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HUMAN FACTORS EVALUATION OF LASER PROTECTIVE VISORS

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13. ABSTRACT

Three laser protective visors and a spectacle-goggle were evaluated by over 100 experienced, rated aircrew members under flight and simulated flight conditions to determine if use of such protective filters would unduly degrade performance of flying duties. Two of the visors and the spectacle-goggle were multiwavelength protective devices. The orange and blue visors provided multiwavelength protection for complementary parts of the near ultraviolet, visible, and the near infrared portions of the electromagnetic spectrum, and the spectacle-goggle essentially combined the protective capability of these visors into one unit. The yellow visor afforded protection specifically against neodymium laser light.

Generally, the orange and yellow visors received favorable evaluations. The spectacle-goggle was not so well accepted because of its high attenuation of light, and the blue visor was rejected. The need to weigh tactical mission requirements against the degree of laser protection afforded by a visor was shown to create a tradeoff between optical density and light transmission. Recommendations were made with regard to further use of protective visors.

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HUMAN FACTORS EVALUATION OF LASER PROTECTIVE VISORS

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FOREWORD

This report was prepared in the Oculo-Thermal Branch of the Radiobiology Division under task No. 778402. The flight evaluations were accomplished at Kelly AFB, Texas, in various bomber, fighter, and cargo aircraft, and the simulator evaluations were done at Bergstrom AFB, Texas, in an RF-4 simulator. The evaluations occurred between May 1971 and May 1972. The paper was submitted for publication on 12 July 1972.

The cooperation of the personnel of Detachment 1 of the 6570th Air Base Group, Detachment 38 (Flight Test) of the San Antonio Air Materiel Area, and the 37th Tactical Fighter Wing, Bergstrom AFB, is gratefully acknowledged.

This report has been reviewed and is approved.

EVAN R. GOLTRA, Colonel, USAF, MC
Commander

ABSTRACT

Three laser protective visors and a spectacle-goggle were evaluated by over 100 experienced, rated aircrew members under flight and simulated flight conditions to determine if use of such protective filters would unduly degrade performance of flying duties. Two of the visors and the spectacle-goggle were multiwavelength protective devices. The orange and blue visors provided multiwavelength protection for complementary parts of the near ultraviolet, visible, and the near infrared portions of the electromagnetic spectrum, and the spectacle-goggle essentially combined the protective capability of these visors into one unit. The yellow visor afforded protection specifically against neodymium laser light.

Generally, the orange and yellow visors received favorable evaluations. The spectacle-goggle was not so well accepted because of its high attenuation of light, and the blue visor was rejected. The need to weigh tactical mission requirements against the degree of laser protection afforded by a visor was shown to create a tradeoff between optical density and light transmission. Recommendations were made with regard to further use of protective visors.

HUMAN FACTORS EVALUATION OF LASER PROTECTIVE VISORS

I. INTRODUCTION

Five laser aircrew visors were contractually developed for the USAF School of Aerospace Medicine (USAFSAM). Two were considered satisfactory to undergo operational test and evaluation (OT&E). These visors, one dark orange and one light blue, provided eye protection from all visible laser radiation and for the neodymium laser whose wavelength is 1,060 nanometers (nm.). Each visor was configured for the HGU 2A/P flying helmets either for the monotrack visor assembly or as the inboard mate of the dual track visor assembly.

Operational test and evaluation on the two visors began in February 1971 at the Tactical Air Warfare Center, Eglin AFB, but within two weeks testing was terminated because of an operational hazards report (OHR) submitted by the testing organization.[1] The hazards reported were a sharp intensity reduction of cockpit red warning lights, and spatial disorientation. As a result of the OHR, the Tactical Air Command (TAC) advised USAFSAM that prior to resuming OT&E, laser visors were to be subjected to a human factors investigation. TAC also stated that the entire spectrum of laser protection must be afforded by a single visor installed in a dual-track visor assembly for reasons of flight safety.

This report presents the results of a human factors investigation conducted on those visors plus an additional visor and a spectacle-goggle.

II. METHODS

Description of devices evaluated

The human factors evaluation was conducted on three laser eye protective visors and a spectacle-goggle. The visors are identical in configuration, shape, and size to the standard Air Force helmet visor (fig. 1). The primary difference in the laser visors from the standard issue visor is that color dye additives are used in the plastic polymers in place of the neutral gray tint of the standard Air Force visor. The laser protective visors were either light blue, dark orange, or yellow. The light blue visor afforded eye protection from emissions of the ruby, helium-neon (HeNe), and krypton (Kr) lasers and had a light transmission value of 53%. The orange visor protected the eye from emissions of the neodymium (Nd), gallium-arsenide

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[1]Operational Hazards Report, OHR #71-2 submitted by 33rd Tactical Fighter Wing.

(GaAs), frequency-doubled neodymium, argon (two wavelengths-514 and 488 nm.), and ultraviolet lasers. Its light transmitting value was 48%. The yellow visor with a light transmission value of 72% afforded protection specifically from neodymium lasers. The spectacle-goggle (fig. 2) contained the absorptive dyes used in both the orange and blue visors and thus provided eye protection (within optical density limits) for all significant lasers which emit in the near ultraviolet (UV), visible, and near infrared (IR) spectrum. This device had a light-transmitting value of 25%. Although the spectacle-goggle was developed for use by maintenance and laboratory personnel, it was included in the evaluation to simulate a single visor with multiwavelength protective capability.

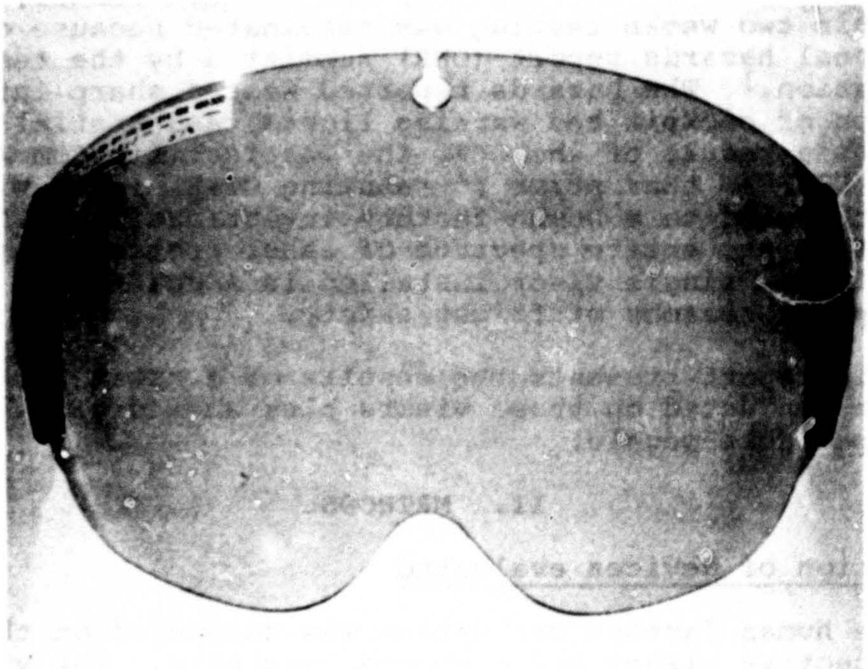

FIGURE 1

A typical laser eye protective visor.

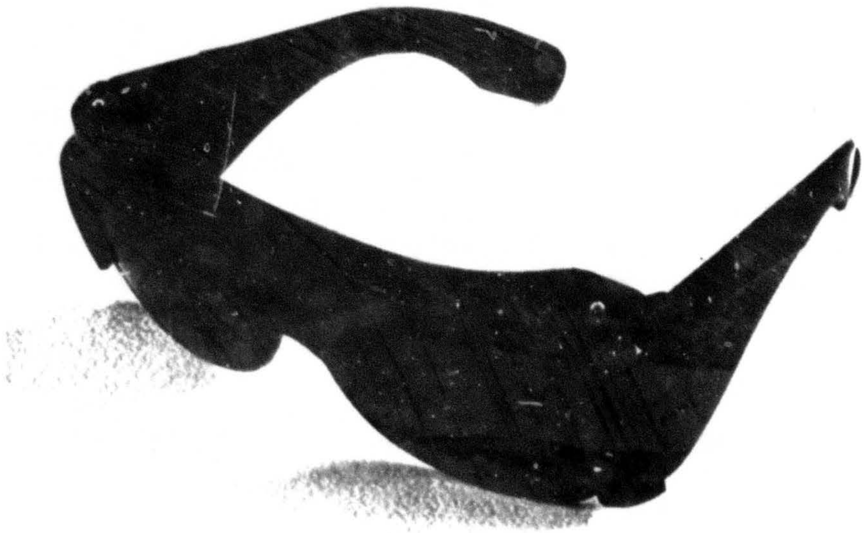

FIGURE 2

The multiwavelength protective spectacle-goggle.

Subjects

Over 100 rated, experienced flying crew personnel were asked to wear one of the test visors either on an actual or simulated flight and then to complete a questionnaire. The specific number of subjects responding is unknown since several tested more than one visor, submitting a questionnaire for each, while other subjects failed to return completed questionnaires. The findings of this report were based upon a total of 134 questionnaires.

Test conditions

Visors were worn 1 to 2 hours in many different aircraft and in an RF-4 simulator. No attempt was made to categorize the limited number of questionnaires according to aircraft. All three visors were used during flight evaluations, whereas evaluations in the simulator were made on the orange and blue visors and on the spectacle-goggle. Missions were divided about two to one between day and night, and some simulated flights were run under both conditions. Daylight data were obtained from 85 questionnaires, and night data came from 49 questionnaires. Weather conditions were generally uniform, clear to partly cloudy with visibility 5 miles or greater. No missions were flown specifically for visor testing; the subjects volunteered to wear these visors in addition to their normal mission requirements. Questionnaires were completed either during the flight or immediately thereafter.

III. RESULTS

A sample questionnaire is presented in figure 3. The number of like responses to a question and the total number of responses to that question are shown as numerator and denominator respectively in the supporting statements below. For example, of 34 questionnaires returned on the blue visor, 28 contained objections to its use; this finding is expressed as 28/34. Generally, the orange and yellow visors were favorably received; the spectacle-goggle less so, primarily because it attenuated too much light; and the blue visor was rejected.

The orange visor. while favorably received for day use (25/30), faded the yellow caution lights and city designations on maps, thus making them difficult to read at night. The enhancement of objects viewed outside the cockpit during the day (16/30) was lost at night (1/19). Three subjects would not complete a day or night mission, citing a need for cockpit illumination in excess of that used for combat operations as their reason.

Only 17 questionnaires were returned on the yellow visor, yet the responses were so uniform that it was felt additional returns would not affect the results. Only two raised any objection and that was a reference to excessive glare when looking outside the cockpit. However, six others claimed an enhanced view outside due to the visor sharpening objects against the background, and the two objectors further stated they could wear the visor despite the glare and effectively complete an assigned mission.

The blue visor attenuated too much light (10/16), particularly in the red (8/16), making it too dim to read the instrument panel or else washing out the red warning lights so that they lost the immediacy of their signaling power. At night, the light loss exerted a greater effect such that mission abort was reported likely (12/14). Over half raising objections (12/16) said they could complete a day mission despite the handicap.

QUESTIONNAIRE FOR LASER EYE PROTECTIVE FILTERS

Visor I. (Yellow) attenuates at 1,060 nanometers wavelength and affords eye protection from neodymium lasers.

Visor II. (Orange, dark) attenuates at 1,060, 840, 530, 514. 488, and 300 nanometer wavelengths and affords eye protection from neodymium, argon and other lasers.

Visor III. (Blue, light) attenuates at 633 and 694 nanometers and affords eye protection from helium-neon and ruby lasers.

Spectacle-Goggle. (Yellow-Green) attenuates at 1,060, 840, 694, 633, 530, 514, 488, and 300 nanometer wavelength and affords multi-laser eye protection.

One questionnaire is to be filled out for each filter worn for each sortie or training session. Significant characteristics to consider during a flight mission are color changes and object visibility during both day and night conditions. Filter need not be worn during takeoff and landing. Each subject please complete the following:

Rank____Organization______________________________Date_____

Type Aircraft____Crew Position__________ ____________________
(flying hours, this aircraft type)

Total Flying Time (Hours)________

Type of Mission____

As Applicable: (General Cloud Cover, Visibility Conditions, Lighting) ____

Time Worn in Hours (Day)________(Night)____________________

Please base comments on your own best judgement in comparison with no visor in use. The following are suggested for observation during flight:

1. Note: Any reduction in visibility and/or color changes in cockpit of:

Indicators	Numerals	Lights, colored warning lights
Dials	Switches	Maps, Charts, Navigational Aids, etc.

Comments:____

____

FIGURE 3

Sample questionnaire used in human factors evaluation.

2. Note: Any visibility reduction or color changes outside the cockpit of:

Contours, Topography.
Terrain features and vegetation (trees, grass, underbrush, water, open areas, hills).
Objects (buildings, roads, bridges, railroads, airports, lights, other aircraft lights).

Comments:____

____

____

SUMMARY:

1. Could mission be performed wearing this visor?__________

2. Do you have any serious reservations or objections to

using this visor?_____Why?____________________________

____

____

3. For your personal protection, would you use this visor in spite of objections?______________________________

4. Other comments encouraged (be specific)________________

____

____

____

PLEASE RETURN TO: USAFSAM/RAT
Brooks AFB, TX 78235

FIGURE 3 (contd.)

The spectacle-goggle eliminated more light than the flying crews liked at night (12/14) or in the day(14/20), yet not enough to thwart their mission. Only four doubted they could continue flying even if the illumination left to them were increased to maximum.

IV. DISCUSSION

The fundamental problem created by all the visors tested is the amount of light, and hence color, attenuated. In the dimness of a cockpit at night it becomes difficult to detect the onset of a signal light. By day a similar difficulty is encountered because the color is so faded that it cannot be effectively discriminated from other lights nearby. However, these difficulties must be further evaluated against the protection afforded by these devices.

In designing suitable laser eye protection it is necessary to provide adequate optical density for various laser wavelengths yet allow sufficient light transmission for the wearer to perform his duties. Visor development has not yet reached the state required by the comparatively low illumination of aircraft cockpit environments of providing full protection with little light or color attenuation. Technology has yet to develop dyes with narrower spectral absorption bands which would pass a greater number of wavelengths than the presently used organic dyes. Two alternatives, neither fully satisfactory, are available to compensate for this deficiency:

1. Reconsider the tactical need for hazard protection to pilots from red line lasers at this time (ruby, HeNe, and Kr). Elimination of these lasers as potential hazards to pilots would eliminate color attenuation in that part of the spectrum permitting increased light transmission of red light. The USAFSAM Laser Awareness Program has indicated no immediate need for pilot protection from friendly lasers of this type.

2. Switch from a multilaser protection device to a single laser protection device. Single laser visors would eliminate the transmission loss resulting from the need to attenuate other laser emissions. Present concern centers about the protection of aircrews from accidental reflected or scattered laser radiation from friendly laser systems. The implication here is that the type laser employed would be known prior to the start of a mission. The proper laser visor to be worn could be made a part of the preflight briefing.

In either case the best tradeoff between operational requirements for laser radiation protection and operational flying mission requirements dictates the balance that can be achieved between optical density and light transmission.

V. RECOMMENDATIONS

It is recommended that:

1. OT&E be conducted on the orange and yellow visors.

2. Despite TAC's desire for a single multiwavelength protective visor, either or both of the above alternatives be adopted until such time as technological advancements overcome present absorptive dye deficiencies.