

BUREAU INTERNATIONAL DES POIDS ET MESURES

Results of the Questionnaire on a Possible Change of Maintained and Reference
Temperatures of BIPM Electrical Standards



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On 20 March 1995 a questionnaire on a possible change of maintained and reference temperatures of BIPM electrical standards was sent to the member laboratories of the CCE as well as to individuals in some 14 laboratories that have recently had resistors or standard cells calibrated at the BIPM. The questionnaire and an introductory cover letter (see Appendix) explaining the proposal to change the reference and physical temperatures used in BIPM resistance and naked standard cell calibration and comparisons from 20 °C to 23 °C. To date twenty laboratories have responded. Their responses are given in Table 1.

The first row of the table heading gives the question number and the second and third rows repeat the questions in abbreviated form. In some responses laboratories distinguished between resistors in oil baths and in air baths. These distinctions are taken into account by splitting the responses into columns labeled "oil/unsp" and "air" meaning, respectively, "oil bath or unspecified" and "air bath". The tabulated numbers are numerical values of temperatures in °C. The fourth and third from last rows give the mean values and standard deviations of the replies. The second last and last rows summarize the "yes or no" responses.

Fifteen laboratories agree that the BIPM reference temperature for resistance measurements should be changed from 20 °C to 23 °C while three oppose the change. Of the subset of laboratories who foresee sending resistors to the BIPM for measurement twelve favor the proposed temperature change and only two oppose it.

Six laboratories agree that the BIPM reference temperature for measurements of naked standard cells be changed from 20 °C to 23 °C and four oppose the change. All four laboratories who foresee sending naked cells to the BIPM for measurement favor the proposed temperature change for standard cells.

The questionnaire gave laboratories the opportunity to make other remarks on the subject and some remarks of general interest are summarized below.

- Some laboratories propose a choice of several temperatures for calibrations.
- One said it would adopt new reference temperatures if the BIPM did.
- One laboratory that favored the change asked that it be implemented only after a three-year wait.
- One laboratory felt that a change by the BIPM would lead other laboratories to change their reference temperatures; it believes that laboratories now working at other temperatures would lose the history of the behavior of the standards. In a similar way, another laboratory questioned whether the gain in accuracy in comparisons would justify the loss of historical data.
- One laboratory thought it would be desirable to use the same reference temperatures for electrical standards as for mechanical standards.

Sèvres
10 May, 1995

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Table 1. responses to temperature questionnaire 2 May, 1995 all numbers represent temperatures in °C

ques no→	lab	country	1.a ref: res oil/unsp	1.a air	1.b ref: s.c.	2.a phys t for oil/unsp	2.a res air	2.b lab: res	2.c cal nak	2.d ref s.c.	3 store s.c.	3 store res	4 lab t	5 res→BIPM	6 nak s.c.→BIPM	7.a BIPM change for res	7.a new res t	7.b BIPM change for s.c.	7.b new s.c. t
	KRISS	Rep. of Korea	25		25	25	23	25	25	30	23	25	23	yes	no	yes	20 25		
	NML	Rep. of S. Africa	23		23	23		23	23	28	23	23	23	yes	no	yes	23	yes	23
	NCM	Bulgaria	20		20	20		20	20	20	20	20		yes	yes	yes	23	yes	23
	NML	Ireland	20		23	20		20	23	23	23	20	23	yes	no	no			
	BNM/LCIE	France	20 23		20	23	20	20	20	27	20	20	20	no	no	no			no
	LME-INETI	Portugal	25			25		25		30	30	25	23	yes		yes	23	no	
	NOM	Hungary	20		20	20		20	20	20	20	20	20	yes	yes	yes		yes	
	PTB	Germany	20			20		20				20	20	no(?)		yes	23		
	NMS	Norway	20 23		20	20		20				20	20	yes	no	yes	23		
	OFMET	Switzerland	23			23		20		20		20	20	no	no	yes	23		
	NPL	United Kingdom	20 23		20	20		20	20	22	22	20	20	no, ex. comp	no				
	NRC	Canada	25	23		25	23	25		30		25	21	yes	no	perhaps	25		
	IEN	Italy	23		23	23		23	23	23	23	23	23	no	no	yes	23	yes	23
	CMI	Czech Republic	20 23		20	20		20	20	20	23	23	22	yes		yes	23		
	BEV	Austria	20		20	as req		20	as req	20	20	20	20	yes	no(?)	no			no
	GIM	Belgium	20 23			20		20				20	20	yes	no(?)	yes	20		
	NMi VSL	The Netherlands	20 25 28		20	23	23	28	23	20	20	28	23	yes	no	yes	23	no	
	INM	Romania	20		20	20		20	20	20	20	20	20	yes	yes	yes	23	yes	23
	COM	Poland	20		20	20		20	20	20	20	20	20	yes	yes	yes	23	yes	23
	NIST	United States of America	23 25	23	28	23	23	23	28	28	28	23	23	yes	no	yes	23		

mean values→	22.14	23.00	21.47	22.44	22.40	22.04	21.92	23.59	22.33	22.19	21.48						23.00		23.00
std dev→	2.29	0.00	2.45	2.21	1.34	2.41	2.53	4.18	3.06	2.33	1.45						1.37		0.00
														Σ yes→	15	4	15		6
														Σ no→	3	11	3		4

excel/res-t-q.xls

APPENDIX

Questionnaire on a Possible Change of Maintained and Reference Temperatures of BIPM Electrical Standards

At the request of the BIPM, the 20th meeting of the Comité Consultatif d'Electricité on 14-15 June 1995 will include a discussion of a proposal to change the values of the physical temperatures at which electrical standards are maintained and measured at the BIPM and to change the value of the temperature to which BIPM calibrations and comparisons are referenced. In order to provide background information for this discussion, we have prepared the following questionnaire that we ask you to please forward to the persons responsible for dc voltage and resistance standards in your laboratory. We request that replies to the questionnaire be sent to the BIPM before 20 April 1995.

At present, the BIPM refers all resistance calibrations and comparisons to a temperature $t_{90} = 20\text{ }^{\circ}\text{C}$. For measurements of one ohm resistors, our reference resistors as well as the resistors under study are placed in temperature regulated oil baths that maintain the temperature near $20\text{ }^{\circ}\text{C}$. For $10\text{ k}\Omega$ resistors, depending on the type, the standards under study are placed in temperature regulated air- or oil baths operating near $20\text{ }^{\circ}\text{C}$. The BIPM $10\text{ k}\Omega$ reference standards are maintained in portable air baths at $\sim 26\text{ }^{\circ}\text{C}$. Naked standard cells calibrated at the BIPM are maintained at $\sim 20\text{ }^{\circ}\text{C}$ and calibration results are referenced to $20\text{ }^{\circ}\text{C}$. Electronic voltage standards referenced to Zener diodes have become very popular travelling standards. At normal laboratory temperatures their output voltages are thought to be independent of temperature. At the BIPM they are measured in a room in which the nominal temperature is $20\text{ }^{\circ}\text{C}$.

From time to time it has been brought to our attention that, for various reasons, $20\text{ }^{\circ}\text{C}$ is an unsatisfactory temperature for maintaining resistance and voltage standards. If changes are made in the nominal temperatures at which standards are maintained, it is clearly desirable to also

change the reference temperatures so that the standards are measured at temperatures close to the reference temperatures. Below we summarise a few of the reasons for and against an eventual change in the physical and reference temperature for cells and resistors from 20 °C to 23°C. We do not feel that it is necessary to use the same temperature for naked cells and for resistors.

Arguments for changing the reference temperature from 20 °C to 23 °C

1. For most standard resistors the temperature coefficients of resistance $\alpha(t)$ at temperature $t = 23$ °C are lower than those at 20 °C.
2. Very many laboratories use physical and reference temperatures above 20 °C for standard resistors and standard cells.
3. Differences in reference temperatures between laboratories lead to increased uncertainties in comparison results because of uncertainties in temperature coefficients and possibly because of hysteretic behaviour of the standards.
4. Maintaining the BIPM laboratories at 20 °C places a heavier load on air conditioning than that required for maintaining a higher ambient temperature. Temperature uniformity requires creating movements of cold air that can be unhealthy.

Arguments against changing the reference temperature from 20 °C to 23 °C

1. A discontinuity in the maintenance conditions of resistors or standard cells can lead to unanticipated discontinuities in the behaviour of the standards.
2. If the BIPM changes its maintained and reference temperatures, any laboratory now using 20 °C for its reference temperature may be inconvenienced in future comparisons with the BIPM.

