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# THE EFFECT OF HEADLAMP BULB REPLACEMENT ON UNIT AIM: A COMPARISON OF SAE AND ECE SYSTEMS

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16. Abstract

The purpose of this study was to estimate headlamp beam aim variance associated with replacement of a burned out unit without reaiming. This was done with both U.S. type sealed beams and replaceable-bulb units of the type used in Europe.

The results indicate that the two types of lighting systems are similar in terms of the variance between the beam and mounting plane of the bulb. Based on this sample, the replaceable bulb units offered better control of vertical variance, the sealed beams better control of horizontal variance.

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# INTRODUCTION

When a headlamp burns out, it is important that it be replaced quickly. In general, cars have been designed to make the job simple. For U.S.-built cars, the task usually involves removal of some trim and a retaining ring. European (ECE)lamps are even simpler, when installed in cars designed for their use. The bulb is accessible from the rear of the lamp mounting and requires removal of a rubber "boot" and spring clip. In either case, bulb replacement is probably a do-it-yourself repair for most people.

Installing a new bulb of either SAE or ECE type will probably change beam aim. Therefore, it has been generally accepted that headlamps should be aimed after replacement. However, many, perhaps most, drivers do not reaim their lamps, whether the replacement is done by themselves or someone else. Thus, aim change due to lamp replacement is a contributing factor to population aim variance.

Some investigators have attempted to estimate the variance associated with bulb replacement. For example, Finch et al. (1969) estimated that about one-half of their sample of 140 lamps would have been outside California lamp adjusting station tolerances if used to replace correctly aimed lamps.

Hull et al. (1972) used mechanical aimers to align the lamps on 27 cars. The bulbs were then replaced with new ones and the aim checked using the same equipment. The authors report standard deviations of 27.5 and 21.8 minutes for the horizontal and vertical dimensions, respectively.

Two cautionary notes must be made concerning the Hull et al. data. First, the mounting and seating devices used for headlamps in cars do not provide a very stable base for measurements of the type attempted, and could well have contributed to the variance. Second, Hull et al. were measuring the relationship between the mounting and aiming planes, rather than that between the beam and mounting plane. Clearly, the latter is of greater significance if the concern is with the effect of bulb replacement on system performance. There is some variance associated with the relationship of the beam and aiming plane, which should be summed to the variance measured by Hull et al.

The present study was undertaken with two goals in mind. First, to develop a more adequate estimate of the relationship between the mounting plane and both the photometric aim and aiming plane for sealed beam bulbs (i.e., those manufactured to conform to FMVSS 108). Second, to compare these data with data on aim change associated with bulb replacement in European (ECE) units.

## METHOD
## SEALED BEAM (SAE) UNITS

The tested lamps were all 7 inch (17.78 cm) diameter round type 2 units. Ten each of four different brands were purchased from various local (Ann Arbor) sources. All low-beam filaments were aged at 12.8 volts for a minimum of four hours. Nine units of each brand were actually tested, the tenth being retained as a spare.

A plate was prepared to provide the mounting plane for the headlamps. This was positioned in a goniometer and set precisely parallel to a screen 25 feet (7.62 meters) distant. A transit was used to mark horizontal and vertical axes centered at the goniometer axis height.

Each lamp was placed in the mounting plate and a spot aimer attached to its face. The goniometer was adjusted until the beam from the aimer was centered on the H-V intercept. The goniometer setting was recorded at this position. This procedure yielded the relationship between the aiming and mounting planes.

At this time the lamp was turned on and set to 12.8 volts. It was allowed to warm up for ten minutes and the aim then adjusted photometrically according to the procedures outlined in SAE standard J 579c.

Figure 1 is a reproduction of the photometric aim diagram provided in J 579c. The process requires that the intensity measured at the point marked by the triangle on the H axis be 20% of maximum beam intensity at the same time that the point marked by the square on the V axis is 30% of maximum beam intensity.

The goniometer was adjusted until readings made with a Pritchard photometer at the test points described above were at the desired levels. The goniometer setting was recorded at this position. This procedure yielded the relationship between the beam and mounting plane. By using the aiming-mounting plane data, it was possible to "correct" the beam-mounting plane data in a way equivalent to using perfectly calibrated mechanical aimers. This addressed the issue of the value of reaiming after lamp replacement.

## METHOD
## REPLACEABLE BULB (ECE) UNITS

The bulbs used in the test were all type H-4. That is, they were dual filament, quartz-halogen bulbs. They were purchased at a number of outlets in the Ottawa (Canada) area. Six bulbs from each of six manufacturers were used in the test.

A single lamp housing (lens and reflector) was used. This was a 7 inch (17.78 cm) round unit which had been employed as a reference lamp in other photometric studies.

The reference lamp housing was mounted in the goniometer of the NRC photometer. Each bulb was appropriately aged and inserted into the housing. The photometer was then operated to produce a matrix of candela values. The resultant data were compared with data from a reference bulb.

The vertical aim of the bulb was determined by examining the candela data and locating on the left side the point at which the transition from low to high levels of illumination was maximum. The horizontal aim was based on the intersection between the horizontal cut-off on the left and the $15^{0}$ upslope on the right. With the location of the horizontal cut-off in hand, it was only necessary to move up a known angle and locate the edge of the upslope in the same way as the horizontal edge had been located, then extrapolate downward to the intersection.

## RESULTS

The most important data from this study are the comparison of variability of photometric aim about the mounting plane for the SAE and ECE units. Table 1 provides the basic data for each lamp.

The standard deviations in the horizontal dimension are 26.2 and 38.1 minutes for the SAE and ECE units, respectively. This difference is significant ($p < .05$), as determined by the F max test (Winer, 1962).

The standard deviations for the vertical dimension are 17.7 amd 9.2 minutes for the SAE and ECE units, respectively. This difference is also significant ($p < .01$), as determined by the F max test.

A question of interest concerns differences between brands of bulb. These data are summarized in Table 2.

The brand differences must be interpreted with caution. The samples are very small (9 each SAE, and 6 each ECE), were purchased in a restricted area in a short time period, and may not be representative of the general quality control practices of the manufacturers. However, it is interesting to note whether the sample brands were homogeneous with respect to the variables of interest.

For the SAE units, the differences between brands in the vertical dimension are not significant ($p > .05$), as determined by the F max test. The differences in the horizontal dimension are significant ($p < .05$), however. In the latter case, if the brand with the largest standard deviation is eliminated (C), the difference becomes non-significant ($p > .05$).

For the ECE units, the differences in the vertical dimension are significant ($p < .05$). Elimination of brand A reduces the difference to

TABLE 1

Comparison of Photometric Aim and Mounting Planes for Sample of SAE and ECE Headlamps

| | SAE | | ECE | |
|---|---|---|---|---|
| | H | V | H | V |
| | 66 | 10 | -14 | 7 |
| | 33 | -22 | 12 | 7 |
| | 59 | - 2 | 11 | 8 |
| | 38 | -17 | 1 | 11 |
| | 28 | 49 | -36 | 5 |
| | 42 | -20 | -13 | 11 |
| | 68 | - 1 | 10 | - 1 |
| | 60 | 14 | -42 | 4 |
| | 41 | 16 | -13 | 14 |
| | - 2 | -53 | -58 | -14 |
| | 3 | -15 | - 5 | 10 |
| | 11 | - 2 | -57 | 4 |
| | 4 | - 4 | 64 | 7 |
| | 7 | -23 | -91 | 18 |
| | 22 | 8 | -37 | 1 |
| | - 2 | -16 | -72 | 11 |
| | -12 | - 1 | -29 | - 7 |
| | 12 | 9 | -55 | 4 |
| | 59 | 8 | -65 | -15 |
| | - 5 | 15 | -43 | -11 |
| | 16 | 6 | -17 | - 9 |
| | 1 | - 1 | -57 | - 4 |
| | 38 | - 1 | -55 | - 7 |
| | -25 | -12 | 43 | - 4 |
| | 20 | 10 | -28 | 7 |
| | -25 | -13 | -49 | - 5 |
| | 56 | 14 | -63 | 19 |
| | 14 | 2 | -74 | 9 |
| | 12 | - 4 | -56 | 0 |
| | - 2 | -24 | -62 | 14 |
| | 9 | - 5 | -42 | 0 |
| | -12 | -18 | -40 | -18 |
| | 12 | 24 | -13 | 7 |
| | 18 | -12 | -53 | - 4 |
| | 8 | -18 | -56 | 4 |
| | -26 | -19 | 44 | -4 |
| Standard Deviation | 26.2 | 17.7 | 38.1 | 9.2 |

Note: Data are in minutes of arc.
Positive values indicate aim to the right or up.

TABLE 2

Comparison of Vertical and Horizontal Photometric Aim Relative to the Mounting Plane for Various Brands of SAE and ECE Bulbs

| Brands | Standard Deviation of Aim (in Minutes) | |
|---|---|---|
| SAE | Vertical | Horizontal |
| A | 22.5 | 15.0 |
| B | 19.2 | 9.8 |
| C | 10.4 | 31.6 |
| D | 14.8 | 14.4 |
| ECE | | |
| A | 2.2 | 18.3 |
| B | 10.0 | 28.9 |
| C | 8.6 | 33.4 |
| D | 4.4 | 42.1 |
| E | 8.9 | 16.0 |
| F | 8.7 | 48.5 |

a non-significant level ($p > .05$). Differences among brands in the horizontal dimension are non-significant ($p > .05$).

The measurement of the relationship between the mounting and aiming planes (SAE units only) yielded standard deviations of 12.4 and 15.8 minutes for the vertical and horizontal dimensions, respectively. These data can be compared to those of Hull et al. (1972), which are 21.9 and 27.7 minutes for the vertical and horizontal dimensions, respectively. These differences are rather substantial and may be attributable to the greater precision possible in the present test.

An analysis was carried out of the variance in photometric aim for the SAE bulbs if the unit were adjusted to compensate for the discrepancy between the aiming and mounting planes. The resultant standard deviations were 16.5 and 24.4 minutes for the vertical and horizontal dimensions, respectively. These do not differ significantly ($p > .05$) from the standard deviations associated with photometric aim and the aiming plane (17.7 and 26.2 minutes for vertical and horizontal, respectively).

## DISCUSSION

The results of this study suggest that the aim variance resulting from bulb replacement is somewhat different for SAE and ECE units. The SAE bulbs appear to offer slightly better control of horizontal aim, the ECE bulbs better control of vertical aim. Under the assumption that control of vertical aim is more important, the advantage would appear to lie with the ECE system.

There were differences between brands for both SAE and ECE units. As noted earlier, these differences cannot be taken as representative of the practices of the manufacturers involved. Therefore, the brands have not been identified. However, it is interesting to compare the relative performance of the two systems by brand.

The main analysis found that the ECE system was better than the SAE in control of vertical aim. As will be noted in Table 2, each brand of the ECE bulbs had a lower standard deviation of aim in the vertical dimension than the best of the SAE brands. In the horizontal dimension, almost the opposite is true. With the exception of SAE brand C, all of the SAE units have a lower standard deviation of aim than the best of the ECE units. Even SAE brand C has a lower standard deviation of aim than three of the ECE brands. This analysis further reinforces the idea that there are differences between the systems in terms of variability between beam and mounting plane. It also raises a question whether these difference are inherent to the system, or whether they can be reduced.

The latter question is an important one, because available data suggest that discrepancies between beam and mounting plane are a major source of population aim variance (Olson and Mortimer, 1974). Olson and

Mortimer assumed a standard deviation of 2.2 inches at 25 feet (25.4 minutes) for photometric aim versus mounting plane for both vertical and horizontal dimensions. The results of the present study are very close to this value in the horizontal dimension (especially for the SAE units), but less in the vertical dimension (especially for the ECE units). Since this is one of the largest individual sources of aim variance, improvements would have a significant impact on population aim variance.

The results of the analysis of "corrected" aim indicate that, for these SAE units at least, the relationship of the beam to the aiming plane is about the same as the beam to the mounting plane. If these data are representative, there is no point in reaiming a sealed beam simply because it has been replaced. In addition, when one considers real-world problems such as out-of-calibration aimers and poorly trained or careless service personnel (which are substantial sources of aim variance), reaiming after replacement may actually increase aim variance.

There is no question that aiming is a major limitation to headlamp effectiveness. The present study has provided some interesting and valuable insights on one source of headlamp misaim, and permitted a comparison of the SAE and ECE systems. Clearly neither system is superior overall in terms of aim variance resulting from bulb replacement. However, the ECE system seems to offer an advantage in that, based on these data, it has better control of vertical aim.

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