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Absorptive and Interference Coatings Applied on Replaceable Headlamp Bulbs

RATIONALE

The technical report covers technology, products, or processes which are mature and not likely to change in the foreseeable future.

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1. SCOPE

This report investigates the use of single and multi-layer coatings on replaceable headlamp bulbs and how such coatings can affect the performance of bulbs in terms of light scattering, which can contribute to glare, and spectral separation in headlamps. Tests were developed to investigate the effects of absorptive and interference (multi-layer) coatings on bulbs, and on bulbs in headlamp systems. These tests provide validation for a proposed bulb color separation test, which establishes limits for spectral separation within the boundaries of SAE J578 white color requirements. The bulb color separation test provides a definitive selection criterion to identify bulbs that cause excessive light scatter (glare) and/or spectral separation in an optical system.

2. REFERENCES

2.1 Applicable Publications

The following publications form a part of this specification to the extent specified herein. Unless otherwise indicated, the latest version of SAE publications shall apply.

1. Bucher, K., Holt, D., King, G., Lüttgens, G., Rice, L., Schug, J., Terburg, B., Visser, A. de, Woodward, R., *"Investigation into the Effects of Absorptive and Interference Coatings Applied on Replaceable Headlamp Bulbs"*, SAE technical publication, SP-1875, #2004-01-0802, Society of Automotive Engineers, Warrendale, PA (2004).

2. Tessnow, T., Reiners, T., Hering, O., *"Optical Near Field Measurements and Ray-Tracing Simulation of Coated and Uncoated Halogen Lamps for Glare Analysis"*, SAE technical publication, SP-1787, #2003-01-0929, Society of Automotive Engineers, Warrendale, PA (2003).

3. ECE Economic Commission of Europe Regulation 5, http://www.unece.org/trans/main/wp29/wp29regs.html.

4. SAE Standard J578, *"Color Specification"*, Society of Automotive Engineers, Warrendale, PA, 2002.

5. ASTM E 308-66, "Method for Computing the Colors of Objects by Using the CIE System", American National Standards Institute, Inc., 25 West 43rd Street, New York, NY 10036-8002.

6. FMVSS (Federal Motor Vehicle Safety Standards) (1998) Standard 108: “Lamps, reflective devices, and associated equipment”. In: Code of Federal Regulations, 49CFR571, Washington, D.C.: Office of the Federal Register.

7. Terburg, B.P., et al. *"Review of Color Coated Bulb Test Methods and Data"*, report to United Nations Economic Commission for Europe's Working Party on Lighting and Light Signaling, report #GRE44/inf.1 (2000).

8. ECE Economic Commission of Europe Regulation 8, http://www.unece.org/trans/main/wp29/wp29regs.html.

9. ECE Economic Commission of Europe Regulation 20, http://www.unece.org/trans/main/wp29/wp29regs.html.

3. INTRODUCTION

The introduction and sale of tinted replaceable headlamp bulbs first appeared in the late 1990s. The lamps initially sold used standard replaceable capsules, which were coated with interference (multi-layer) coatings to produce a “HID color”. A survey of bulbs that were being sold in the aftermarket showed that some of the bulbs did not meet performance specifications for light output or wattage. Another characteristic of the multiple-layer interference coating was that the light output was separated into bands of color which depending on the viewing angle could range from reddish to greenish to blue-ish white. The color separation was still noticeable when placed in a headlamp.

An oncoming vehicle could produce a change of color that could confuse drivers or more typically produced a higher level of offending glare.

Existing tests and regulations did not anticipate tinted headlamp bulbs. To address this issue an international group of engineers from the bulb manufacturers under auspices of SAE assembled a task force to investigate the effects and recommend the appropriate test methods for governing their design and use.

4. BACKGROUND AND TEST METHODS

The initial investigation of color separation focused on the investigation of the color separation as it pertains to the light output from the bulb. The typical US replaceable bulbs were used in the investigation. These bulbs were ANSI 9004, 9005, 9006 and 9007.

After the first round of tests were completed and a proposed method was documented, the scope of the investigation was broadened to include the consideration of the effects of glare from the bulb in a lighting system such as a headlamp. For this reason the testing was separated into Round 1 Testing and Round 2 Testing.

Round 1 testing initially investigated two types of methods: The Bulb Haze Method and Bulb Color Separation test. A color separation test standard was later adopted into European regulations and a US version was developed simultaneously. These methods are described below.

Round 2 testing investigated four potential test methods: the Bulb Haze Method, a Reference Reflector Method, Bulb Optical Properties and Near Field Imaging. Of these the Reference Reflector method and the Near Field Imaging were used. Near field imaging is widely accepted method in the study of the optical performance of bulbs [2].

5. PHYSICS OF COLOR SEPARATION

In understanding what causes spectral (color) separation in certain types of coated bulbs, one has to investigate the phenomena that occur when white light from a tungsten filament in a halogen bulb traverses the glass bulb wall of the coated bulb. A coated bulb has the outside bulb wall coated with a thin film that filters light either through absorption, or through interference. In the latter case the thin film is a multi layer film. In either case of filter technologies the purpose of the filter is to achieve a more bluish white color of light, either by absorbing some light in the yellow wavelengths (absorption coating), or by reflecting yellow and red light out of the spectrum (interference coating). The process of light traversing the coating is illustrated in Figure 1. Note that the schematics in Figure 1 are simplified to show the processes that occur in the coating layer only. Specular reflection and transmission on the surfaces of glass bulb wall have not been graphically depicted.