HEADLAMP PERFORMANCE IN TRAFFIC SITUATION

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ABSTRACT

The photometric requirements of today's headlamps do not relate to the headlights as built into the vehicle, but to the individual headlamp before its installation. The aim of this survey is to demonstrate the relation between technical requirements of individual headlamps and the actual situation on the road. For that purpose headlamps were measured: on the one hand those of known vehicles (reference vehicles) with correctly adjusted and cleaned headlamps; on the other hand headlamps in everyday traffic, i. e. possibly incorrectly adjusted and soiled.

It could be shown that the glare of illuminance of the gas discharging headlamps in the measuring point of the human eyes of an on-coming car is lower than of normal traffic vehicles.

INTRODUCTION

The legal requirements of headlamps vary from country to country. These regulations relate to the place, levelling and photometry.

MEASURING

The measuring can be divided into the following items:

- Photometric measuring points (ECE and MVSS / SAE)
- Dynamic courses of the photometrics measuring points
- Dry road
  Situation:
  - Humid
  - Rain
- Wet road
  Situation:
  - Humid
  - Rain
- Reference vehicles
- Normal traffic

All in all twelve combinations are possible. The measuring points are shown in Figure 1 and Table 1.

Table 1.
Measuring Geometry.

Measuring Geometry		
Measuring Point	Measuring Distance d / m	Position
50L	50.4	left road side
VL	50.4	left shoulder 1m left 2.50 m height
50R	50.4	right road side
VR	50.4	right shoulder 1m right 2.50 m height
75R	75.1	right road side
B50L	75.1	Direction as defined by relevant regulations
HV	95.4	Direction as defined by relevant regulations

Street Geometry

The measuring equipment was set up on a "Bundesstraße" with a speed limit of 44 mph. The drivers were not informed about the measuring taking place.

Photometric Measuring

The photometric measurements were made by single ($V(\lambda)$-adapted) photoelements in the directions and distances as listed in Table 1. All values described later are recalculated for a distance of d = 25m and valid for a light distribution of a system with two superimposed headlamps. The possible forward reflection on the pavement into the direction of the photoelements was shielded. The whole measuring system was controlled by a system-timer of the computer used for the data collection.

Photometric Requirements

For the measurings a set of measuring directions as listed in Table 1 and shown in Figure 1 were selected. The new measuring points VR and VL describe the situation of the illumination at traffic signing. The photometric limiting values except those for VR and VL can be taken from the relevant ECE-Regulation. The photometric requirements for headlamps are based on certain test voltages. These voltages can differ from those measured at the headlamp mounted on a car. There are many other effects influencing the photometric values of headlamps for example

- ageing of headlamps and lenses
- ageing of filament lamps
- changing of the plugs' resistance, etc.

Therfore, a large variety of measured values could be expected.

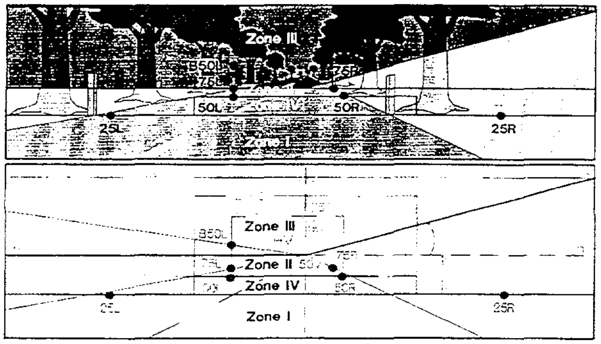

Figure 1. Measuring Points in Street Geometry.

RESULTS

The speed of the vehicles varied from 40 to 48 mph (reference vehicles) and from 44 to 68 mph (normal traffic).

The results are split into four items:

Vehicles

- in normal traffic
- with gas discharging headlamps
- with H4-Headlamps
- with modular build up illumination

Situation on the road (normal traffic)

In Figure 2 the illumination E(HV) of vehicles in normal traffic are shown. Ē describes the arithmetic mean value.

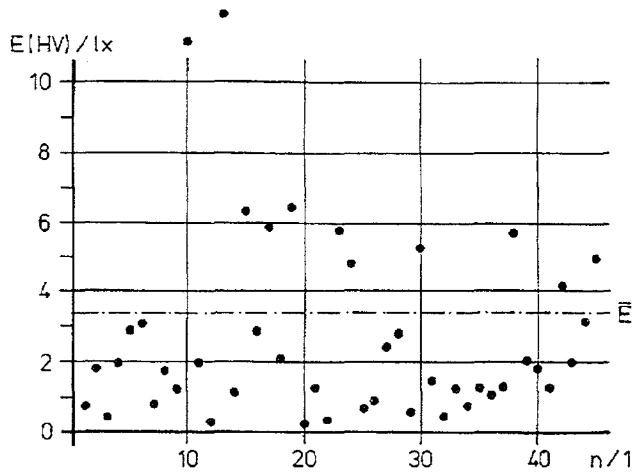

Figure 2. Illumination E(HV) for Normal Traffic. Number of Measurings: n = 78

The figure illustrates the great variety of results in the HV-point. The mean value Ē follows after measuring pairs of headlamps in normal traffic. The values' scattering results from a high gradient in the HV-point, incorrectly adjusted and/or soiled headlamps. The single headlamp's mean value exceeds the legal maximum value of the ECE regulation which amounts to E = 0.7 lx. Apart from the already mentioned reasons, the high voltage in the vehicle and its variation (mean value 13.5 V instead of the supposed 12 V) are responsible for this effect.

Figures 3 and 4 show the frequency distribution f of the E(B50L) and E(75R). A normal distribution ensues from both diagrams. The mean values amount to

E(B50L) ≈ 1.04 lx and
E(75R) ≈ 10.3 lx.

While the glare point of B50L surpasses the legal standard of 0.4 lx (per individual headlamp) only slightly, the minium value of 12 lx in 75R is not achieved by far. Consequently, the distance of recognition is shortened and this results in a decrease of safety in traffic.

The measurings were repeated on several days during like weather conditions. Figure 5 plots the mean values of four sensors during six/seven different measurings in normal traffic. Every sketched value is based on a minimum of 33 and a maximum of 406 different vehicles. The discrepancies, which become particularly visible in the HV-value, again refer to insufficiently adjusted and soiled headlights.

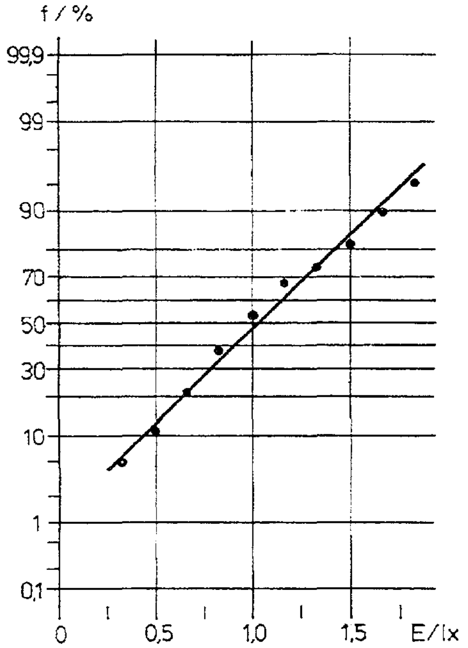

Figure 3. Frequency Distribution f of the Illumination E(B50L) for Normal Traffic. Number of Measurings: n = 78

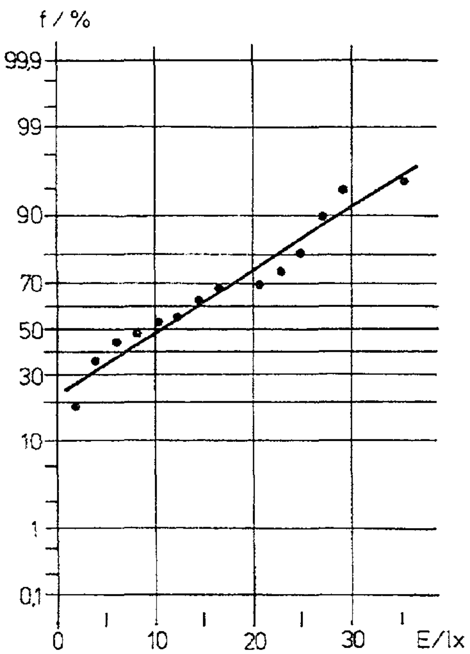

Figure 4. Frequency Distribution f of the Illumination E(75R) for Normal Traffic. Number of Measurings: n = 78

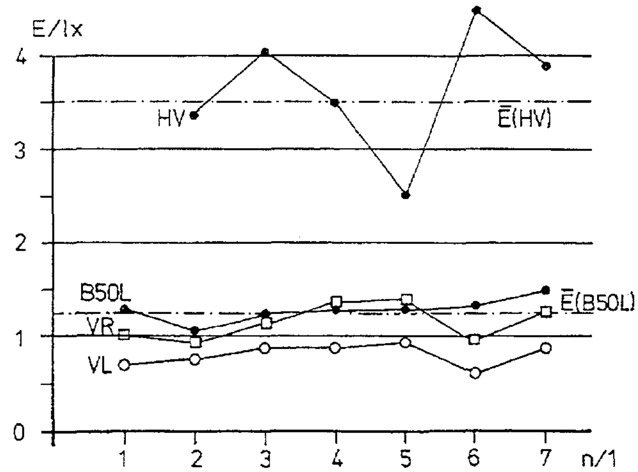

Figure 5. Mean Values of the Illumination E for Different Measurement Series n.
HV, B50L: Illumination in the Measuring Direction HV, B50L
VR, VL: Illumination in the Measuring Direction of Shoulder Mounted Traffic Signs (R: Right Shoulder, L: Left Shoulder)
Ē(HV), Ē(B50L): Calculated Mean Values

The relation between E (B50L) and E (75R) is shown in figure 6. The mean values of the glare-point and the range amount to 1.06 lx and 12.3 lx respectively. As a conclusion follows:

$$\frac{\overline{E}(B50L)}{\overline{E}(75R)} = \frac{1}{10}$$

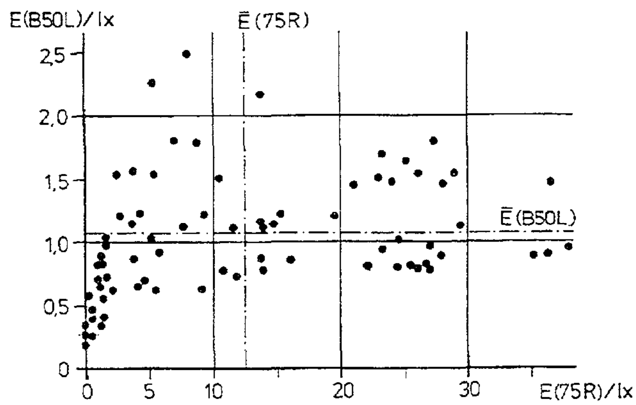

Figure 6. Illumination E(B50L) and E(75R) for Normal Traffic.
Ē(HV), Ē(B50L): Calculated Mean Values
Number of Measurings: n = 78

Gas Discharge Headlamps (GDL)

During the last years the glare of headlights with GDLs has been discussed. The road users' subjective judgements usually declare them as being more glaring than those headlamps common up to now. Because of that, vehicles with these light sources were separately analysed so that an objective conclusion could be drawn. Figures 7 and 8 depict the luminous flux of a vehicle with correctly adjusted headlights in the points of B50L and 75R. The mean values amount to $\bar{E} \approx 1.1$ lx and $\bar{E} \approx 38$ lx respectively and fulfil the legal requirements. The glare values do not exceed those in normal traffic, that is to say, those of vehicles with conventional halogen headlamps.

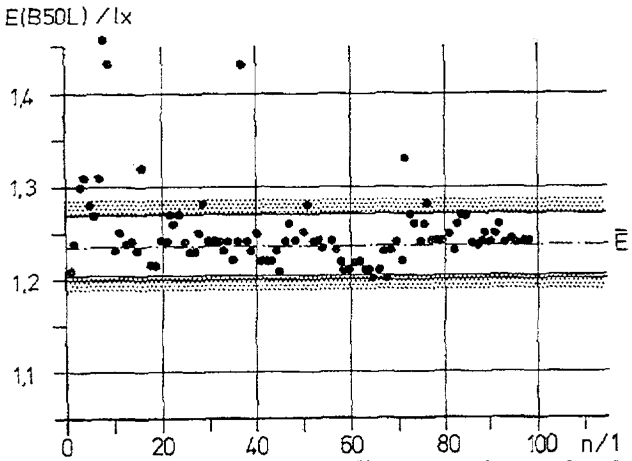

Figure 7. Illumination E(B50L) for Single Measuring for One Car with Gas Discharge Headlamps.
Ē: Calculated Mean Value for E(B50L)
Number of Measurings: n = 95

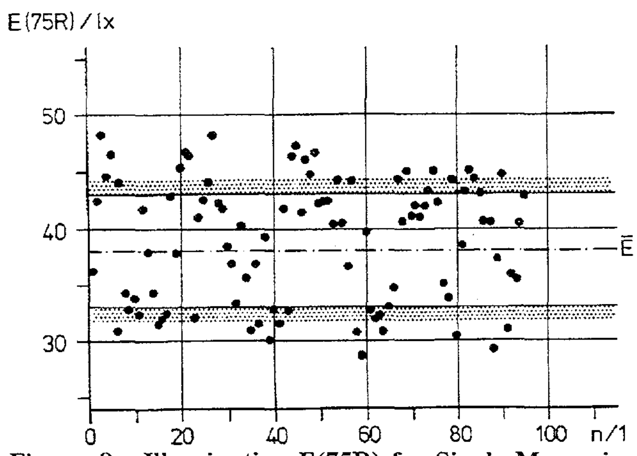

Figure 8. Illumination E(75R) for Single Measuring for One Car with GDL-Headlamps.
Ē: Calculated Mean Value for E(75R)
Number of Measurings: n = 95

The GDL's relation of glare and range, however, comes up to about 1:30 and reaches a value three times as high as the one measured during normal traffic. An intensified use of GD-Headlamps would therefore contribute to the enhancement of vehicle safety.

For reference measurings and the comparison of knowingly correctly adjusted and clean headlamps with those of normal traffic, eleven different vehicles were employed and taken into account. 10 to 87 times each of these were driven along the measuring range, which resulted in 358 individual measurings. In Figure 9 the measuring point B50L of correctly adjusted and clean headlamps as well as the values gained during normal traffic are plotted. It shows that the glare values in the second survey of identified headlamps are in most cases lower.

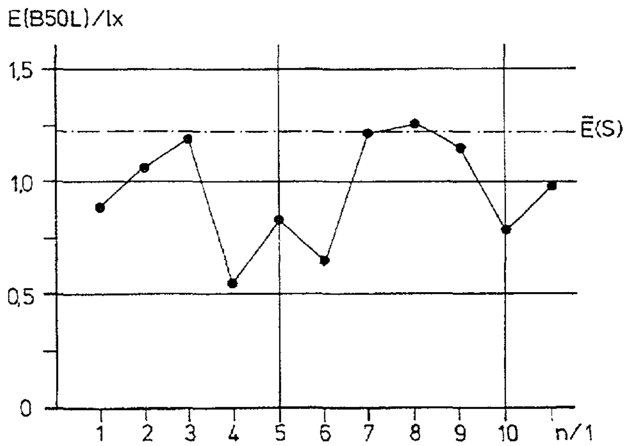

Figure 9. Mean Values of the Illumination E(B50L) for Single Cars.
Ē(S): Calculated Mean Value for E(B50L) for Normal Traffic
Number of Measurings: n = 10...87

A comparison of glare and range in Figure 10 reveals that its relation comes up to 1:50 in the case of correctly adjusted and clean headlamps. Due to these results, enhanced vehicle and traffic safety could be achieved by further use of headlamp washers as well as by ensuring that headlights will correctly be adjusted.

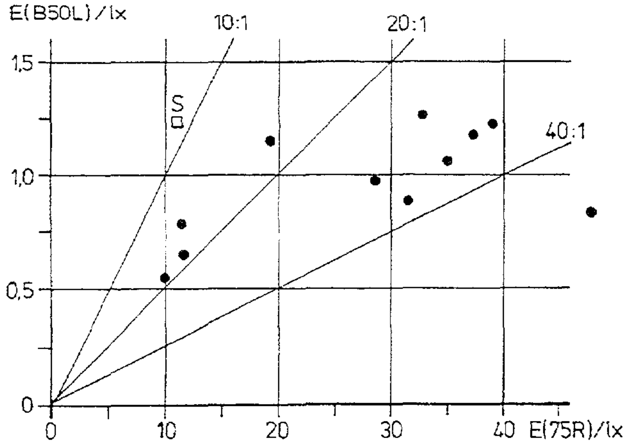

Figure 10. Mean Values of the Illumination E(B50L) and E(75R) for Different Types of Headlamps.
Number of Measurings: n = 95
S: Calculated Mean Value During Normal Traffic

Comparison of Various Tests

The comparison of various headlamps in different measuring points on dry road is plotted in Figures 11 and 12. The following categories of vehicles are shown:

- normal traffic (n=363)
- individual vehicles with GDLs (n=82)
- individual vehicles with H4-headlamps (n=97)

The mean values are plotted logarithmically.

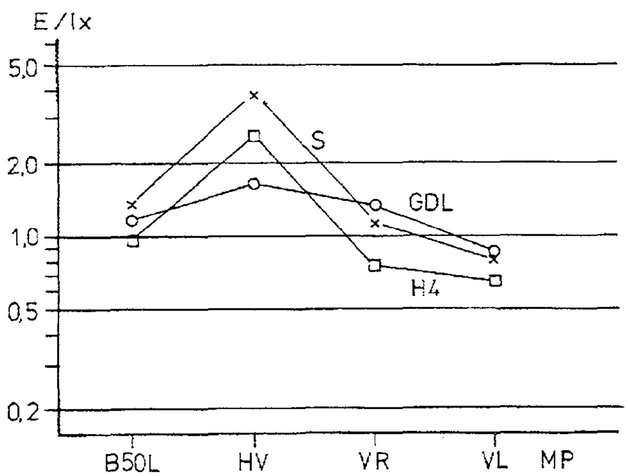

Figure 11. Mean Values of the Illumination E in Different Measuring Directions for Cars with Different Headlamps.

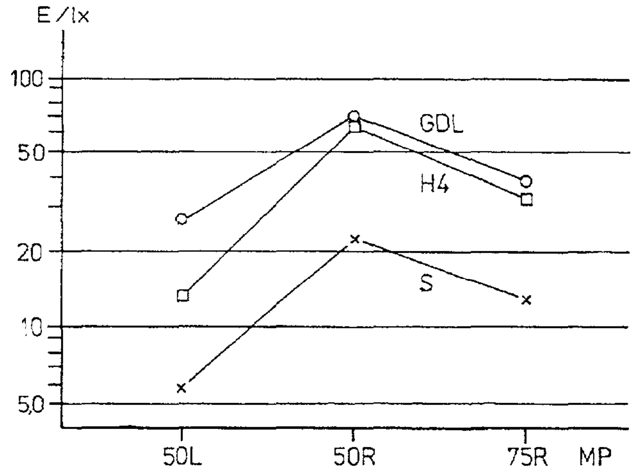

Figure 12. Mean Values of the Illumination E in Different Measuring Directions for Cars with Different Headlamps.

A comparison of the measured values demonstrates that the illumination of the GD-headlamps is better than any other, i. e. the glare value is lower and the other measured values higher than those of the other categories. (Only in B50L almost all headlamps show the same value of the luminous flux). Once again, it can be ascertained that the GD-headlamps could provide for an enhancement of vehicle safety.

Adverse Weather Condition

The tests on dry road excluded the measuring of the forward reflection. On humid or wet road that kind of reflection accounts for a significant share in the measuring points – especially in the glare-point B50L. Due to this fact, the set-up was modified for these tests. The changes of the measured values can be seen in the Figures 13 and 14.

The periods of rain are divided into three phases:

Table 2:
Comparison of E(B50L) on Dry and Wet Road

from n	to n	Rain	$\bar{E}_d/\bar{E}_w$	
			H4	GDL
1	18	Heavy	1:10	1:9
19	50	Normal	1:2.5	1:2
51	70	Medium*	1:7	1:6

*dry road conditions

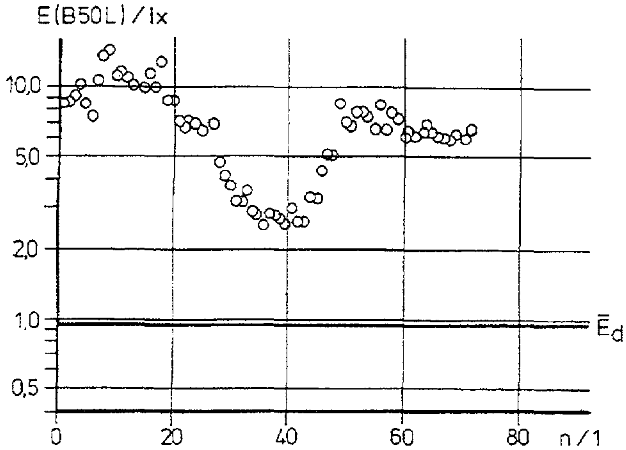

Figure 13. Variation of the Illumination E(B50L) of H4-Headlamps of Single Car During a Rainfall Period.
$\bar{E}_d$: Calculated Mean Value for E(B50L) Under Dry Weather Conditions
Number of Measurings: n = 71

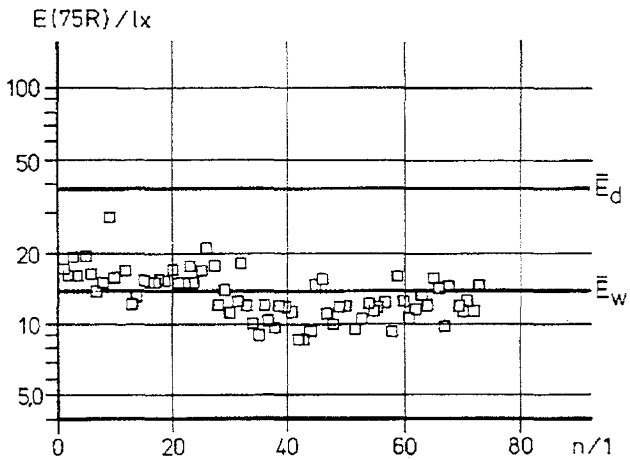

Figure 14. Variation of the Illumination E(75R) of GDL-Headlamps of Single Car During a Rainfall Period.
$\bar{E}_d$: Calculated Mean Value for E(75R) Under Dry Weather Conditions
$\bar{E}_W$: Calculated Mean Value for E(75R) Under Wet Weather Conditions
Number of Measurings: n = 71

During the different intensities of rain, varying degrees of increased luminous flux in the glare-point can be observed (cf. Table 2). By contrast, the luminous flux in 75R are similarly high as the values on dry road.

The results gained of the vehicles in normal traffic appear to be more randomly distributed. An increase in the luminance in B50L, however, can be perceived, which amounts to the factor 1:3.

LITERATURE

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