Color Measurement near the Cut-off Line of Automotive Headlamps

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INTRODUCTION

An automotive low beam headlamp today consists of tungsten halogen or HID lamps, reflectors, baffles and lenses. According to the legal requirements the color of the beam has to be white within the limits of a specified color area in the CIE chromaticity diagram. Due to influences of the optical systems in the headlamps, however, a narrow zone with more or less saturated rainbow colors appears often close to the cut-off line between the high and low intensity areas. This paper deals with the practical measurement of this colored area by using high quality tristimulus colorimeters and computer-controlled goniophotometers. As a result graphical presentations of measured headlamp color distributions will be shown, and the performance parameters and measurement uncertainties will be discussed.

METHOD

The colorimeter head is mounted at a distance of 25 m from the rotation center of the goniophotometer. The headlamp is aligned with its optical center to the goniophotometer and illuminates the colorimeter head perpendicularly. The colorimeter head is connected directly to photocurrent amplifiers, the output currents are lead over a 40 m special cable to fast A/D converters and a display unit containing a 3-channel display with 4-3/4 digits (32.000 points) resolution each. The measurement system is controlled by a PC with WINDOWS and modern measurement software and can handle up to 1000 readings per second. The color distribution measurement is done by scanning the light distribution across the interesting angular zone in 0.05 deg steps from about ± 9 deg horizontally and ± 2 deg vertically. The reading of the colorimeter is done while moving the goniophotometer with about 40 deg/s.

The data is processed by the software. Different methods of presentation of the results are used.

ACCURACY PARAMETERS

The measurement accuracy depends mostly on the quality characteristics of the colorimeter head, additionally the operation conditions of the test sample, measurement conditions in the laboratory, and the accuracy of angular measurement influence the total measurement uncertainty of the results.

The influence of the non-uniform illumination on the colorimeter heads light sensitive surface, especially in the beam pattern of an automotive headlamp with sharp cut-off, will be discussed. It will be shown how the use of diffuse filters and reflecting material within the colorimeter head provide a high degree of independence of the signal from non-uniform illumination.

For the colorimeter head the spectral responsitivity of the 3 channels used for the measurement of X, Y and Z is most important. The spectral correction of the Si-photoelements used in the head will be described, and several methods of characterization, as discussed in CIE D2 are applied and their results will be shown.

The calibration of the colorimeter with CIE standard illuminant A in units of lx as an illuminance meter allows the evaluation of the intensity distribution from the tristimulus values. The accuracy of the measured intensities is directly related to the accuracy of the color measurement, so the methods and requirements for photometrical measurements of light sources are applied and will be discussed.

It will be shown, how the estimation of the performance characteristics, which are measured and calculated under standardized test conditions, are related to the measurement uncertainties of the color measurement. Especially the measurement of spectral responsitivity of the colorimeter head with respect to method, bandwidth, step width, and other parameters will be discussed, and it will be shown how the numerical methods of data processing for the calculation of the performance parameters can influence the results.

RESULTS AND CONCLUSIONS

The described method of color distribution measurements provides reliable results with excellent repeatability while requiring only very short measurement time. The results provide enough information for the developers of optical systems for headlamps, but also allow product analysis for quality control or certification procedures. The estimated measurement uncertainties based mostly on the quality parameters of the tristimulus colorimeter are small enough for the purpose of these measurements. Based on these quality parameters it is possible to give recommendations for minimum performance requirements for colorimeters to provide measurement data with sufficient accuracy.

REFERENCES

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