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Bilateral Comparison of 1 Ω and 10 kΩ resistance standards between the INPL and the BIPM, December 1998

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Comparisons of the reference standards of resistance of the BIPM and the INPL were carried out at the 1 Ω and 10 kΩ values. One 1 Ω and one 10 kΩ standard were brought from the INPL to the BIPM and measured from 4 December 1998 to 8 January 1999. The BIPM values are referenced to $R_{K\text{-}90}$ realized with the BIPM quantum Hall resistance standard via a group of reference resistors. The type B uncertainty for this step is 1.5 parts in 10^8. The INPL values are referenced to $R_{K\text{-}90}$ via extrapolation from the results of previous calibrations at the BIPM.

Table 1 lists the results of the comparison at 1 Ω. Details of the INPL values and uncertainties are contained in INPL Calibration Certificates No. 6332 SE/98, dated 29 December 1998 and 6516 SE/99 dated 14 April 1999. Details of the BIPM results are reported on Calibration Certificate number 10 of 3 June 1999. The final result is calculated by extrapolation of the values measured by the INPL to the mean date of the mean of the BIPM measurements. The simple interpolation model was used to calculate the type-B uncertainty for the INPL measurements at mean date of the BIPM measurements assuming that the type-B uncertainties of the INPL before and after measurements are correlated. **With respect to the original comparison report, this revised version corrects a calculation error affecting the fourth row of Table 1, the return measurement result at INPL, referenced to 25 °C and 1013.25 hPa. This error was discovered in November 2003.**

The final results of the 1 Ω comparison are presented as the difference between the value assigned to a 1 Ω standard by the INPL, r_{INPL} and that assigned by the BIPM, r_{BIPM} on the reference date. This gives

$$r_{\mathrm{INPL}} - r_{\mathrm{BIPM}} = 0.18\ \mu\Omega; \qquad u_c = 0.15\ \mu\Omega, \text{ on } 1998/12/20,$$

where u_c is the combined type A and type B standard (1-σ) uncertainty from both laboratories.

Table 2 lists the results of the comparison at 10 kΩ. Details of the INPL values and uncertainties are contained in INPL Calibration Certificates No. 6331 SE/98, dated 29 December 1998 and 6538 SE/99 dated 14 April 1999. Details of the BIPM results are reported on Calibration Certificate number 9 of 3 June 1999. The final result is calculated by interpolation of the values measured by the INPL to the mean date of the mean of the BIPM measurements. The simple interpolation model was used to calculate the type-B uncertainty for the INPL measurements at mean date of the BIPM measurements assuming that the type-B uncertainties of the INPL before and after measurements are correlated.

The final results of the 10 kΩ comparison are presented as the difference between the value assigned to a 10 kΩ standard by the INPL, R_{INPL} and that assigned by the BIPM, R_{BIPM} on the reference date. This gives

$$R_{\mathrm{INPL}} - R_{\mathrm{BIPM}} = -0.008\ 3\ \ \Omega; \qquad u_c = 0.005\ 9\ \Omega, \quad \text{on } 1998/12/20,$$

where u_c is the combined type A and type B standard (1-σ) uncertainty from both laboratories.

Two factors limit the completeness of the uncertainty budget. First, for each value of resistance, only a single traveling standard was used. It would have been preferable to use three well-characterized resistors of each value. Second, BIPM resistance measurements are carried out at 23 °C and INPL measurements are carried out at 25 °C. Since the uncertainties in the values of the temperature coefficients are not given, and perhaps not known, it is not possible to evaluate the contribution to the uncertainty of the final results due to the difference in temperatures.

Table 1. Results of the comparison at 1 Ω, referred to 25.000 °C using the temperature coefficients supplied by the INPL.

Serial number	1915154
Mean date (yy/mm/dd)	98/12/20
INPL value, before transport	0.999 996 48 Ω
INPL value, after transport	0.999 996 77 Ω
INPL value on mean date R_{INPL}	0.999 996 65 Ω
INPL type-A standard uncertainty	0.02 μΩ
INPL type-B standard uncertainty	0.15 μΩ
INPL combined standard uncertainty	0.15 μΩ
BIPM value on mean date R_{BIPM}	0.999 996 47 Ω
BIPM type-A standard uncertainty	0.001 μΩ
BIPM type-B standard uncertainty	0.015 μΩ
BIPM combined standard uncertainty	0.015 μΩ
$(r_{INPL}-r_{BI})$	0.18 μΩ
Combined Type-A and type-B uncertainty in $(r_{INPL}-r_{BI})$	0.15 μΩ

Table 2. Table 2. Results of the comparison at 10 kΩ, referred to 25.000 °C using the temperature coefficients supplied by the INPL.

Serial number	1914468
Mean date (yy/mm/dd)	98/12/20
INPL value, before transport	9 999.896 5 Ω
INPL value, after transport	9 999.896 2 Ω
INPL value on mean date R_{INPL}	9 999.896 3 Ω
INPL type-A standard uncertainty	0.000 2 Ω
INPL type-B standard uncertainty	0.005 9 Ω
INPL combined standard uncertainty	0.005 9 Ω
BIPM value on mean date R_{BIPM}	9 999.904 6 Ω
BIPM type-A standard uncertainty	0.000 03 Ω
BIPM type-B standard uncertainty	0.000 15 Ω
BIPM combined standard uncertainty	0.000 15 Ω
(R_{INPL}-R_{BI})	–0.008 3 Ω
Combined type-A and type-B uncertainty in (R_{INPL}-R_{BI})	0. 005 9 Ω