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Note: The following paper has been produced by Dr Karl Manz, chairman of the GTB ADB (Adaptive Driving Beam) taskforce and chairman of the GTB SVP (Safety and Visual Performance) scientific advisory working group. It has been produced in response to the request for clarification from the expert of Japan at the 64th session of GRE.

Adaptive Driving Beam System
Threshold Conditions for the Minimum Detection Distance of the Sensor System

Extract of the Student Research Project of Andree Hohm [1]

Karl Manz

Introduction

The investigation titled "Physiologische und Photometrische Untersuchungen zur Herleitung von Randbedingungen für eine Abblendautomatik (Physiological and Photometric studies on the derivation of boundary conditions for an automatic dipping system)" was carried out in 2005 by Andree Hohm[1] at the TU Darmstadt.

Part one – Photometric Measurements:

For the determination of the minimum detection distance in the case of a preceding vehicle the following experimental design was used to measure the glare illuminance. In the preceding vehicle a photometer head was installed, in the equivalent position of the driver's eye. The values were measured in relation to the separation distance between the preceding and the following vehicle ("glare" source), which had its driving beams switched on (Audi A6 with H7 driving beams marked with the reference number 27.5).
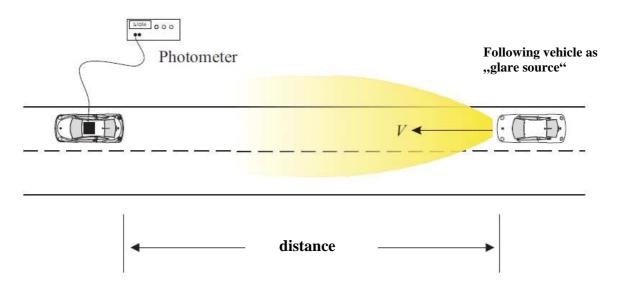

Figure 1: Experimental design of the first part.

The investigation was carried out on a dark air field having a length of 1200m.

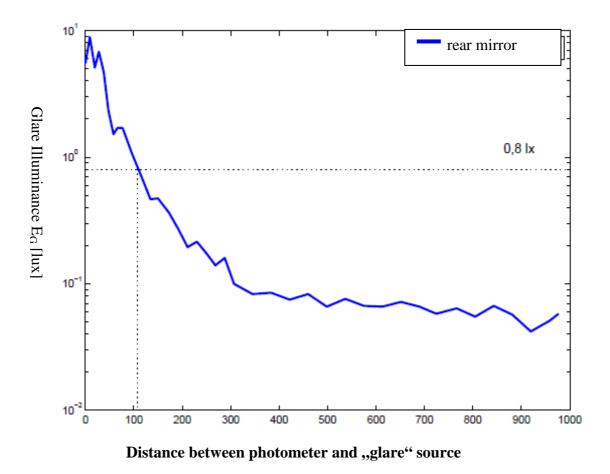**Distance between photometer and „glare" source**

Figure 2: Measured values in relation to the distance between photometer and "glare" source

The results showed that the illuminance of 0.8 lx will be reached at around 100m.

On the basis of the results of the first part of the experiment described above, calculations using the discomfort glare model of Bindels and Schmidt-Clausen [2] were made. These results showed, that the borderline between "just acceptable" (level 5 on the DeBoer Scale) and "disturbing" (level 3 on the DeBoer Scale), i.e. the level 4 on the DeBoer Scale, that could describe as "starting to be disturbing", was reached at nearly 50m.

The calculations were made according to the following relationship [2]

$$W = 5 - 2 \cdot \log \frac{E_B}{C_{p00} \cdot \left(1 + \sqrt{\frac{L_A}{C_{pL}}}\right) \cdot \Theta^{0,46}}$$

$L_A = \overline{L_U}$ (see below) with the constants:

$$C_{p00} = 3,0 \cdot 10^{-3} lux \cdot min^{-0,46}$$
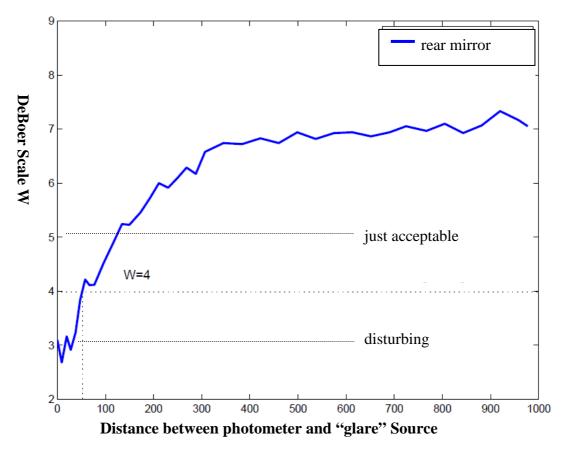$$C_{pL} = 4,0 \cdot 10^{-2} cd \cdot m^{-2}$$

Figure 3: Calculated DeBoer levels, W, according the relationship of Bindel and Schmidt-Clausen [2/] on the basis of the photometric measurements.

Part 2 - Investigation with observers:

The second part of this investigation was carried out with observers (test persons) in the preceding vehicle. The test road was arranged with retro-reflective road markings, to represent a normal road. Each test person made a minimum of 15 repetitions of the experiment. The task of the test person was to indicate the moment when the glare reached the level 4 on the DeBoer Scale, i.e. the discomfort starts to become disturbing. Eight observers with ages in the range of 25 to 32 years participated and a total of 405 test drives were carried out. The approaching speed of the following vehicle was around 80km/h, whilst the preceding vehicle with the observer remained in a fixed position.
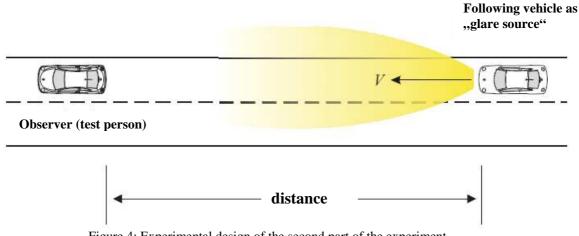

Figure 4: Experimental design of the second part of the experiment.

The surrounding luminance (adaptation level), produced by the illumination of the preceding vehicle with the observers (test persons), was determined by a number of test targets in the road scene. The measured mean value was calculated using:

$$\overline{L_U} = 0,59 \frac{cd}{m^2}.$$

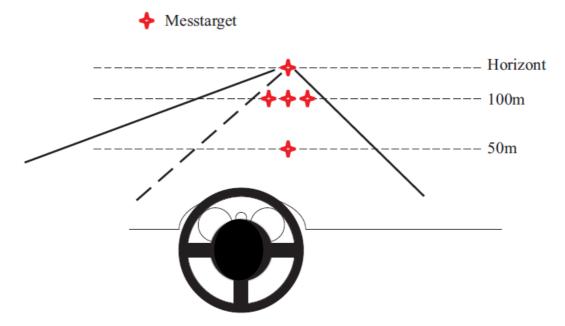And for the calculations above $\overline{L_U} = L_A$.

Figure 5: Positions of the test targets for the evaluation of the adaptation level.

The mean value of all test results, determined using the experimental design of the second part described above with observers, was a distance of 91,65m to reach the level 4 on the DeBoer Scale.

Conclusion

Comparing the photometric measurements of the first part of the experiment and the results of the observations, the threshold was reached either at approximately 100m, based upon a threshold illuminance of 0.8lx or, at approximately 50m using the calculated DeBoer ratings, with a threshold value of 4.

However, it is necessary to take into account the so called "glare angle", which has an influence upon the discomfort glare. This angle was around 58° and, therefore, relatively large so it is reasonable to based the conclusions on the observed results and this gives the minimum detection distance in the case of a preceding vehicle as 100m.

Literature:

[1]   Andree Hohm, "Physiologische und Photometrische Untersuchungen zur Herleitung von Randbedingungen für eine Abblendautomatik", Studienarbeit S 201/2005, TU Darmstadt October 2005.

[2]   Bindels, Schmidt-Clausen, Assesment of discomfort glare in motor vehicle lighting, *Lighting Research and Technology* 1974 No.6: p.79

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