NATIONAL BUREAU OF STANDARDS REPORT

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REPORT

on

THE LUMINOUS FLUX OF FOUR LAMPS

for

THE NATIONAL PHYSICAL LABORATORY

by

Ray P. Teele

NBS

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

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Radio Standards. High Frequency Standards. Microwave Standards.

- Office of Basic Instrumentation
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Photometry and Colorimetry Section
Optics and Metrology Division
(File Ref. 1100)

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The Luminous Flux of Four Lamps

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This report describes the method of measurement and gives the values of luminous flux for four lamp standards of the National Physical Laboratory. These four NPL standards are designated as group 199 39 in this report. These standards have been measured a number of times both at the National Physical Laboratory and at the National Bureau of Standards as well as one time at the Bureau International des Poids et Mesures.

1. Purpose

The measurements were made to assist in establishing the relationship between the unit of luminous flux for gas-filled, tungsten-filament lamps as realized at the National Physical Laboratory and at the National Bureau of Standards.

2. Material

The lamps are of a special type used by the National Physical Laboratory and have a 300-watt, 200-volt nominal rating. They have been returned to the NPL by a staff member of the NBS who carried them by hand to avoid the danger of damage by commercial shipment.

3. Previous Measurements

The lamps were first measured by the NPL in 1950; measured by the NBS twice, returned to the NPL and remeasured by the NPL in 1952; and measured by the BIPM and again remeasured by the NPL in 1953. In the present report the earlier results are summarized and the results of the 1955 measurements at the NBS are given.

The results of the 1950 to 1953 measurements are given in the first six rows of Table I. The last row gives the average result for the present measurements.

Table I. Average Values for the Four NPL Lamps (Group 199 39) Operated at the Currents Given in Table II

Laboratory	Date	Voltage	Lumens
NPL	1950	192.2_8	4228
NBS	1952 (Feb.)	192.2_4	4188
NBS	1952 (May)	192.3_0	4182
NPL	1952	192.4_8	4231
BIPM	1953	192.2_7	4260 (1952 unit)
NPL	1953	192.3_2	4233
NBS	1955	192.3_2	4216

4. Present Measurements

The four lamps of group 199 39 were measured at the same time as the four standards recently taken to the BIPM for the forthcoming (1955-56) international intercomparisons by using NBS reference group 5872A as standards. The unit represented by the NBS values for the 1955-56 international intercomparison lamps and by the NBS 1955 values for the NPL lamps is, consequently, the same.

The paired-determinations method of Youden and Conner* was used to intercompare four NBS reference groups of standards. Group 5872A is one of these four groups and was shown by this intercomparison to be representative of the four groups of reference standards to within 0.1 percent. Thus the 1955 values reported herein may be considered to be based upon all four of the NBS reference groups of gas-filled tungsten-filament lamps rather than upon a single group of standards.

The values for the individual lamps are given in Table II.

Table II. Values for NPL Lamps, Group 199 39

Lamp	Amperes (Set)	Volts	Lumens
199 A 39	1.5704	194.00	4356
199 D 39	1.5420	189.76	4012
199 J 39	1.5588	192.30	4231
199 O 39	1.5608	193.22	4265
Average		192.32	4216

5. Discussion

The NBS unit of luminous flux at 2788°K has been represented in the international comparisons of 1948 and 1950-52 by a group of four lamps, NBS 2288, NBS 2289, NBS 2290, and NBS 2291, hereinafter designated as the NBS 2288 group. The records on these lamps show the results given in Table III.

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*New Experimental Designs for Paired Observations. W. J. Youden and W. S. Conner, NBS J. Research, Vol. 53, No. 3, September 1954, R. P. 2532.

Table III. Average Values for Four NBS Lamps (Group NBS 2288)

Date	Laboratory	Lumens	
		Reported	Corrected to 1952 BIPM Unit
September 1948	NBS (Report 118363)	2327	
December 1948	BIPM (Letter 12-2-49)	*2377	2374
February 1949	NPL " "	2338	
October 1949	BIPM " "	*2375	2372
June 1950	BIPM	**2365	2372
February 1951	NBS (Report 127556)	2377	
December 1951	BIPM	**2361	2368
October 1955	NBS	2334	

*1948 provisional BIPM unit
**1948 definitive BIPM unit

It does not seem, in view of the 1948 and 1955 NBS values that the high value obtained at the NBS in 1951 represents the NBS unit. The average of the original 1948 value and that now found is 2330 lumens. Comparing this with the NPL 1949 value of 2338 lumens, we get a ratio of 1.003. We would expect the same ratio for measurements on the NPL 199 39 group of lamps at the two laboratories. Our 1955 measurements, reported in Table II, result in an average of 4216 lumens and the NPL average is 4230, giving a ratio of 1.003. The ratio of the NPL average of 4230 to the NBS average of 4195 is 1.008.

We can find no explanation for the high values found for the NBS 2288 group of lamps at the NBS in 1951, particularly since the NPL measurements on this group of lamps made in 1949 seem concordant with the NBS 1948 and 1955 values.

One additional indirect check on the NBS unit is furnished by an interlaboratory check test carried out in this country in 1954. A group of 100-watt gas-filled tungsten-filament lamps was measured at the NBS and 6 commercial laboratories. The average of all of the seven participating laboratories was 1606 lumens and the NBS value was 1606 lumens. This is pointed out to indicate that the unit of luminous flux at 2788°K in general use in this country is in good agreement with the unit represented by the values both herein reported for the NPL lamps and reported to the BIPM for the lamps in the 1955-56 international intercomparison now in progress.

The ratios of the units of the NBS and NPL to the 1952 BIPM unit can be determined from the data on the two groups of lamps (NPL 199 39 group and NBS 2288 group) given in Tables I and III. These ratios are given in Table IV.

Table IV. Ratio of Units at 2788°K to BIPM 1952 Unit
(Average of 4 values in Column 4 of Table III = 2371.5)

Date	Laboratory	Group	Ratio to BIPM
1948	NBS	NBS 2288	1.019
1948-1951	BIPM	"	1.000
1949	NPL	"	1.014
1951	NBS	"	.998
1955	NBS	"	1.016
1950	NPL	199 39	1.008
1952	NBS	"	1.017
1952	NBS	"	1.019
1952	NPL	"	1.007
1953	BIPM	"	1.000
1953	NPL	"	1.006
1955	NBS	"	1.010
Average NPL			1.009
NBS except 1951			1.016
Ratio NBS unit to NPL unit			1.007

From table IV it is evident that the 1951 results did not represent the NBS unit. From table I the average of the NPL values for the NPL 300-watt lamps, group 199 39, is 4231 lumens, the NBS average is 4195 lumens, and the BIPM value is 4260. These values give 1.007 for the NPL unit and 1.015 for the NBS unit, relative to the BIPM 1952 unit. Similarly the data of table IV for the NBS 2288 group give values of 1.014 and 1.018 for the NPL and NBS units respectively relative to the BIPM 1952 unit if the NBS 1951 results are excluded.

THE NATIONAL BUREAU OF STANDARDS

Functions and Activities

The functions of the National Bureau of Standards are set forth in the Act of Congress, March 3, 1901, as amended by Congress in Public Law 619, 1950. These include the development and maintenance of the national standards of measurement and the provision of means and methods for making measurements consistent with these standards; the determination of physical constants and properties of materials; the development of methods and instruments for testing materials, devices, and structures; advisory services to Government Agencies on scientific and technical problems; invention and development of devices to serve special needs of the Government; and the development of standard practices, codes, and specifications. The work includes basic and applied research, development, engineering, instrumentation, testing, evaluation, calibration services, and various consultation and information services. A major portion of the Bureau's work is performed for other Government Agencies, particularly the Department of Defense and the Atomic Energy Commission. The scope of activities is suggested by the listing of divisions and sections on the inside of the front cover.

Reports and Publications

The results of the Bureau's work take the form of either actual equipment and devices or published papers and reports. Reports are issued to the sponsoring agency of a particular project or program. Published papers appear either in the Bureau's own series of publications or in the journals of professional and scientific societies. The Bureau itself publishes three monthly periodicals, available from the Government Printing Office: The Journal of Research, which presents complete papers reporting technical investigations; the Technical News Bulletin, which presents summary and preliminary reports on work in progress; and Basic Radio Propagation Predictions, which provides data for determining the best frequencies to use for radio communications throughout the world. There are also five series of nonperiodical publications: The Applied Mathematics Series, Circulars, Handbooks, Building Materials and Structures Reports, and Miscellaneous Publications.

Information on the Bureau's publications can be found in NBS Circular 460, Publications of the National Bureau of Standards ($1.25) and its Supplement ($0.75), available from the Superintendent of Documents, Government Printing Office. Inquiries regarding the Bureau's reports and publications should be addressed to the Office of Scientific Publications, National Bureau of Standards, Washington 25, D. C.

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