Original Article

Light transmission characteristics of aircrew visors and goggles

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Good visibility and optimum visual performance is one of the primary requirements of military flying. Indian Air Force pilots are required to carry out their missions over different terrains and vastly varying illumination conditions. Use of visor / goggle is, thus, mandatory for a pilot who is likely to encounter high levels of illuminations. In the IAF, visors and goggles from foreign and indigenous sources are being used. Light transmission characteristics of some of the visors, two Ray-Ban goggles and an antiglare spectacles were studied. The results are discussed in the light of military standard 43511 B. There is a need to critically examine various aspects before accepting or rejecting a visor or goggle.

Keywords : Illumination, Glare, Visual performance, Goggle, Visor, Luminous transmission.

Flying is a complex and stressful task. Technological advancement in the field of aviation has enhanced the capabilities of the aircraft which inturn imposes an increased stress on human physiology. The pilot's efficiency and performance may be influenced by physical, physiological and psychological stresses that are acting continuously on him.

One of the senses that is affected by these stresses is vision and is of special significance as almost 80% of information needed to fly is provided by the eyes [1]. It is a subjective affair involving attention and perception [2]. The various environmental factors which could influence a pilot's visual performance in flight are glare, illumination of target, the contrast between target and background, and flashes of high intensity light.

During low level flight, the pilot may be dazzled by reflected sunlight from the surface of a lake, pond or snow which may momentarily prevent him from seeing. The same difficulty can arise if the aircraft flies over terrain with very high reflectivity such as desert or chalky soil. At night, dazzle is most commonly experienced by the pilot when he approaches the runway light under poor visibility conditions. At high altitude, the reversal of light distribution takes place, which is a potent source of dazzling glare. This may reduce the sensitivity of the retina for a considerable period of time.

For providing protection against dazzle, external glare and an undiminished view of the flight instruments, tinted visors are used by aircrew. A high degree of distortion or non-uniform transmission of light can seriously hamper pilot's visual performance and compromise safety. Loss of vision and pilot error may also be introduced while viewing through aircraft transparency with improper transmission qualities.

As per amendment - 2 to MIL specification 43511 B, the neutral gray gradient visor should have a luminous transmittance value in the range 15-25% and that the variation in transmittance value between the left and right regions of the visor be less than 3% [3].

In the IAF, visors associated with different aircraft and therefore of different make are being used. Efforts are also on to fabricate visors indigenously. Owing to large variation of illuminance levels in our terrains, the acceptable range of luminous transmittance of visors assumes great significance. In the present paper, the results obtained for some of the visors, two Ray-Ban goggles and an antiglare spectacles are discussed.

Materials and methods

To determine the light transmission through visors, the following set-up was made.

Luxmeter : An IC based digital luxmeter with liquid crystal display of 4.5 digit and measuring range of 0-1, 99, 990 Lux was fabricated (M/s Research Instrumentation, India). The meter is provided with knobs for precision zero set and linearity check and can be operated on 6V DC as well as on mains.

The sensor (a Silicon Photodiode) has a spectral response characteristics similar to that of an average human eye. A diffuse outer cover on the sensor provides the cosine correction and the output of the sensor is proportional to the actual incident illumination.

Light Source : Sunlight is used was the source to determine the percentage of light transmission under different illumination conditions through the visor screen. For this, the luxmeter probe was fixed on a tripod stand inside the laboratory. In the absence of any artificial or reflected light, the illumination level was measured at a convenient place. This was called the incident illumination level. Critical area of vision of the eye protective device was kept in close contact with the probe and a number of readings on illumination levels through the visor screen were taken. Average of these readings were computed and percentage transmission values determined using the following relationship:-

Percentage luminous transmittance

$$= \frac{\text{Illumination level through visor}}{\text{Incident illumination}} \times 100$$

The experiemnt was repeated for different incident illumination levels inside the laboratory as well as in the open sun. In this manner, luminous transmittance in respect of visors of Mirage (tinted Green), Jaguar (tined Green), MiG series (GSH-3 & GSH - 6, both tinted Brown), Kiran (ABEU Mk II, tinted Grey), light weight integrated helmet for use in LCA (tinted grey), prototype helmet for use in Cheetah, Chetak or Russian helicopters (tinted Grey) and also for two Ray-Ban goggles and an antiglare spectacles were determined.

Results

The luminous transittance of antiglare spectacles and two Ray-Ban goggles, in the incident illuminance range of 2,000 - 22,000 Lux, are given in Table I. The antiglare spectacles gave a transmittance around 11% whereas the two Ray-Ban goggles transmitted around 15% and 16% of incident light. There was not much difference in the transmittance values for the right and left lenses of the antiglare spectacles or of the goggles.

Table II represent the luminous transmittance in the incident illumination range of 1,000 - 1,15,000 Lux for visors of Jaguar, Mirage, MiG series (GSH-3 & GSH-6), Kiran (ABEU Mk II), light weight integrated helmet for use in LCA and prototype helmet for use in Cheetah, Chetak or Russian helicopters. From the table, it is seen that Jaguar and Mirage visors have a luminous trnsmittance of around 13% and 12%. GSH-3 and GSH-6 have a luminous tranmittance around 14% and 17% respectively. ABEU Mk II has a transmittance of around 23%. The visors for LCA and helicopter helmets have an average luminous transmittance of around 23% and 18% respectively.

All the visors were tested by six subjects having normal visual acuity and colour vision. It was seen that the LCA and helicopter visors do accentuate the red colour as compared to Jaguar and Mirage visors, where the colour contrast appears to be very good.

Discussion

MIL specification 43511 B advocates a luminous transmittance of 12-18% with no more than 3% variation in the left and right side of visor as a necessary prerequisite quality for aeromedical acceptability [4]. The antiglare spectacles, Ray-Ban goggles and the visors studied excepting that of Kiran and the proposed LCA visor have average transmittance below 18%

Table I : Percentage of luminous transmittance of Antiglare Spectalces and Ray-Ban Goggles

Incident illuminance (Lux)	Antiglare spectacles		Ray-Ban goggles G-15 LM		Ray-Ban goggles B-15 LM	
	Left	Right	Left	Right	Left	Right
2,000	12.4	12.3	16.4	16.9	17.5	17.8
4,000	12.3	12.1	15.9	16.5	17.1	17.5
6,000	11.4	11.3	15.5	15.7	16.3	16.7
8,000	10.9	10.8	14.9	15.1	15.8	16.2
10,000	10.5	10.2	14.6	14.8	15.3	15.9
15,000	10.3	10.0	14.2	14.5	15.0	15.5
22,000	10.0	9.8	14.0	14.2	14.8	15.1
Average	11.1	10.9	15.1	15.4	16.0	16.4

Table II : Percentage of luminous transmittance of visors

Incident illuminance (Lux)	Jaguar	Mirage	GSH-3	GSH-6	Kiran	LCA	Heli-copter
1,000	13.0	12.0	14.1	16.2	24.4	24.2	18.5
2,000	13.3	11.9	13.8	16.4	23.9	23.9	18.3
5,.000	13.1	11.9	13.99	16.6	23.5	23.2	18.0
10,000	12.9	11.8	14.2	16.9	23.3	22.7	17.0
20,000	12.8	11.7	14.3	17.0	22.9	22.3	16.8
1,15,000	12.8	11.6	15.0	17.0	22.2	22.0	16.1
Average	13.0	11.8	14.2	16.7	23.4	23.1	17.5

However, amendment - 2 to the MIL specification [3] requires visors to have tranmittance between 15-25% which would disqualify visors of Mirage, Jaguar, GSH-3 and the antiglare spectacles due to their lower transmittance values. It is also reported that sunglasses and visors should have a luminous transmittance of the order of 10-15% with an aim to reduce the level of bright ambient light reaching the cornea to approximately 1,000 lux where form acuity and contrast sensitivity are maximal [5].

In the absence of a uniformly acceptable transmittance standard for visors/goggles worldover and having no military standard of our own on this acount, there is an element of uncertainity in accepting or rejecting a visor from the point of view of transmittance of light in the visible range.

If one considers the visual acuity changes with ambient illuminance, the optimum visual acuity is shown to be around 3,000 lux falling on the eye and to be progressively lower on either side of this value. Beyond 3,000 lux to around 16,000 lux illumination, the visual acuity decreases in a negatively accelerated fashion [6].

Laboratory studies [7] have shown that increasing the levels of illumination alone results in reduction in the size of objects and increase in visual performance until it levels off. Where the visual performance levels off is different for different tasks. For difficult visual taks i.e., smaller the details or lower the contrast, higher illumination levels are required for visual performance leveling. In the case of aircraft cockpit, pilot's spot detection ability and contrast sensitivity are of great importance. How it varies with illumination levels is of great consequence. Thus, before deciding upon the proper allowable transmittance for visors, goggles, etc. it is essential to know the range of illumination levels available in aircraft cockpits.

It has been reported that the average illumination as seen from an aircraft at 20,000 ft on a clear day, looking away from the sun, to be around 22,000 lux [8] whereas another study cites the illuminance between

11,000 - 21,000 lux [9].

For illumination levels between 10,000 - 22,000 lux a visor with 18% transmission value will allow 1,800-3,960 lux at the eye level which may be sufficient for good visual acuity [1]. However, transmittance of 10, 15 or 25% will also not make any significant difference since the acuity changes are linear on logarithmic scale [11].

For ambient illumination levels in the range of 1,00,000 lux what kind of transmittance is allowable for visors particularly for use in modern cockpit where a lot of visual information is available on video screen? While viewing the outside objects in very high illuminations, the visual functions must be protected by the visor to maintain them around optimal level of performance. For inside viewing, the transmittance value should be high enough to maintain good luminance ratio between the cockpit illuminance and video screen illumination [12].

In our context, thus, it appears very pertinent to establish a clear-cut picture of maximum illumination levels likely to be encountered by a pilot at different altitudes as well as at different azimuth of the sun on clear days before deciding upon the acceptable luminous transmittance value for visors. Studies on different aspects of visual acuity such as form detection, spot detection, contrast sensitivity and colour contrast sensitivity changes with incident illumination levels will have to be undertaken before deciding upon the standard specifications.

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