NATIONAL BUREAU OF STANDARDS REPORT

5317

REPORT
ON
THE LUMINOUS INTENSITY OF 8 LAMPS
AND
THE LUMINOUS FLUX OF 8 LAMPS
USED IN
INTERCOMPARISONS MADE
AT
BUREAU INTERNATIONAL DES POIDS ET MESURES

By
Velma I. Burns
Ray P. Teele

U. S. DEPARTMENT OF COMMERCE
NATIONAL BUREAU OF STANDARDS

THE NATIONAL BUREAU OF STANDARDS

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This report gives the results of measurements made on 16 lamps after their use in intercomparisons made at the Bureau International des Poids et Mesures. These lamps represent the photometric units as maintained at the National Bureau of Standards, these units being, (1) the candela at 2042°K, (2) the candela at 2353°K, (3) the lumen at 2353°K, and (4) the lumen at 2788°K. These "after" measurements are made to ascertain the stability of the lamps by the same methods and in terms of the same standards used to obtain the values given in National Bureau of Standards Report 4341. "Report on the Luminous Intensity of 8 Lamps and The Luminous Flux of 8 Lamps for Intercomparisons to be Carried Out at Bureau International des Poids et Mesures" In addition to measurement against the various groups of National Bureau of Standards standards the lamps were evaluated in terms of lamps retained at the NBS which had been measured originally with the lamps sent to the BIPM.

1. PURPOSE

This report gives the values found in 1957 which serve to determine the stability of the lamps measured in 1954 and 1955.

2. MATERIAL

The lamps are all of special construction in accordance with the desires of the BIPM, which supervised the manufacture of the lamps in France.

3. STANDARDS

The lamps were calibrated in terms of groups of standards representing the four photometric units maintained at the National Bureau of Standards. These groups of standards are as follows:

(a) Candela at 2042°K. Group consisting of lamps BS2395, BS2398, BS2399, BS2400, BS2401, BS2402, BS2407, and BS2270. The mean of the eight lamps is 16.81_7 candelas. This group of lamps was originally calibrated against the primary black body in 1937 and their stability was checked by reference to other standards prior to the measurements reported herein. The lamps were shown to have remained stable, the intercomparisons agreeing to better than 0.1 percent.

(b) Candela at 2353°K. Group consisting of lamps BS2987, BS2990, BS2991, BS2992, and BS2993. The mean of the five lamps is 33.60_8 candelas. This group of standards is the current reference group maintained at this Bureau.

(c) Flux at 2353°K. Group consisting of lamps BS5470, BS5472, BS5473, BS5477, BS5478, and BS5485. The mean of the six lamps is $444._0$ lumens. This group of standards is the current reference group.

(d) Flux at 2788°K. Group consisting of lamps BS5872A, BS5873, BS5875, BS5876, BS5877, BS5878. The mean of the six lamps is 7564 lumens. This group of standards is the current reference group.

4. METHOD

(1) Luminous Intensity. The luminous intensity measurements were made by a substitution method on a horizontal bar photometer with the lamps operating in a base down position. The orientation was such that the plane of the filament was perpendicular to the photometer axis and the glass supporting structure was turned away from the photometer. The perpendicularity of the plane of the filament was determined by projecting a beam of light at right angles to the photometer axis and aligning the shadow of the filament on a target card.

The photometric distance (measured to the plane of the filament) for the lamps at 2042°K was 1.56 meters. The photometric distance for the lamps at 2353°K was 1.25 meters.

(2) Luminous Flux. The luminous flux measurements were made by a substitution method in an 88-inch integrating sphere with the lamps operating in a base up position.

(3) Photometric Measurements. All measurements were made photoelectrically. With the voltage held constant at the designated value, readings were taken of the current and luminous intensity or luminous flux. Measurements were made in the following order: three standards, the test lamps, and the remaining standards. Three or more sets of measurements were made, the order of taking the readings being reversed in alternate sets. The values given in 5. Results are the averages of all readings taken.

5. RESULTS

The results are given in Tables A, B, C, and D. The uncertainty of the luminous value (intensity or flux) for each individual lamp was estimated by calculation at the 0.1 percent confidence level from the variation in the results in the several sets of measurements. The uncertainty of the average was also computed in this way, and, in addition, was estimated as one-fourth of the square root of the sum of the squares of the uncertainties of the individual lamps. The latter uncertainty estimates are shown in parentheses.

Table A. Luminous Intensity at 2042°K (BIPM 1951 Scale) (2039°K NBS Scale). Measured at 1.56 meters.

Lamp No.	Volts	Amperes	Candela	Uncertainty
NBS 3757	97.200	.5543	11.67	±0.05
NBS 3759	97.900	.5599	11.99	±0.05
NBS 3760	98.600	.5581	11.90	±0.00
NBS 3762	98.200	.5587	11.96	±0.08
			11.88_0	$\pm 0.01_0$
				$(\pm 0.02_7)$
		Lamps retained at NBS		
NBS 3758	96.000	.5551	11.59	± .04
NBS 3761	98.200	.5381	11.53	± .06

Table B. Luminous Intensity at 2353°K (BIPM Scale) (2352°K NBS Scale). Measured at 1.25 meters.

Lamp No.	Volts	Amperes	Candela	Uncertainty
NBS 3764	92.300	0.3403	22.30	±.33
NBS 3765	91.700	Loose base		
NBS 3769	91.800	.3407	22.04	±.04
NBS 3770	97.800	.3539	26.98*	±.14
Average			23.77	±.17
				(±.10)
		Lamps retained at NBS		
NBS 3767	90.900	0.3437	21.61	±.09
NBS 3768	91.300	.3483	23.00	±.12
NBS 3771	90.900	.3464	21.99	±.09
Average			22.20	±.08
				(±.05)

*In terms of retained lamps before damage to NBS 3770.

Table C Luminous Flux at 2353°K (BIPM Scale) (2356°K NBS Scale)

Lamp No.	Volts	Amperes	Lumens	Uncertainty
NBS 3780	99.000	0.3208	232.7	±0.8
NBS 3782	98.500	.3208	231.7	±0.5
NBS 3783	98.200	.3198	225.8	±0.5
NBS 3784	99.100	.3217	232.8	±0.3
Average			230.8	±0.5
				(±0.3)
		Lamps retained at NBS		
NBS 3785	98.600	0.3201	230.2	± .6
NBS 3786	98.500	.3202	229.6	± .3
NBS 3787	98.200	.3192	226.6	± .3
Average			228.8	± .0
				(± .1)

Table D Luminous Flux at 2788°K (BIPM 1951 Scale) (2811°K NBS Scale)

Lamp No.	Volts	Amperes	Lumens	Uncertainty
NBS 3772	108.900	1.7373	2720	±23
NBS 3773	110.000	1.7574	2780	±19
NBS 3775	109.000	1.7338	2727	±29
NBS 3776	108.900	1.7432	2732	±35
Average			2740	±16
				(±.14)

Table Continued

Lamps retained at NBS

NBS 3777	110.100	1.7608	2782	±17
NBS 3778	108.400	1.7246	2729	±19
NBS 3779	110.300	1.7614	2794	±24
			2768	±19
				(±12)

Table E. Comparison of Luminous Intensity at 2042°K "Before" and "After" BIPM Measurements

	Amperes		Candela		
Lamp No.	"Before"	"After"	"Before"	"After"	Mean
NBS 3757	0.5541_9	0.5543	11.85±0.10	11.67±0.05	11.76
NBS 3759	$.5593_9$	.5599	11.84±0.10	11.99±0.05	11.92
NBS 3760	$.5577_0$	.5581	11.88±0.17	11.90±0.00	11.89
NBS 3762	$.5590_3$	.5587	12.14±0.13	11.96±0.08	12.05
Average			11.92_8±0.02$_1$ ($\pm0.06_4$)	11.88_0±0.01$_0$ ($\pm0.02_7$)	11.90_5

Lamps retained at NBS

NBS 3758	0.5551_6	0.5551	11.63±.31	11.59±.04
NBS 3761	$.5381_3$	.5581	11.56±.23	11.53±.06
Average			11.60±.04	11.56±.05
			(±.19)	(±.04)

If the lamps retained at the NBS were used as a base the "After" values would be increased by .04 candela bringing the "After" values for the average of the 4 lamps into close agreement with the "Before" average. It is concluded that there have been real changes in three of the four lamps. We would like to have the mean of the "Before" and "After" values used to represent our unit of luminous intensity at 2042°K.

Table F. Comparison of Luminous Intensity at 2353°K "Before" and "After" BIPM Measurements.

	Amperes		Candela		
Lamp No.	"Before"	"After"	"Before"	"After"	Mean
NBS 3764	0.3402_0	0.3403	22.38±0.12	22.30±0.33	22.34
NBS 3765	loose base		loose base		
NBS 3769	$.3402_3$	.3407	22.03±0.15	22.04±.04	22.04
NBS 3770	$.3543_1$	.3539	26.93±0.11	26.98±.14	23.96
Average			23.78±0.08	23.77±.17	23.78
			(±0.07)	(±.10)	

Table Continued

Lamps retained at NBS

NBS 3767	0.34343_3	0.3437	21.74±0.22	21.61±.09
NBS 3768	$.34828_8$	.3483	22.82±0.33	23.00±.12
NBS 3771	$.34623_3$	.3464	21.92±0.21	21.99±.09
Average			22.16±0.25	22.20±.08
			(±0.06)	(±.05)

If the lamps retained at the NBS were used as a base the "After" values would be decreased by 0.04 candela. The estimated uncertainty of the individual lamps or of the mean does not justify any changes

Table G. Comparison of Luminous Flux at 2353°K "Before" and "After" BIPM Measurements

	Amperes		Lumens		
Lamp No.	"Before"	"After"	"Before"	"After"	Mean
NBS 3780	0.32053_3	0.3208	232.7±0.2	232.7±0.8	232.7
NBS 3782	$.32056_6$	.3208	231.6±0.6	231.7±0.5	231.6
NBS 3783	$.31963_3$	.3198	226.3±0.7	225.8±0.5	226.0
NBS 3784	$.32151_1$	.3217	233.7±0.2	232.8±0.3	233.2
Average			231.1±0.3	230.8±0.5	230.9
			(±0.2)	(±0.3)	

Lamps retained at NBS

NBS 3785	0.32000_0	0.3201	230.1±0.9	230.2±0.6
NBS 3786	$.32012_2$	.3202	229.8±1.1	229.6±0.3
NBS 3787	$.31915_5$	.3192	226.6±1.5	226.6±0.3
			228.8±1.1	228.8±0.0
			(±0.7)	(±0.2)

No significant changes have taken place in these lamps.

Table H. Comparison of Luminous Flux at 2788°K "Before" and "After" BIPM Measurements

	Amperes		Lumens		
Lamp No.	"Before"	"After"	"Before"	"After"	Mean
NBS 3772	1.7369	1.7373	2719±12	2720±23	2720
NBS 3773	1.7580	1.7574	2778±15	2780±19	2779
NBS 3775	1.7336	1.7338	2730±27	2727±29	2728
NBS 3776	1.7437	1.7432	2733±11	2732±35	2732
Average			2740±16	2740±16	2740
			(±9)	(±14)	

Lamps retained at NBS

NBS 3777	1.7611	1.7608	2780±25	2782±17
NBS 3778	1.7237	1.7246	2721±25	2729±19
NBS 3779	1.7594	1.7614	2778±18	2794±24
			2760±23	2768±19
			(±13)	(±9)

No significant changes have taken place in these lamps. If the lamps retained at the NBS were used as a base the "After" values would be decreased by 8 lumens. The larger uncertainties estimated for the "After" values do not justify such a change.

Conclusions. Although there is some indication of change in a few of the lamps, the estimated uncertainties do not justify discarding any lamps. For the sake of uniformity of treatment it is suggested that the mean of the "Before" and "After" values be used for all lamps to represent their value at the time of the comparisons carried out at the BIPM.

U. S. DEPARTMENT OF COMMERCE

Sinclair Weeks, *Secretary*

NATIONAL BUREAU OF STANDARDS

A. V. Astin, *Director*

THE NATIONAL BUREAU OF STANDARDS

The scope of activities of the National Bureau of Standards at its headquarters in Washington, D. C., and its major field laboratories in Boulder, Colorado, is suggested in the following listing of the divisions and sections engaged in technical work. In general, each section carries out specialized research, development, and engineering in the field indicated by its title. A brief description of the activities, and of the resultant reports and publications, appears on the inside front cover of this report.

WASHINGTON, D. C.

Electricity and Electronics. Resistance and Reactance. Electron Tubes. Electrical Instruments. Magnetic Measurements. Dielectrics. Engineering Electronics. Electronic Instrumentation. Electrochemistry.

Optics and Metrology. Photometry and Colorimetry. Optical Instruments. Photographic Technology. Length. Engineering Metrology.

Heat and Power. Temperature Physics. Thermodynamics. Cryogenic Physics. Rheology and Lubrication. Engine Fuels.

Atomic and Radiation Physics. Spectroscopy. Radiometry. Mass Spectrometry. Solid State Physics. Electron Physics. Atomic Physics. Nuclear Physics. Radioactivity. X-rays. Betatron. Nucleonic Instrumentation. Radiological Equipment. AEC Radiation Instruments.

Chemistry. Organic Coatings. Surface Chemistry. Organic Chemistry. Analytical Chemistry. Inorganic Chemistry. Electrodeposition. Gas Chemistry. Physical Chemistry. Thermochemistry. Spectrochemistry. Pure Substances.

Mechanics. Sound. Mechanical Instruments. Fluid Mechanics. Engineering Mechanics. Mass and Scale. Capacity, Density, and Fluid Meters. Combustion Controls.

Organic and Fibrous Materials. Rubber. Textiles. Paper. Leather. Testing and Specifications. Polymer Structure. Organic Plastics. Dental Research.

Metallurgy. Thermal Metallurgy. Chemical Metallurgy. Mechanical Metallurgy. Corrosion. Metal Physics.

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Building Technology. Structural Engineering. Fire Protection. Heating and Air Conditioning. Floor, Roof, and Wall Coverings. Codes and Specifications.

Applied Mathematics. Numerical Analysis. Computation. Statistical Engineering. Mathematical Physics.

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- Office of Basic Instrumentation
- Office of Weights and Measures

BOULDER, COLORADO

Cryogenic Engineering. Cryogenic Equipment. Cryogenic Processes. Properties of Materials. Gas Liquefaction.

Radio Propagation Physics. Upper Atmosphere Research. Ionospheric Research. Regular Propagation Services. Sun-Earth Relationships.

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