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7. Author(s) Paul L. Olson and Michael Sivak		8. Performing Organization Report No. UM-HSRI-82-10
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16. Abstract

This project consists of two phases. In Phase 1, based on extensive review of the literature, and several studies concerning glare in rearview mirrors, recommendations were made for modifications to the low-beam lighting systems. Hardware embodying the revised photometrics was made available by a cooperating manufacturer. Using these lamps, two demonstrations were conducted, comparing the new system with standard SAE sealed beams. The results of the demonstrations were encouraging, yielding a number of useful comments.

In Phase 2 a number of studies will be carried out, using a variety of lighting systems, in an effort to better define acceptable and/or desirable maximum and minimum photometric values for low-beam headlamps.

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INTRODUCTION

This is a brief overview of a project entitled "Improved Low-Beam Photometrics," being carried out under contract DOT-HS-9-02304 for the National Highway Traffic Safety Administration (NHTSA) by the University of Michigan Highway Safety Research Institute (HSRI). Most of the material which will be reviewed is fully described in an Interim Report for the above-mentioned project (Olson and Sivak, 1981).

Purpose

The purpose of this project is to develop recommendations for improvements to the low-beam lighting system used on cars in the United States. To accomplish this the project was divided into two phases. In Phase 1, by a combination of review of the literature, consultation with lighting experts the world over, and independent research, the investigators were to arrive at recommendations for modifications to low-beam photometrics. In Phase 2, further studies will be carried out in an effort to better define desirable maximum and minimum candela values for low-beam headlamps.

Present Status of the Project

Phase 1 of the project has been concluded. Its end-product was the Interim Report referenced above. Phase 2 has been approved by the sponsor. At the time that this report is being written, headlamps having the desired photometrics are in the process of fabrication. At least two other, different low beam systems are being prepared as well by other organizations, and are scheduled to be evaluated in this study. The sample headlights are due to be delivered on or about April 1, 1982. A workplan will also be written and delivered to the sponsor describing in some detail the research activities to be carried out during Phase 2. The entire project is scheduled to be completed by December 31, 1982.

Organization of this Report

The bulk of this report describes the activities carried out in Phase 1 of the program, and the photometric recommendations which resulted.

While Phase 2 activities have not yet been finalized, some indication of the probable nature of the research will be provided.

PHASE 1

Background

This project is a follow-on of a previous NHTSA-funded project entitled "Evaluation of the Feasibility of a Single-Beam Headlighting System" (Halstead-Nussloch et al., 1979). In that project a great number of different beam patterns were examined, using a computer model, to determine their relative merits. This work gave the present investigators an indication of promising avenues for modifications to the low beam lighting system.

Project Effort

The project began with a detailed review of the literature. Particular attention was paid to recent publications in areas such as discomfort and disability glare. Based on this review, a conclusion was reached that additional information was required concerning the problems of glare from the rearview mirrors.

Four studies were carried out on the question of rearview mirror glare. Two of these were laboratory studies and two were carried out in the field. One of the field studies was designed to verify the findings of the laboratory work on disability glare, and the other field study dealt with the issue of discomfort glare. This work is summarized and the findings are presented in the Interim Report referred to earlier (Olson and Sivak, 1981). In brief, the data indicate that discomfort and disability glare are significant problems at the illumination levels currently provided by sealed-beam (SAE) low-beam lighting systems. Clearly, photometric modifications which result in additional glare in the rearview mirrors would only add to the problem. However, it is the opinion of the investigators that this is a correctable problem, and it ought not to be viewed as an important argument against increased output on the part of the low-beam headlamps. It is true that further research on the rearview mirror systems (particularly on the exterior mirror) is probably warranted. However, in a car equipped with a dual-reflectivity interior mirror, it is possible for the driver, by a combination of intelligent use of the interior mirror and judicious aiming of the exterior mirror, to largely avoid uncomfortable and disabling glare from those sources.

Having arrived at certain decisions regarding acceptable glare levels, the basic beam development work was done with the assistance of a computerized headlamp seeing distance model (Mortimer and Becker, 1973). The work done to this point suggested to the investigators that the only place in the forward field toward which additional illumination might profitably be directed was along the right edge of the road. We started with a mid-beam system which had been investigated as part of the single beam study. This mid-beam consisted basically of an SAE low beam with an additional 60,000 candela narrow-beam unit directed along the right edge of the road. That configuration far exceeded what was felt to be tolerable glare limits for a low beam system. Therefore, the computer model was used to assess trade-offs between reduced intensity and seeing distance. The final configuration arrived at retained the basic low beam pattern, with the additional mid-beam lamp adjusted to 25% of the initial value. This pattern, originally produced by three lamps, was then reformulated as a two-lamp system.

Table 1 is a candela matrix showing both a "standard" low beam and the proposed modified low beam. Note that Table 1 represents a single lamp from a two-lamp system. The major difference between the two systems is just to the right of the V axis and near the H axis. Based on the computer simulation work, we estimate that the new system would improve seeing distances to low-contrast targets placed along the right edge of the road to a point about halfway between the seeing distances provided by the current SAE low and high beams.

TABLE 1

COMBINED LOW BEAM CANDELA MATRIX

	Degrees Left									Degrees Right									
	8	7	6	5	4	3	2	1	0	1	2	3	4	5	6	7	8	9	10
2.0	200	225	225	250	250	250	300	350	400	500	550	550	550	500	500	500	450	400	350
2.0	200	225	225	250	250	250	300	450	600	800	900	800	700	600	550	500	450	400	350
1.0	300	300	350	350	400	450	475	600	700	800	900	900	900	800	750	700	700	650	500
1.0	300	300	350	350	400	500	650	1000	1700	3650	3750	2800	2000	1200	950	900	800	700	500
0	500	500	500	500	530	600	700	1000	2000	4000	7000	7500	7000	6000	5500	4000	3500	2000	1250
0	500	500	600	650	700	800	1200	1800	5750	11000	12000	10500	7800	6600	5750	4200	3600	2100	1275
1.0	1000	1000	1100	1100	1200	1500	2000	2500	5000	12000	15000	14000	12500	11000	10500	9000	7500	6000	4500
1.0	1000	1100	1150	1200	1400	1900	2700	4000	8200	17500	19000	17800	13700	12000	10400	9400	8300	6200	4650
2.0	2000	2000	2000	2200	2500	3000	3500	4000	7000	15000	20000	18000	16500	14000	12000	11000	10500	9000	6500
2.0	2000	2200	2400	2700	3000	3600	3900	5300	8500	16800	22000	19500	17200	15000	13700	11600	10900	9350	6700
3.0	2000	2100	2200	2400	3500	4000	4300	5000	5500	10000	12000	12000	11500	11000	10500	10000	8000	7000	5200
3.0	2000	2400	2700	3200	3900	4300	4850	5700	6800	11000	13000	12900	12800	12000	11400	9800	8200	7200	5600
4.0	2000	2000	2000	2350	2650	3175	4000	4700	5200	5700	7200	7200	7200	7200	6650	6150	5100	4400	4050
4.0	2000	2000	2050	2350	2650	3175	4000	4700	5200	5700	7200	7200	7200	7200	6650	6150	5100	4400	4050

Note: For each row, values on top are for reference, "standard" SAE low beam. Values on bottom are for suggested modified low beam.

PHASE 2

Preliminary copies of lamps approximating the new photometrics described in Table 1 were fabricated by Stanley Electric of Japan. Three of these lamps were made available to the project in the Fall of 1981. Two of these were mounted on a test automobile and used for preliminary evaluations. The initial concern was to subjectively assess improvements in seeing distance by making side-by-side comparisons with standard SAE lamps. In the Fall of 1981 a demonstration was held in Washington for interested persons from NHTSA. About one month later another demonstration was held in Ann Arbor, Michigan for interested members of the SAE Lighting Committee. The results of both of these demonstrations indicated that the proposed system provided improved visibility and that the glare levels may be acceptable. Approval was received from our sponsor to go ahead with Phase 2 and the lamps were subsequently ordered.

About the time that the Interim Report for Phase 1 of this project was written a new paper appeared on the subject of discomfort glare (Lulla and Bennett, 1981). This paper dealt with the glare range effect. Briefly, what Lulla and Bennett did was to utilize two ranges of glare values to investigate what effect, if any, this had on judgments of BCD. The two ranges had the same minimum values, but the maximum values differed by 10:1. The investigators noted that the BCD for the greater range was seven times greater than for the lower range. This is an important finding, if it generalizes to automotive lighting, because it implies that judgments of discomfort glare are determined, in part, by context.

We felt it important to determine whether the glare range effect described by Lulla and Bennett applied to the somewhat different situation of automotive headlighting. A study was carried out, duplicating, insofar as possible, the methodology employed by Schmidt-Clausen and Bindels (1974). Half the subjects in this study made judgments of discomfort glare using the same range of glare values employed by Schmidt-Clausen and Bindels. Half used a range which was truncated at the upper end by a factor of about 6. The results of this study show that the same glare values were assigned significantly lower (more uncomfortable) ratings by the group experiencing the truncated range.

The next step in this program will be to evaluate the effect of glare attenuation at the lower end of the continuum. The reason is that a modified lighting system such as that described in Table 1 would have the effect of raising average glare levels, reducing the incidence of low glare levels, but not affecting high glare levels. This can be approximated by a glare-range study wherein the glare distribution is truncated at the lower end. If the glare-range effect holds in this condition as well, it suggests that the driving population would adapt to a higher-glare lighting system more readily than would have been expected otherwise.

Other work considered for Phase 2 include seeing-distance studies using targets of various size and levels of reflectivity, glare evaluations, computer analyses using both the HSRI and Ford models, and a "semi-alerted" detection study similar to that employed by Halstead-Nussloch et al. (1979).

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