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TINTED WINDSCREENS IN U. S. ARMY AIRCRAFT

By

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MARCH 1968

U. S. ARMY AEROMEDICAL RESEARCH UNIT
Fort Rucker, Alabama

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ABSTRACT

A spectrophotometric analysis was performed on the tinted windscreen of the U. S. Army AH-1G helicopter. The results of this test, considered in conjunction with the conclusions of other researchers working with both aircraft and automobile tinted windshields, have led to the recommendation that no tinted media should be positioned between the pilot and his normal field of view during heavy overcast days, at twilight, or at night.

APPROVED: Robert W. Bailey

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LTC., MSC
Commanding

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TINTED WINDSCREENS IN U. S. ARMY AIRCRAFT

INTRODUCTION

The U. S. Army helicopter AH-1G, termed the "Huey Cobra", has recently been introduced into the Aviation inventory. This aircraft, manufactured by the Bell Helicopter Corporation, incorporates an undesirable design feature not found in other helicopters, i. e. the entire windscreen has been tinted a bluish color.

In the past, tinted windscreens have been placed in strategic locations, i. e. overhead, in certain aircraft. However, that area of the windscreen normally used by the pilot or co-pilot for observation has traditionally remained clear.

PURPOSE

The purpose of this report is to evaluate the concept of tinted windscreens in U. S. Army aircraft. This can best be accomplished by establishing the transmission characteristics of the AH-1G windscreen, reviewing the work of others and applying this existing information directly to the problem.

BACKGROUND

Literature dealing with tinted windscreens in aircraft is virtually nonexistent, since there has been general agreement that such devices are undesirable. However, several studies have been conducted by researchers concerning the use of tinted glass in automobiles. The results of these studies are directly applicable, in most instances, to the use of tinted windscreens in aircraft.

in front of the eyes. No improvement in vision of any sort was found when tinted windshield glass was used".

The American Standard Safety Code[2] has stated that automobile glass should have a light transmission of no less than 70 percent to be considered safe from a visual standpoint. There is at least one publication that relates this transmission requirement to aircraft. This work was done by Glover[3], who analyzed various transparent surfaces that are commonly used for aircraft windscreens, canopies, and visors. On the basis of tests performed with these materials, standards were recommended for the minimum amount of light a transparent windscreen should transmit at various angles in respect to the line of sight. These standards indicate that "highly desirable" transmission ranges from 71 percent to 99 percent depending upon the slant of the windscreen. The ranges classified as "minimum value" are from 64 percent to 89 percent, again depending upon the windscreen slant.

A resume of pertinent research concerning the effects of age upon night vision is presented by Jayle, Ourgaud, Baisinger, and Holmes[4]. They conclude that higher thresholds (the need for more light) appear at 40 years of age, and become even more pronounced after 50. They further state that, "It is generally agreed that a definite deterioration of all forms of night vision functions occurs with age". It is apparent that the reduction in light accompanying the use of a tinted aircraft windscreen would present a problem to the younger pilots, but could seriously interfere with the night vision of the older pilots.

Heath and Finch[5] studied tinted automobile windshields and their effect upon targets such as road signs, boxes, posts, etc. having varying reflectance values. The results obtained showed rather large variations, with loss in visibility distance through the tint ranging as high as 22 percent. However, due to the variation of data, they state that it does not appear feasible to assign an overall percentage value to represent the difference between clear and tinted glass. They conclude that, "The use of tinted windshields appears to cause a reduction in visibility distances in night driving".

Studies by Roper[6] and Doane and Rassweiler[7] also showed visibility reduction as the result of viewing targets through automobile tinted glass. However, they were of the opinion that this reduction in visibility was more than offset by the beneficial effects of glare reduction and heat absorption during daytime driving.

Miles[8] conducted clinical tests and reported that at luminance levels involved in night driving, the resolving power of the eye was greatly reduced. He found that a pair of targets which appeared distinctly separate at 100 feet in unrestricted vision, when seen through a clear windshield, had to be brought within 25 feet of the observer when they were viewed through a tinted windshield. This is highly significant when detection closure rates of aircraft, wire strikes during low altitude flight, etc. are considered in terms of flight safety during night operations in RVN. Even in the course of aviation training, pilots are often subjected to aircraft operation under "maximum darkness" in which they perform normal aircraft functions (to include landing) under ambient night luminances without the aid of aircraft or ground artificial lighting.

Blackwell[9] found a 23 percent loss in detection distance when viewing targets through a tinted windshield in the laboratory. As distance for detection without tinted filters became smaller because of a reduction of target size or luminance level, the percentage loss in detection distance increased rapidly with the tinted filter. He concludes that, "The losses in visual detection capability resulting from the use of optical filters at low luminance appear to be sufficiently great so that the use of such filters can scarcely be recommended unless drivers using such filters slow their vehicular speeds accordingly".

Stone and Lauer[10] evaluated the effect of filters, tinted glasses and windshields as they affect seeing at night, and found that on the average all results showed a deleterious effect. They conclude, "Results indicated that the use of colored lenses (windshield) as compared with clear lenses (windshield) result in reduced visual discrimination under the conditions studied".

Haber[11] calculated the theoretical effect of tinted windshield glass upon visibility and found a reduction of 9 to 15 percent when targets were viewed through a tinted windshield at distances greater than 200 feet. However, if the contrast between target and background is low, so that detection through a clear windshield is possible only at a short distance, the percentage loss in visibility may be as high as 35 to 45 percent with a tinted windshield.

McFarland, Domey, Warren, and Ward[12] studied the relationship of age and tinted windshield upon dark adaptation. They found that the interposition of a clear windshield between the test light of the adaptation instrument and the eye of the subject at terminal levels of dark adaptation resulted in a greater demand for light just to see the stimulus. When a tinted windshield was interposed, there was a significantly greater demand for light than with the clear glass. The dark adaptation rate was found to be a function of age. The eldest subjects (80 to 89 years of age) who viewed the test patch through the tinted windshield required 50 minutes to achieve a degree of dark adaptation achieved by the youngest subjects without any filter after only 5 minutes.

TRANSMISSION CHARACTERISTICS OF THE AH-1G WINDSCREEN

Spectrophotometric analysis of the tinted windscreen used in the AH-1G (Huey Cobra) helicopter is shown in Figure 1. The instrument used was the Beckman DU Spectrophotometer, and the samples were obtained from the Bell Helicopter Corporation. Two thicknesses (.150 inch and .187 inch) of material are employed in the production of the AH-1G windscreen, and the transmission characteristics of each are shown.

Figure 1 shows that the material transmits a greater percentage of light in the blue or lower end of the visual spectrum than in the red or upper end. This, of course, accounts for the bluish color of the windscreen and indicates that it would in fact reduce or eliminate near and far infrared. It is a physiological fact that blue light is scattered more in the eye than the longer wavelengths, and that the eye is myopic for blue light. The latter is further complicated by the presence of so-called 'night myopia'.

Due to the absorption and transmission characteristics of this windscreen, a pilot viewing a red light at night would be less apt to see it. With the majority of aircraft exterior warning lights being red, it is highly possible that the presence of this tint would make visual sighting of other aircraft difficult, if not impossible, especially during marginal VFR conditions.

Assuming the visual spectrum to range from 400 to 700 millicrons, a step-by-step analysis of the transmission characteristics throughout this range was accomplished for both the "thin" (.150 inch) and "thick" (.187 inch) samples. The average transmission was found to be 80.9 percent and 75.6 percent, respectively.

In computing the final level of light that enters the eye of the pilot at night, it is necessary to consider at least three major factors, other than chromaticity, that can adversely affect light transmission. These are:

1. The presence of moisture and/or dirt on the windscreen.

2. The angular relationship of the windscreen and the line of sight of the pilot. Wulfeck, Weisz, and Raben[14] reported on a comparison of loss of "visual range" due to the inclination and

TRANSMISSION OF BLUE WINDSCREEN OF AH-1G (HUEY COBRA)

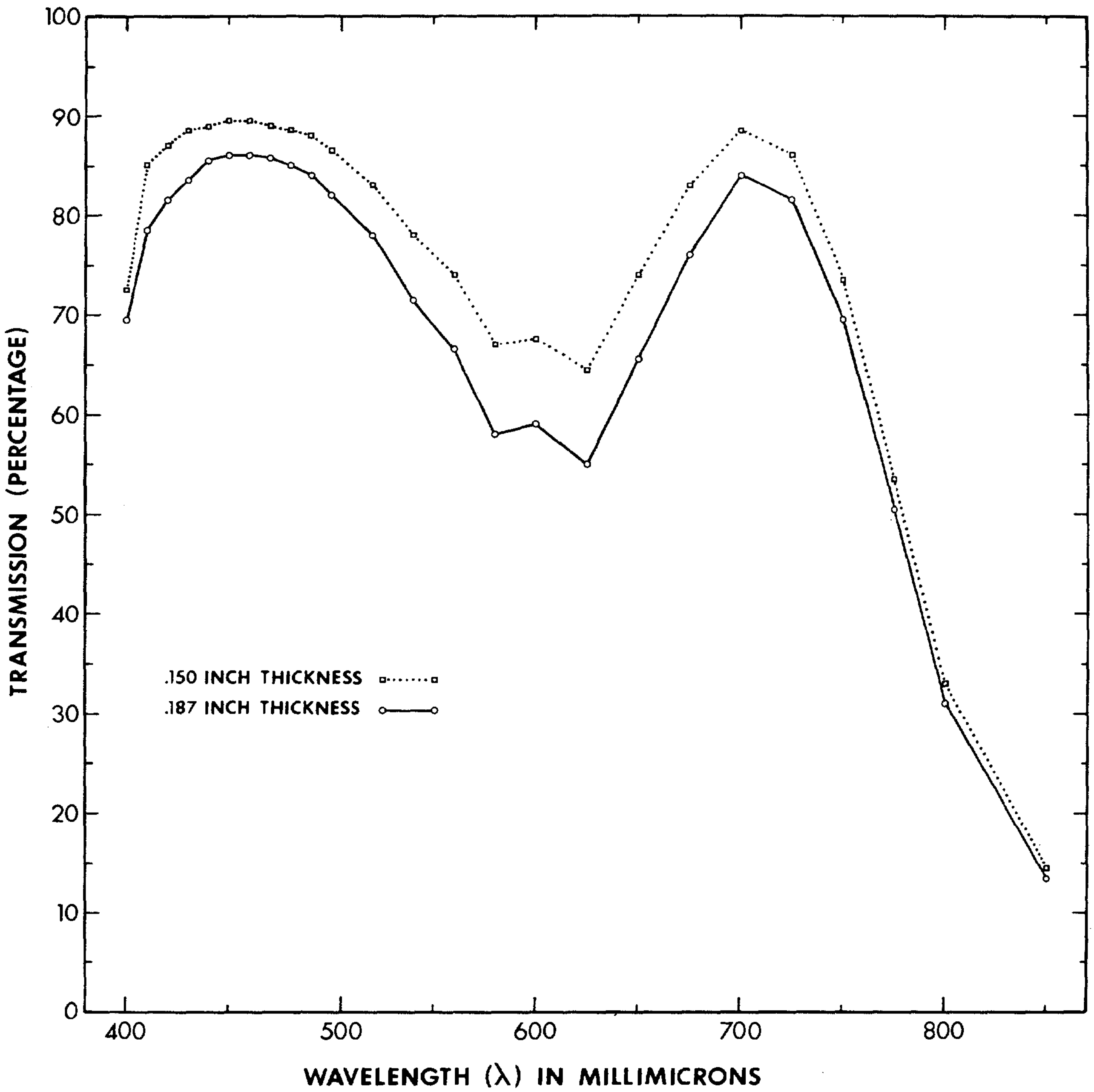

Figure 1.

material of the windscreen. They show that at zero degrees inclination, a clean plastic windscreen reduces the "visual range" 2.8 percent, and a dirty one 7.3 percent. At 45 degrees inclination these figures become 9.3 percent and 16.8 percent, respectively. The flat center portion of the AH-1G windscreen is inclined at approximately 42 degrees from the line of sight.

3. Upon striking a piece of glass or plastic, light can be reflected, refracted, or absorbed. The percentage of light that is reflected from a surface is increased with the use of a tint. Light reflections from aircraft windscreens are a serious problem with the current clear windscreen and would most certainly be considerably worse with the incorporation of a tint.

There are other factors which play a significant role in the visual performance of the pilot, but these are not considered to fall in the realm of this particular report.

A consideration of all the factors affecting light transmission through the aircraft windscreen indicates that under conditions frequently encountered in flight, the "minimum value" light transmission range as established by Glover[3] would not be met in the case of the Huey Cobra. If the tint were not present, the light transmission characteristics of the AH-1G would fall into the "highly desirable" range, and would be considered visually acceptable for use in this aircraft.

CONCLUSIONS

The Council of Industrial Health, American Medical Association[13] has stated that, "The use of any 'night-driving' lens or windshield, whether tinted, reflecting, or polarizing, reduces the light transmitted to the eye, and renders the task of seeing at night more difficult".

The Committee on Night Visibility of the Highway Research Board stated in 1952, "It is axiomatic that anything which interferes with clear vision will increase the hazards of driving, particularly at night when illumination at best is inadequate -------. In light of present knowledge it is concluded that any media, except clear, corrective spectacles, introduced at night between the eye and a stimulus object or situation on the roadway, are not to be recommended for night driving".

Based upon the research that has been conducted to date, it is our opinion that the use of a tinted media positioned between an aircraft pilot and his normal field of view during heavy overcast days, at twilight, or at night is contraindicated. The reduction of heat within the aircraft should be accomplished through methods other than a tint placed in the windscreen. High luminance levels encountered during normal daytime flight can best be controlled through the use of low transmission conventional flying goggles, or the tinted helmet visor.

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