INFLUENCES FOR DISCOMFORT GLARE OF HEADLAMPS

Stephan Voelker - Technische Universität Berlin, Germany  
Michael Freyer, Sabine Raphael - L-LAB Paderborn, Germany  
Michael Meyborg - FH Wilhelmshaven, Germany

1. INTRODUCTION
A large number of studies on discomfort glare evaluation of headlamps can be found in literature. Unfortunately, the majority of these studies with real headlamps did not control independent variables appropriately. Therefore, these findings cannot be used to develop an accurate discomfort glare evaluation method.

2. INFLUENCE FACTORS OF DISCOMFORT GLARE
It is generally agreed that discomfort glare produced by an individual source basically depends on four main parameters:
I. Source luminance into the direction of the observer’s eye ($L_g$)  
II. Solid angle subtended by the source at the observer’s eye ($\Omega_p$)  
III. Angular displacement of the source from the observer’s line of sight ($\Theta$)  
IV. Overall field luminance controlling the adaptation level of the observer’s eye ($L_{ad}$)

The subjective sensation of discomfort glare experienced by the observer can be related to the four main parameters by a general expression of the following type:

$$G = \frac{L_g \cdot \Omega_p \cdot f(\Theta)}{L_{ad}}$$

$G$ is a quantity called Glare Constant expressing the subjective sensation on a semantic/numerical scale, $a$, $b$ and $c$ are suitable weighting exponents and $f(\Theta)$ is a complex function of the displacement angle, which takes separately into account its vertical and azimuthal components.

3. GLARE ILLUMINANCE
A substantial number of investigations show the clear influence of glare illuminance on glare rating. Schmidt-Clausen published: If the illuminance increases by one power of ten the glare judgement increases to 2 points on the de Boer scale. Other authors presented other results.

Per change of the average luminance by a power of ten the glare rating changes by one point on the de Boer scale. An average luminance of 5.00 cd/m² is rated as tolerable; 500.000 cd/m² leads to a rating 'just admissible to disturbing' which corresponds to a glare illuminance of 1 lx.

In sum, lab tests, tests with a model headlamp in the light tunnel and field test have shown that both - glare illuminance and glare luminance - are responsible for glare rating.

4. UNIFIED GLARE RATING FOR AUTOMOTIVE LIGHTING
The basic structure for the equation corresponding to the UGR model comes from the analysis of all main components. Only $p$ was replaced through $\Theta$ as a peripheral angle between the viewpoint and the glare source.

$$UGR = \frac{L_g \cdot \Omega_p \cdot f(\Theta)}{L_{ad}}$$

Because the $UGR_{\text{var}}$ value should be within the range of the de Boer scale, equation is enhanced by the factor $c_1$ and summand $c_2$. This is important for comparing the results with the results of other authors, who use the de Boer scale. An additional summand $X$ should consider the light color ($X = 0$ for halogen lamps and $X = 1$ for gas discharge lamps and lamps with high blue content).

$$UGR_{\text{var}} = c_1 \cdot \frac{L_g \cdot E_g}{L_{ad} \cdot \Omega_p} + c_2 + X$$

For the standard glare rating point B50L the following equation can be used:

$$UGR_{\text{var,B50L}} = 0.0001 \cdot L_g \cdot E_g + 6.5 - X$$

5. SUMMARY
Like the material presented shows, discomfort glare is proportional to the illuminance at the eye and luminance of the glare source and inversely proportional to the adaptation luminance and the angle between glare source and fixation point. The influence of spectral power distribution can be taken into account with an addend. All other influence factors can explain the difference between the investigations up to a range of 1 de Boer scale point.