WEST VIRGINIA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
MATERIALS CONTROL, SOILS AND TESTING DIVISION

MATERIALS PROCEDURE

METHOD OF TEST FOR DETERMINING PHOTOMETRIC REQUIREMENTS OF HAZARD WARNING LIGHTS

1.0 PURPOSE

1.1 The purpose of this procedure is to establish a standard method of test for the photometric evaluation of hazard warning lights used in the control of traffic.

2.0 SCOPE

2.1 This method of test is applicable to both the flashing and non-flashing varieties of hazard warning lights.

3.0 APPARATUS AND EQUIPMENT

3.1 One (1) goniometer which allows the unit under test to be rotated through fixed horizontal and vertical axes.

3.2 One (1) DC power supply with a range of 0-150 volts and 0-3 amperes.

3.3 One (1) DC digital voltmeter capable of measuring at least 150 volts and accurate to 0.1 volt.

3.4 One (1) standard lamp of known illumination at a certain specified voltage.

3.5 One (1) barrier-layer type photocell, color corrected to correspond to viewing conditions of the average human eye.

3.6 One (1) vacuum photoelectric tube and matching socket used to detect the intensity and length of flash of the unit under test.

3.7 One (1) dual channel oscilloscope which is used to display the intensity time relationship curve of the unit under test.

3.8 A means of recording the intensity time relationship curve. This can be done photographically or by means of an oscilloscope capable of holding a trace.

3.9 One (1) picoammeter has an accuracy of at least two (2) percent of full scale reading, a decade switch changes the scale ratio to permit readings over a total range from 10^{-2} to 10^{-12} amperes.

4.0 TEST PROCEDURES

4.1 Determination of Voltage When Flashing

4.1.1 Because of the voltage drop which occurs when the unit is flashing, the peak voltage at the lamp, when the unit is flashing, must be determined. This is done by taking voltage measurements of the batteries supplied by the manufacturer with a digital DC voltmeter accurate to 0.1 volt. These batteries are then installed in the unit being tested and the output of the lamp circuit is then connected to one channel of a dual channel oscilloscope. The rated voltage of the batteries as was determined above is then set by using a DC power supply (monitored by digital DC voltmeter) of the oscilloscope. Both channels of the oscilloscope are calibrated with reference to voltage.

When the unit under test is turned on, one channel displays the voltage level of the batteries and the other displays a decrease in this voltage level corresponding to the voltage drop exemplified by the circuit during its flash.

4.2 Intensity - Time Relationship Curve

4.2.1 This curve is obtained by placing the unit under test before a vacuum photoelectric tube. The output of the photoelectric tube is then displayed by means of a catrode ray oscilloscope when the unit under test is energized. The intensity-time characteristics are then recorded photographically or by other suitable means. For definition purposes, flash duration is defined as that time that elapses from the point at which the applied voltage reaches 90% of the peak, and that point when the voltage drops below 10% of the peak.

4.3 Measurements on Test Light and Calibration

4.3.1 The unit under test is now mounted on a goniometer which allows it to be rotated about fixed horizontal and vertical axes. The units electrical circuit is by-passed so that it may be operated steadily at the peak voltage previously determined, for purpose of achieving intensity distribution measurements. A barrier-layer photocell is then positioned at a distance of approximately 3 m from the unit to act as a receiving device. The photocell is then connected to a picoammeter which is capable of reading very small electrical currents.

Each light is aligned on the goniometer so that its geometrical center is on the same level as the photocell. The light is then photometrically centered by making the horizontal and vertical angular settings of the goniometer 0.0 for the position of the light which produces an equal distribution of energy to the left and right of center as well as above and below center. The goniometer is then rotated through traverses whose minimum vertical and horizontal angles are 9? left and right and 5? up and down from the assigned photometric center (0.0) and which also inscribe a symmetrically oval beam pattern. Meter readings are taken and recorded at the traverses indicated above.

Without changing distance, a standard lamp of known intensity for a given voltage is then placed on the goniometer and illuminated to its peak intensity. A meter reading of the light striking the photocell is then taken and recorded. A yellow filter with known transmission factor is then placed in front of the photocell and a second reading of the standings is taken and recorded.

4.4 Calculation of Steady State Intensity (I_S)

4.4.1 Meter readings obtained by illuminating the photocell with and without filter in front of same, are now corrected in the following manner before determining I_S:

(1) (Mr) (F) = Cmr

(2) $\frac{Cmr}{Mrf} = k$

(3) $\frac{Mr}{k} = Msc$

(4) Check - (Msc) (F) = Mrf

Where Mr = Meter reading of photocell illuminated by standard lamp.

Mrf = Meter reading with filter in front of photocell illuminated by standard lamp.

F = Correction factor of filter.

Cmr = Calculated meter reading with filter in front of photocell and illuminated by standard lamp.

k = Ratio of calculated value to actual value of photocell reading with filter and illuminated by standard lamp.

Msc = Corrected meter reading of photocell illuminated by standard lamp.

Meter readings taken at the angular traverses noted in 1.3 are now computed for Steady State Intensity values by utilizing the following formula:

$$I_S = \frac{Mt}{Msc} (S_L) \left(\frac{DT}{D_L}\right)$$

Where I_S = Steady State Intensity in candlepower.

Mt = Meter readings taken at angular traverses which inscribe a symmetrically oval beam pattern.

Msc = Corrected meter reading of photocell illuminated by standard lamp.

S_L = Rated candlepower of standard lamp.

DT = Distance from photocell to light under test.

D_L = Distance from photocell to standard lamp.

4.5 Determination of Effective Intensity (I_E)

4.5.1 Effective intensity for anti-collision lighting devices is determined from the following relationship:

$$I_E = \frac{\int_{t_1}^{T_2} I(t)\, dT}{0.2 + (T_2 - T_1)} \quad (1)$$

The next step is to enlarge the photograph of the intensity-time curve to a convenient size. This is done by simply plotting the steady state intensity in candlepower as the ordinate and the flash duration, as determined by the oscilloscope time base, as the abscissa on graph paper.

Referring to the formula (1) we see that the numerator of the fraction is really the total candlepower-seconds between the limits of t_1 and t_2 where the time between t_1 and t_2 is the flash time interval in seconds. The denominator of the formula is the flash time interval in seconds plus the constant 0.2.

If the graph paper is scaled in inches on which the intensity-time curve is enlarged, the formula (1) may now be reduced to:

$$I_E = \frac{\text{Areas in sq. mm} \times \text{seconds/mm} \times \text{candles/mm}}{(t_2 - t_1 \text{ mm}) \times \text{seconds/mm} + 0.2} \quad (2)$$

Where the area is square millimeters is the area under the curve between the limits t_1 and t_2.

The candles per millimeter is determined by the calibration of the ordinate scale.

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The seconds per millimeter is determined by the calibration of the ordinate scale.

The seconds per millimeter is determined by the abscissa scale.

The limits t_1 and t_2 are obtained in the following manner. Since this is a maximizing formula, it is necessary to establish t_1 and t_2 at the points of the curve which give the highest effective intensity. Since it is not known where these points are, it is first necessary to make an arbitrary estimate. An estimated effective candlepower point is selected and a vertical line established at that point on the graph. From the point of the intersection of this line with the candlepower curve, perpendiculars are dropped to the base line. These perpendicular lines represent the time t_1 and t_2. The factor t_2 and t_1 can then be measured in millimeters.

The area under the intensity-time curve between the limits t_2 and t_1 is then measured with a planimeter (or other suitable means) and all collected parameters are then applied to the formula (2).

If the result is greater than the estimate, it is then necessary to make a second estimate slightly higher than the first, which will cause a decrease in the area under the curve as well as in t_2 and t_1. If the result is lower than the estimate, then the procedure is reversed.

The calculated value of the ratio of the peak candlepower to the effective candlepower is expressed as a percentage in formula (2). Since the shape of the candlepower time curve has not changed with the angle of view, this percentage value holds true for any point of the distribution curve.

It is then only necessary to apply this percentage figure to the I_S values in 4.4.1 at the angular sittings desired, to find the effective intensity values.

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