INTERLABORATORY INTERCOMPARISONS
OF
500-WATT TUNGSTEN-FILAMENT STANDARDS
OF LUMINOUS FLUX

by

Velma I. Burns
THE NATIONAL BUREAU OF STANDARDS

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INTERLABORATORY INTERCOMPARISONS

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Photometry and Colorimetry Section

Optics and Metrology Division

IMPORTANT NOTICE

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U. S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS
Interlaboratory Intercomparisons
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Abstract

A group of six inside-frosted and seven clear 500-watt lamps were measured by eight laboratories. The average luminous flux was 96.47 lumens for the frosted lamps and 95.14 lumens for the clear lamps. The average of the percent deviations from the overall average for the eight laboratories was .39% in the case of the inside frosted lamps and .34% in the case of the clear lamps.

I. Introduction

This intercomparison was undertaken to determine the uniformity of measurements of luminous flux for these types of lamps at the participating laboratories. The laboratories participating and the order of reading are as follows:

I. Champion Lamp Works
II(a). Sylvania Electric Products, Inc. (using 60 in. sphere 3 runs)
II(b). Sylvania Electric Products, Inc. (using 100 in. sphere 2 runs)
III. Electrical Testing Laboratories, Inc.
IV. Westinghouse Lamp Division
V. Duro Test Corporation
VI. General Electric Company
VII. National Bureau of Standards
VIII. Electrical Testing Laboratories, Inc.
IX. Sylvania Electric Products, Inc.
X. Interlectric Corporation
XI. Champion Lamp Works

The order in which the laboratories made their readings was chosen to reduce shipment of the lamps as much as possible. Each laboratory followed its own customary procedure in making the measurements. The Electrical Testing Laboratories Inc., Sylvania Electric Products Inc., and Champion Lamp Works measured the lamps more than once and all values reported are listed in the tables which follow. Only the first values reported by these laboratories, however, were used in calculating averages for all laboratories.
II. Results of Measurements

The values of current reported by each laboratory are given in Table I. The values of luminous flux are given in Table II. For all measurements the lamps were operated at 120 volts.

The range of the average values in percent are shown below.

<table>
<thead>
<tr>
<th>Lamp Type</th>
<th>Current Range</th>
<th>Luminous Flux Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Frosted</td>
<td>0.53%</td>
<td>1.61%</td>
</tr>
<tr>
<td>Clear</td>
<td>0.72%</td>
<td>1.54%</td>
</tr>
</tbody>
</table>

An analysis of the results was made as follows:

Let

\[ F = \text{Luminous flux measured value.} \]

\[ F_{La} = \text{Luminous flux measured by a given laboratory, L, for a given lamp, a.} \]

\[ \bar{F} = \text{Average of all luminous flux measurements made by all the laboratories for one type of lamp.} \]

\[ \bar{F}_L = \text{Average luminous flux for all the lamps of a given type measured at a given laboratory.} \]

\[ \bar{F}_a = \text{Average of luminous flux measurements made on a given lamp at all the laboratories.} \]

\[ \Delta = \text{deviations} \]

\[ \Delta_L = \bar{F}_L - \bar{F} \]

\[ \Delta_a = \bar{F}_a - \bar{F} \]

The residual error, \( \psi \), for each lamp measured at each laboratory, was found by the following formula

\[ \psi = F_{La} - \bar{F} - \Delta_L - \Delta_a \]

The probable error in the average value, \( \bar{F}_L \), is given by the expression

\[ PE = \frac{0.8453 \sum \psi}{n \sqrt{n-1}} \]

where \( n \) is the number of observations.
The huge error in $\bar{F}_L$ is

$$\text{HE} = 4.9 \times \text{PE}$$

The huge error for each laboratory is a measure of how closely the average reported by that laboratory ($\bar{F}_L$) represents measurements made at that laboratory. The huge error for each laboratory in percent of $\bar{F}$ is shown in Table II. It can be shown that laboratories having $\%\Delta_L$ larger than $\%\text{HE}$ may be on a basis of measurement different from that of the other laboratories.

### III. Discussion

There is fair agreement between the participating laboratories on values of current and luminous flux. The range in the average values of current reported for frosted lamps is 0.53% of the average values reported by all laboratories. For the clear lamps the range is 0.72%. The range in the average values of luminous flux reported for the frosted lamps is 1.61% of the average of values reported by all laboratories and for the clear lamps the range is 1.54%.

By treating the average values reported by each of the eight laboratories as a series of eight measurements and by using the formula

$$\text{HE} = 4.9 \frac{0.8453\Sigma\Delta_L}{n\sqrt{n-1}}$$

the huge error in the average for all the laboratories ($\bar{F}$) was found to be 0.61% for the frosted lamps and 0.53% for the clear lamps. Then by using the same series of measurements and the formula

$$\text{HE} = 4.9 \frac{0.8453\Sigma\Delta_L}{\sqrt{n(n-1)}}$$

the huge error in the average reported by any one laboratory was found to be 1.71% for the frosted lamps and 1.51% for the clear lamps.

The average percent deviation in luminous flux values reported ($\bar{\Delta}_L$) is 0.39% for the frosted lamps and 0.34% for the clear lamps.
Table I

Interlaboratory Intercomparisons of Current in Amperes of 500-Watt Lamps Operated at 120 volts

<table>
<thead>
<tr>
<th>Inside Frosted</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Order of reading</td>
<td>I II III IV V VI VII X VIII IX XI</td>
</tr>
<tr>
<td>NBSL266</td>
<td>.416</td>
</tr>
<tr>
<td>NBSL267</td>
<td>.4165</td>
</tr>
<tr>
<td>NBSL269</td>
<td>.418</td>
</tr>
<tr>
<td>NBSL270</td>
<td>.4155</td>
</tr>
<tr>
<td>Ave of 6</td>
<td>.4149</td>
</tr>
<tr>
<td>Δ</td>
<td>+.009</td>
</tr>
<tr>
<td>%Δ</td>
<td>+.22</td>
</tr>
</tbody>
</table>

| Clear           |               |
| Lamp No.        |               |
| Ave of 7        | .4146 | .4141 | .4134 | .4116 | .4114 | .4126 | .4133 | .4126 | .4133 | .4127 | .4123 | 4.131 |
| Δ               | +.013 | +.008 | +.001 | -.017 | +.008 | -.007 | .000 | -.007 | -.006 | -.010 | -.002 |
| %Δ              | +.31 | +.19 | +.02 | -.41 | +.19 | -.17 | 0 | -.17 | -.14 | -.24 | -.05 |
### Table II

**Interlaboratory Intercomparisons of Luminous Flux in Lumens, $F_L$ of 500-Watt Lamps Operated at 120 Volts**

<table>
<thead>
<tr>
<th>Inside Frosted</th>
<th>Champ. Syl. ETL West. Duro. GE NBS Int. Ave $\Delta_a$ (F$_a$ - F)</th>
<th>Syl. 100</th>
<th>ETL</th>
<th>Syl. Champ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Order of reading</td>
<td>Lamp No.</td>
<td>I II(a) III IV V VI VII X</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NBSL265</td>
<td>9634</td>
<td>9682</td>
<td>9790</td>
<td>9744</td>
</tr>
<tr>
<td>NBSL266</td>
<td>9431</td>
<td>9506</td>
<td>9550</td>
<td>9508</td>
</tr>
<tr>
<td>NBSL267</td>
<td>9602</td>
<td>9661</td>
<td>9760</td>
<td>9674</td>
</tr>
<tr>
<td>NBSL268</td>
<td>9442</td>
<td>9521</td>
<td>9680</td>
<td>9673</td>
</tr>
<tr>
<td>NBSL269</td>
<td>9813</td>
<td>9836</td>
<td>9840</td>
<td>9814</td>
</tr>
<tr>
<td>NBSL270</td>
<td>9199</td>
<td>9513</td>
<td>9730</td>
<td>9595</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Clear</th>
<th>Champ. Syl. ETL West. Duro. GE NBS Int. Ave $\Delta_a$ (F$_a$ - F)</th>
<th>Syl. 100</th>
<th>ETL</th>
<th>Syl. Champ.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lamp No.</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NBSL271</td>
<td>9572</td>
<td>9451</td>
<td>9570</td>
<td>9586</td>
</tr>
<tr>
<td>NBSL272</td>
<td>9822</td>
<td>9782</td>
<td>9890</td>
<td>9807</td>
</tr>
<tr>
<td>NBSL273</td>
<td>9666</td>
<td>9586</td>
<td>9760</td>
<td>9634</td>
</tr>
<tr>
<td>NBSL274</td>
<td>9461</td>
<td>9396</td>
<td>9480</td>
<td>9417</td>
</tr>
<tr>
<td>NBSL275</td>
<td>9459</td>
<td>9389</td>
<td>9540</td>
<td>9523</td>
</tr>
<tr>
<td>NBSL276</td>
<td>9255</td>
<td>9184</td>
<td>9340</td>
<td>9317</td>
</tr>
<tr>
<td>NBSL277</td>
<td>9440</td>
<td>9458</td>
<td>9590</td>
<td>9519</td>
</tr>
</tbody>
</table>

$$\Delta_L = \frac{F_L - F_{L-\text{F}}}{F_L}$$

$\% \Delta_L$ and $\% \Delta E$
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 laboratories in Boulder, Colo., 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 publications, appears on the inside front cover.

WASHINGTON, D. C.


Office of Basic Instrumentation. Office of Weights and Measures.

BOULDER, COLORADO


