of | -100 °C to 0 °C | | By comparison with reference standards (totally or partially submerged) Partially submerged thermometers have a bigger CMC than mentioned | P1-02-T.005 |
| 5 °C | | 2,0 °C | | |
| 2 °C | | 0,80 °C | | |
| 1 °C | | 0,40 °C | | |
| 0,5 °C | | 0,20 °C | | |
| 0,2 °C | | 0,090 °C | | |
| 0,1 °C | | 0,060 °C | | |
| 0,05 °C | | 0,060 °C | | |
| Liquid in glass thermometers with a resolution of | 0 °C to 275 °C | | By comparison with reference standards (totally or partially submerged) Partially submerged thermometers have a bigger CMC than mentioned | P1-02-T.005 |
| 5 °C | | 2,0 °C | | |
| 2 °C | | 0,80 °C | | |
| 1 °C | | 0,40 °C | | |
| 0,5 °C | | 0,20 °C | | |
| 0,2 °C | | 0,070 °C | | |
| 0,1 °C | | 0,050 °C | | |
| 0,05 °C | | 0,025 °C | | |
| Surface temperature probes | ambient to 300 °C | 0,50 % × $t$ + 0,50 °C | By comparison with reference standards | P1-02-T.012 |

Radiation thermometry

| **Measured quantity, instrument or gauge** | **Range** | **expanded uncertainty (*)** | **Remarks** | **Calibration procedure** |
|---|---|---|---|---|
| Infrared thermometry | -17 °C to 100 °C | 0,50 °C | By comparison with reference standards | P1-02-T.010 |
| | 100 °C to 200 °C | 0,60 °C | | |
| | 200 °C to 400 °C | 1,7 °C | | |
| | 400 °C to 600 °C | 0,60% | | |
| | 600 °C to 800 °C | 0,70% | | |

Temperature controlled chambers

| **Measured quantity, instrument or gauge** | **Range** | **expanded uncertainty (*)** | **Remarks** | **Calibration procedure** |
|---|---|---|---|---|
| Charcterisation of ovens and climatic chambers | -100 °C to -38,5 °C | 1,6 °C | Using thermocouple type K | P2-02-S.040 |
| | -38,5 °C to 230 °C | 0,080 °C | Using Pt100 probes | |
| | 230 °C to 600 °C | 1,5 °C | Using thermocouple type R & S | |

Other temperature enclosures

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Block calibrators | -100 °C to 650 °C | 0,040 °C + 0,000 05 × \|*t*\| | Full evaluation following DOC EM/CG/13 "Guidelines on the Calibration of Temperature Block Calibrators" Or calibration with known evaluation information | P1-02-T.003 P1-02-T.002 |

Cold junction compensation

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Cold junction compensation B, R & S | 0 °C | 0,25 °C | | P2-02-T.015 |
| Cold junction compensation | 0 °C | 0,060 °C | | |

Onsite calibration

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Temperature probe with or without readout | -100 °C to -20 °C | 0,11 °C | By comparison in Block calibrators with external reference standards | P2-02-S.002 |
| | -20 °C to 50 °C | 0,09 °C | | |
| | 50 °C to 250 °C | 0,16 °C | | |
| | 250 °C to 650 °C | 0,22 °C | | |

(*) the smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

## Temperature Louvain-La-Neuve

## Calibration and Measurement Capabilities

| Inhouse calibrations | | | | |
|---|---|---|---|---|
| **Measured quantity, instrument or gauge** | **Range** | **Expanded uncertainty (*)** | **Remarks** | **Calibration procedure** |
| Platinum resistance thermometers which meet the specifications of the ITS-90 or close to these specifications | -196 °C | 0,01 °C | By comparison with reference standards in liquid nitrogen at atmospheric pressure | PL-02-A.032 |
| | | | Fixed points | PL-02-A.032 |
| | -38,834 °C | 0,004 °C | Triple point of mercury | |
| | 0,010 °C | 0,001 °C | Triple point of water | |
| | 29,765 °C | 0,004 °C | Melting point of gallium | |
| | 156,594 °C | 0,004 °C | Triple point of indium | |
| | 231,928 °C | 0,004 °C | Melting point of tin | |
| | 419,527 °C | 0,006 °C | Freeze point of zinc | |
| Temperature probes with indicators (eg: resistance probes and thermocouples) | -196 °C | 0,01 °C | By comparison with reference standards in liquid nitrogen at atmospheric pressure | PL-02-A.032 |
| | -100 °C to <-80 °C | 0,022 °C | By comparison with reference standards in thermal baths or ovens | |
| | -80 °C to <-20 °C | 0,010 °C | | |
| | -20 °C to <300 °C | 0,008 °C | | |
| | 300 °C to <450 °C | 0,010 °C | | |
| | 450 °C to <660 °C | 0,012 °C | | |
| | 660 °C to <1064 °C | 0,80 °C | | |
| | 1064 °C to 1550 °C | 1,60 °C | | |
| | -40 °C to <120 °C | 0,07 °C | By comparison with reference standards in a climatic chamber | PL-02-A.032 |
| | 120 °C to 180 °C | 0,18 °C | | |
| Liquid in glass thermometers | -80 °C to <-58 °C | 0,11 °C | By comparison with reference standards in thermal baths or ovens | PL-02-A.032 |
| | -58 °C to <160 °C | 0,01 °C | | |
| | 160 °C to <300 °C | 0,03 °C | | |
| | 300 °C to 350 °C | 0,10 °C | | |

Remarks:

- According to ITS-90 (International Temperature Scale of 1990)
- Expanded uncertainties are only associated to the probes and calibration means of the laboratory. Final uncertainty associated to the calibration of thermometer shall not be inferior to expanded uncertainty.

| Calibration and characterisation of block calibrators | | | | |
|---|---|---|---|---|
| **Measured quantity, instrument or gauge** | **Range** | **Expanded uncertainty (*)** | **Remarks** | **Calibration procedure** |
| Calibration of block calibrators | -100 °C to 650 °C | from 0,02 °C up to 0,10 °C | By comparison with a reference standard in a boring of the block calibrator | PL-02-A.032 |
| Calibration and characterisation of block calibrators | -100 °C to 650 °C | Uncertainty determined during characterisation may vary depending on how many borings are characterised | In addition to the calibration of the block calibrator, determination of axial homogeneity alongs the borings and determination of temperature differences between the borings according to DOC EM/CG/13 "Guidelines on the Calibration of Temperature Block Calibrators" | PL-02-A.037 |

| Onsite calibrations | | | | |
|---|---|---|---|---|
| **Measured quantity, instrument or gauge** | **Range** | **Expanded uncertainty (*)** | **Remarks** | **Calibration procedure** |
| Temperature probe with or without readout (pyrometers excepted) | -196 °C to <232 °C | 0,05 °C | By comparison with reference standards in thermal baths or ovens | PL-02-A.035 |
| | 232 °C to <420 °C | 0,06 °C | | |
| | 420 °C to <660 °C | 0,08 °C | | |
| | 660 °C to <1064 °C | 1,00 °C | | |
| | 1064 °C to 1550 °C | 1,90 °C | | |

Remarks:

- According to ITS-90 (International Temperature Scale of 1990)

- Expanded uncertainties are only associated to the probes of the laboratory. Final uncertainty of a thermometer calibration shall not be inferior to expanded uncertainty and shall also depend on, among others, the availbility of equipment onsite, environmental conditions...

(*) The smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Humidity Wommelgem**

**Calibration and Measurement Capabilities**

Hygrometers

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| RH meters with sensor type: resistive, capacitive, electrolytic, impedance, … | 5 % RH to 6 % RH @ ambient temperature | 0,30 % RH | by comparison with two pressure humitiy generator | P2-02-H.008 |
| | > 6 % RH to 10 % RH @ ambient temperature | 0,50 % RH | | |
| | 10 % RH to 95 % RH @ ambient temperature | 0,50 % RH | | P2-02-H.005 |
| | 10 % RH to 95 % RH @ 10 to 35 °C | 1,0 % RH to 0,50 % RH | | |
| | 10 % RH to 95 % RH @ -10 to 10 °C | 2,5 % RH to 0,50 % RH | | |
| | 10 % RH to 95 % RH @ 35 to 70 °C | 1,5 % RH to 0,50 % RH | | |
| Ambient thermometer / humidity meters with sensor type: resistive, capacitive, electrolytic, impedance, … | 30 % RH to 85 % RH -20 °C to 140 °C | 4,0 % RH 0,10 °C | by comparison with standard sensor in a climate chamber | P2-02-H.004 |

Other instruments for humidity

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Dew point meters | -70 °C to 0 °C | 0,10 °C | Temperature frost- or dewpoint | P2-02-H.003 |
| | 0 °C to 10 °C | 0,12 °C | | |

Generators for Humidity

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Humidity generator | 10 % RH to 90 % RH | 0,10 % RH to 0,90 % RH | by comparison with dewpoint meter | P2-02-H.007 |

Humidity of temperature controlled chambers

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Characterisation of climatic chambers | 10 % RH to 90 % RH | 1,5 % RH | Only between -20 °C to 100 °C | |

(*) the smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Humidity Louvain-La-Neuve**

**Calibration and Measurement Capabilities**

**Inhouse calibrations**

| Measured quantity, instrument or gauge | Range | Expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Dew point meters, impedance hygrometers and psychrometers | -60 °Cdp to -40 °Cdp | 0,10 °Cdp | Temperature frost- or dew point | P2-02-H.010 |
| | -40 °Cdp to 60 °Cdp | 0,11 °Cdp | | |
| | 60 °Cdp to 80 °Cdp | 0,13 °Cdp | | |
| | Relative humidity from 5% rh up to 95% rh | From 0,3% rh up to 1,5% rh (see table hereunder) | Temperature from -20 °C up to +80 °C, by comparison with reference standards in a humidity generator | P2-02-H.009 |

(*) The smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Details**

Absolute uncertainty for relative humidity depending on the temperature and the relative humidity (95%)

| | Relative humidity (% rh) | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **T (°C)** | **5** | **10** | **20** | **30** | **40** | **50** | **60** | **70** | **80** | **90** | **95** |
| **-20** | 0,3 | 0,3 | 0,4 | 0,5 | 0,7 | 0,9 | 1,0 | 1,1 | 1,3 | 1,4 | 1,5 |
| **0** | 0,3 | 0,3 | 0,4 | 0,5 | 0,6 | 0,8 | 0,9 | 1,1 | 1,2 | 1,3 | 1,4 |
| **10** | 0,3 | 0,3 | 0,3 | 0,4 | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 | 1 | 1,1 |
| **20** | 0,3 | 0,3 | 0,3 | 0,4 | 0,5 | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 | 0,9 |
| **30** | 0,3 | 0,3 | 0,3 | 0,3 | 0,4 | 0,5 | 0,6 | 0,6 | 0,7 | 0,8 | 0,8 |
| **40** | 0,3 | 0,3 | 0,3 | 0,3 | 0,4 | 0,5 | 0,5 | 0,6 | 0,7 | 0,7 | 0,8 |
| **50** | 0,3 | 0,3 | 0,3 | 0,3 | 0,4 | 0,4 | 0,5 | 0,6 | 0,6 | 0,7 | 0,7 |
| **60** | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,4 | 0,5 | 0,5 | 0,6 | 0,6 | 0,7 |
| **> 60** | 0,3 | 0,3 | 0,3 | 0,3 | 0,3 | 0,4 | 0,4 | 0,5 | 0,5 | 0,6 | 0,6 |
| **70** | 0,3 | 0,3 | 0,3 | 0,3 | 0,4 | 0,5 | 0,6 | 0,7 | 0,7 | 0,8 | 0,9 |
| **80** | 0,3 | 0,3 | 0,3 | 0,3 | 0,4 | 0,5 | 0,6 | 0,6 | 0,7 | 0,8 | 0,8 |

**Onsite calibrations**

| Measured quantity, instrument or gauge | Range | Expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Dew point meters, impedance hygrometers and psychrometers | -20 °Cdp to +60 °Cdp | 0,21 °Cdp | Temperature frost- or dew point | PL-02-A.035 |
| | Relative humidity from 5% rh up to 95% rh | From 0,3% RH up to 2,1% rh (see table hereunder) | Temperature from -20 °C up to +60 °C, by comparison with reference standards in a humidity generator | PL-02-A.035 |

**Details**

Absolute uncertainty for relative humidity depending on the temperature and the relative humidity (95%)

| | Relative humidity [% rh] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **T (°C)** | **5** | **10** | **20** | **30** | **40** | **50** | **60** | **70** | **80** | **90** | **95** |
| **-20** | / | / | / | 0,8 | 1,0 | 1,2 | 1,4 | 1,6 | 1,8 | 2 | 2,1 |
| **0** | / | 0,4 | 0,5 | 0,7 | 0,9 | 1,1 | 1,3 | 1,5 | 1,7 | 1,9 | 2,0 |
| **10** | 0,3 | 0,4 | 0,5 | 0,7 | 0,9 | 1,0 | 1,2 | 1,4 | 1,6 | 1,7 | 1,8 |
| **20** | 0,3 | 0,3 | 0,5 | 0,6 | 0,8 | 0,9 | 1,0 | 1,1 | 1,2 | 1,4 | 1,4 |
| **30** | 0,3 | 0,3 | 0,5 | 0,6 | 0,7 | 0,8 | 1,0 | 1,1 | 1,2 | 1,3 | 1,4 |
| **40** | 0,3 | 0,3 | 0,4 | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 | 1,0 | 1,1 | 1,2 |
| **50** | 0,3 | 0,3 | 0,4 | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 | 1,0 | 1,1 | 1,1 |
| **60** | 0,3 | 0,3 | 0,4 | 0,5 | 0,5 | 0,6 | 0,7 | 0,8 | 0,9 | 1,0 | 1,0 |

(*) The smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Chemical Analysis Louvain-La-Neuve**

**Calibration and Measurement Capabilities**

| **Inhouse calibrations** | | | | |
|---|---|---|---|---|
| **Measured quantity, instrument or gauge** | **Range** | **Expanded uncertainty (*)** | **Remarks** | **Calibration procedure** |
| Gas analyzers | 0 % (mol/mol) CO2 up to 10 % (mol/mol) CO2 | 0,06 % (mol/mol) $CO_2$ | By comparison with ISO/IEC 17025 accredited gas cylinders | P1-02-C.005 |
| | 10 % (mol/mol) CO2 up to 20 % (mol/mol) CO2 | 0,11 % (mol/mol) $CO_2$ | | |

| **Onsite calibrations** | | | | |
|---|---|---|---|---|
| **Measured quantity, instrument or gauge** | **Range** | **Expanded uncertainty (*)** | **Remarks** | **Calibration procedure** |
| Gas analyzers, $CO_2$ incubators | from 0 % (mol/mol) CO2 up to 20 % (mol/mol) CO2 | 0,24 % (mol/mol) $CO_2$ | By comparison with reference standards in the chamber of the customer | P1-02-C.005 |

(*) The smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Reference materials Wommelgem**

**Calibration and Measurement Capabilities**

Hardness

| Measured quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Hardness tester | 0 Shore A to 100 Shore A | 0,50 Shore A | | P1-02-M.018 |
| | 0 Shore D to 100 Shore D | 0,50 Shore D | | P1-02-M.018 |
| Reference for hardness tester | Shore A | 2,0 mN | | P2-02-M.018 |
| | Shore D | 6,0 mN | | |

(*) the smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.

**Volume Wommelgem**

**Calibration and Measurement Capabilities**

Volume

| Measure quantity, instrument or gauge | Range | expanded uncertainty (*) | Remarks | Calibration procedure |
|---|---|---|---|---|
| Volume measuring devices, pipettes | 10 µl to 50 µl | 0,40 µl | Gravimetric method | KI/02/KC/V.01 |
| | 50 µl to 100 µl | 0,50 µl | | |
| | 100 µl to 500 µl | 0,60 µl | | |
| | 500 µl to 1 ml | 1,0 µl | | |
| | 1 ml to 10 ml | 10 µl | | |
| | 10 ml to 25 ml | 20 µl | | |
| | 25 ml to 50 ml | 50 µl | | |
| Volume measuring devices, glass cups, recipients, … | 50 ml to 100 ml | 1,0 ml | Gravimetric method | KI/02/KC/V.51 |
| | 100 ml to 200 ml | 1,5 ml | | |
| | 200 ml to 300 ml | 2,0 ml | | |
| | 300 ml to 500 ml | 2,5 ml | | |
| | 500 ml to 1000 ml | 3,0 ml | | |
| | 1 l to 5 l | 3,5 ml | | |

(*) the smallest uncertainty of measurement the laboratory can provide to its customers, expressed as the expanded uncertainty having a coverage probability of approximately 95%.