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MATERIALS SUITABLE FOR CLOTHING AIRCRAFT FIRE CRASH RESCUE WORKERS

PART IV : VIZORS

bv

P. L. Hinkley and D. L. Simms

Summary

Tests have been carried out on materials suggested for use as vizors in helmets used in aircraft fire crash rescue work. The transmission coefficient in the visible and infra-red regions have been determined and the possible hazards of the materials examined.

February, 1956.

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Fire Research Station, Boreham Wood, Herts. Part IV : VIZORS

bу

F. L. Hinkley and D. L. Simen

Introduction

Frevious sections of this report (1, 2, 3) have described tests on protective clothing suitable for aircraft fire crash rescue workers. Protection must also be given to the face against thermal radiatin, without unduly obstructing the vision.' The radiation from a petrol fire is largely in the infra-red portion of the spectrum, and ideal protection for the face would be provided by a vizor which, whilst being transparent to visible radiation, reflects the infracred radiation Reflection of the heat is preferable to absorption, both reduce the transmission but in the latter case the heat is retained in the vizer. It must not ignite in the most severe exposure conditions; it should not become deformed or lose its optical properties on heading; and it must not shatter if it is sprayed with water or floam when hot. paper describes experiments to test these properties of some vizors submitted by the Ministry of Supply (RDAE). The helmetadesigned for use with the protective clothing is shown in plate 1. The vizor can be opened upwards to provide ventilation and be quickly closed. The first vizor was made of clear Perspex but this was found to afford insufficient protection against a radiant intensity of 2 W/cm2, adopted as representative of the fire to be approached, and further vizors were therefore supplied for test. Details of these are given in Table 1.

Visors tested in this investigation

Reference	Description	Compositi n	Thickness
. D	Experimental crash duty vizor.	Plain Perspex	5
A		Perspex with a semi reflecting coating of Piomic on inside. Half of coating lacquered.	5
С	n n n	As A, but coating of Aluminium.	5
K1 and K2	Experimental crash dury vizors (Plate 2)	Plain Perspex backed by 40 mesh 34 s.w.g. bright steel wire gauze. K ₁ - gauze riveted to top and sides of Perspex, wires parallel to edges, K ₂ - heavy gauge wire soldered to edge of gauze, riveted to top of Perspex only, wires diagonal.	5 mm of Ferspex
Ġ.	R.A.F. pilot's vizor 15 per cent optical transmission (nominal)	Tinted Perspex	2•7
IX.	R.A.F. pilot's vizor 30 per cent optical transmission (nominal)	Tinted Perspex	2•6

Sec. 1

TABLE 1 (cont'd)

Reference	Description	Composition	Thickness
T ₁	Glass vizor Composite vizor	Laminated glass Two sheets of glass bonded together with a semi reflecting layer (believed to be copper) between them, separated by an air gap from a plastic sheet.	2-7 Lamina ted glass 3 mm. Air gap about 2 mm. Plantic 2 mm.

2. Experimental procedure and results

2.1. Transmission of Vizors

The source of radiation was a gas fired panel (4) operating at about 850°C and the radiant intensity was measured by a water cooled Moll type thermopile (5). The vizor was placed 1½ in. in front of the thermopile at a point where the intensity of radiation was 2 W/cm². The radiation falling on the thermopile increased as the vizor became hot and began radiating. The output of the thermopile was measured immediately the vizor was placed in position and again after one minute; a longer heating period could not be allowed since this might have damaged the vizor for subsequent tests.

The transmission of light by the vizors was measured using a photographic exposure meter, with a spectral response approximately same as that of the eye. The instrument was directed at a window and readings were taken with and without the vizor in front of it.

TABLE 2
Transmission of radiation by the vizors

Reference	Vizor	Gas fired par Transmittance (Initial value) per cent		Visible radiation transmittance per cent	Ratio of visible transmittance to infra-red transmittance	
D ·	Plain Perspex	10	10•5	95	9•5	
Α	Niomic coated Perspex	. 8	9	` 60	8	
C	Aluminium coated Perspex	3	. 4	45	15	
K ₁ and K ₂	Perspex, backed with wire gauze	7	8	45	6•5	
C;	Tinted Perspex (15 per cent optical transmission - nominal)	12•5	16•5	20	1•5	

Reference	Vizor	Gas fired pa Transmittance (Initial value)	mel radiation Effective transmittance (including re-radiation) after 1 min. per cent	Visible radiation transmittance	Ratio of visible transmittance to infra-red transmittance
F	Laminated glass	22	-	95	4•5
	Composite vizor	1·7	1•7	30	17•5

2.2. Effect of prolonged irradiation

The vizors were exposed to radiation of an intensity of 2 W/cm² from the gas fired panel and any deterioration of the vizor was noted. After about 30 seconds the Perspex vizors softened, and started to deform. As the time for serious deformation to occur was rather indefinite it could only be estimated. If the vizor was then removed from the radiation deformation tended to continue for a few seconds. Since the helmet may tend to prevent deformation of the vizor, the wire gauze backed Perspex vizors (K₁ and K₂) were also tested while attached to the helmet.

A jet of water was directed at the front face of the glass vizors after 2 minutes exposure (Plate 3).

The results of these experiments are given in Table 3.

TABLE 3

Effect of prolonged radiation on vizors

•	`			•	
	Refere	nce	Vizor	Time for serious deformation sec.	Notes
	, D	,	Plain Perspex (Plate 4)	90	After 120 sec. bubbles formed in Perspex. (Deformed inwards).
	A		Niomic coated Perspex (coating towards source)	60	Lacquered coating became translucent, some deterioration of unlacquered coating.
	c {	Aluminium coated Perspex (Coating away from source)	90		
		}	(Coating towards source)	110	Unlacquered coating darkened, lacquered coating became translucent.
	K.		Wire gauze backed Perspex (wires parallel to edges)	70	The Perspex tended to bend outwards and the wire gauze bulged inwards. Bubbles formed in Perspex after 90 sec. (Plate 5).

		1	70.4
Reference	Vizor	Time for serious deformation sec.	Notes
K ₁	Attached to helmet Wire gauze backed Perspex (wires parallel to edges)	90	The Perspex bent outwards at the edged and the wire gauze bulged inwards, and in spite of the protecting bridge would have touched the wearer's face (Plate 6). Bubbles appeared in Perspex after 90 sec.
K ₂	Attached to helmet Wire gauze backed Perspex (wares diagonal to edges)	90	Perspex badly distorted but very little distortion of the wire gauze. Bubbles appeared in Ferspex after 90 sec.
G	Tinted Perspex (15 per cent optical transmission - nominal)	75	
Н	Tinted Perspex (30 per cent optical transmission- nominal)	85	(Plate 7)
F	Laminated glass	-	After 105 sec. bubbles appeared between laminations. On application of jet of water front glass lamination was badly cracked but the rear lamination remained intact. (Plate 8).
E	Composite vizor.		Application of water after 2 minutes had no effect. Vizor was irradiated at 3 watt/cm² for a further minute. The plastic sheet touched the glass and an opaque blister formed. A jet of water was again directed at front face. Front glass lamination cracked but rear glass lamination remained intact. (Plate 9).

2.3. <u>Ignition of Perspex by radiation</u>

The test method is described in detail elsewhere (6). Specimens of plain Perspex 2 in. square and of three different thicknesses (1/4 in., 3/16 in. and 1/8 in.) were tested in front of the gas-fired radiant panel. The times for them to ignite spontaneously when exposed to radiation of different intensities were noted. The results are shown in Fig. 1, each point is the mean of six tests.

Once ignited, Perspex continues to burn slowly in the absence of supporting radiation.

2.4. Tests on wire gauze backed vizor fitted to helmet

The helmet worn by an observer, was exposed to radiation from the radiant panel for one minute. A 40 s.w.g. thermocouple was attached inside the helmet in order to measure the air temperature in a position chielded from radiation. One test was carried out with a radiant intensity of 1 W/cm² on the vizor, one of 1.5 W/cm², and two of 2 W/cm²; a different subject was used for each test and the helmet allowed to could between tests. Only slight discomfort was experienced by the observers. Except in one test during which the observer held his breath when the maximum temperature reached was 45°C, the air temperature in the helmet did not exceed body temperature.

3. Discussion

3.1. Transmission of radiation by the vinous

The figures given in Table 2 refer to a radiant panel operating at 850°C while a petrol fire may attain a temperature of 1000°C. Although the transmission of radiation from a petrol fire may be slightly greater than of that from the panel, the difference is not considered to be important.

The maximum tolerable intensity of radiation for long term exposure of human skin is about 0.14 W/cm² (7) and this may be considerably lower if air circulation is restricted. On the basis that the rescue worker is exposed to 2 W/cm² the vizor must transmit less than 7 per cent of the radiation from a petrol fire.

The wire gauze backed Perspex vizors have a transmittance of 7 per cent and the experiments show that these provide satisfactory protection against an intensity of 2 W/cm² for at least one minute. However the measured rates of visible transmittance to heat transmittance is lower than for plain Perspex. This is presumably due to scattered radiation which is measured by the thermopile but not by the directional photographic exposure meter. The scattered visible radiation reduces the clearness of vision through the gauze. Although scattering could be reduced by oxidising the gauze, this might then become unduly hot.

The aluminium coated Perspex vizor has the best transmission characteristics since it has a high ratio of visible to heat transmittance and a 45 per cent visible transmittance. However the unlacquered aluminium layer is easily rubbed off and deteriorated on heating while the lacquered aluminium layer becomes translucent on heating.

The composite vizor has the highest ratio of visible to heat transmittance but its visible transmittance is only 30 per cent.

The tinted Perspex vizors have a higher transmission in the infrared than the plain Perspex one. This is due to the reduced thickness, the transmission of clear Perspex 3 mm thick was found to be 16 per cent.

3.2. Hazards of the materials of the vizors

3.2.1. Perspex vizors

3.2.1.1. Ignition of Perspex

At the intensities of radiation to which rescue workers are normally likely to be exposed for long periods, Perspex does not ignite although bubbles form in it after exposure for about 2 minutes to 2 W/cm². At the highest intensity available from the gas-fired panel (8 W/cm²), Perspex ignites in about 15 sec. However, the formation of bubbles in the Perspex should act as a warning.

3.2.1.1. Softening of Perspex

When irradiated at 2 W/cm2, a Perspex vizor becomes sufficiently soft in about 90 sec. to deform under its own weight and it might then touch the wearer's face. This would result in a burn since the temperature of the Perspex would be more than 110°C.

The 40 mesh gauze riveted to the top and sides of the Perspex viser was not strong enough to prevent deformation and shrinkage of the Persper although it did control the direction of bending. The gauze itself bulged inwards and would have touched the wearer's face resulting in a burn. A similar gauze soldered to a wire frame with the wires diagonal and riveted to only the top of the vizor was not distorted. Although it did not prevent deformation of the Perspex it would have protected the wearer against injury from this cause.

Placing the gauze outside the Perspex might delay the coset of deformation but, since the contribution of the gauze to the attenuation is small compared with that of the Perspex, the difference would not be of practical value, while the wearer would be unprotected against the hot Perspex.

5.2.2. Laminated glass vizors

The principal hazard that might be expected with a glass vizor is shattering when sprayed with water whilst it is hot. Although the glass vizors tested cracked under these conditions, they did not shatter and they may therefore be considered safe. Even if the glass in the composite vizor did shatter, the face would be protected by the plastic sheet, while the air gap reduces the rate of heat transfer to the face if the outer glass becomes hot. An improved method of spacing the sheets is required since at one point the plastic touched the glass and was damaged. 1 % * * *

Unfortunately, the glass vizors cannot be made with curvature in two dimensions, which precludes their use with the present design of

Conclusions usions

- 4.1. The most satisfactory vizor is the composite one.
- The state of the s 4.2. The aluminium coated Perspex vizor has the best transmission characteristics but the unprotected coating is easily damaged and the protective lacquer used clouds over when heated.
- 4.3. A 40 mesh polished wire gauze reduces the transmittance of a plain Perspex vizor by 30 per cent to a net transmittance of 7 per cent but, owing to scattering of light from the wire, visibility is disproportionately reduced. .
- 4.4. A Perspex vizor may deform when hot and touch the wearer's face. The risk of danger to the wearer can be minimised by placing a suitable support behind the vizor as was done with vizor K2.
- 4.5. A Perspex vizor may ignite under exceptional conditions and would continue to burn slowly. The formation of bubbles in the Perspex would seem to act as a warning of this.

Acknowledgments The investigation into the ignition of Perspex by radiation was carried out by Miss Margaret Law.

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6. References

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PLATE.I. EXPERIMENTAL CRASH DUTY HELMET.

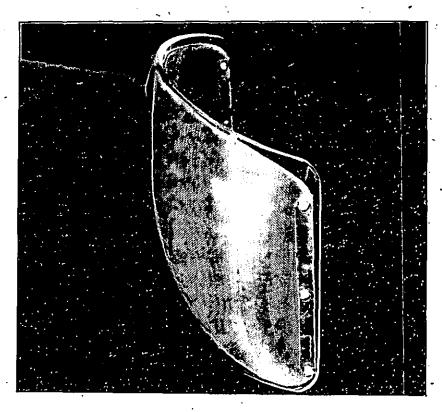


PLATE.2. EXPERIMENTAL CRASH DUTY VIZOR.

(Perspex backed by wire gauze):

Z.11189.R.

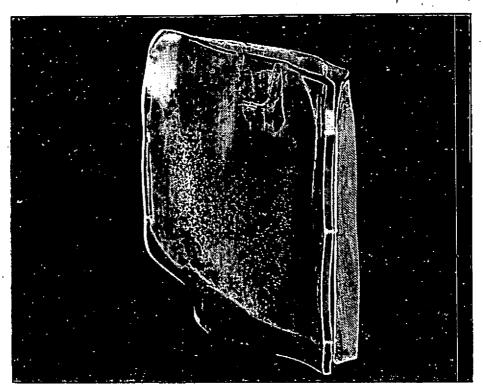


PLATE.5. PERSPEX AND WIRE GAUZE VIZOR (KI)
AFTER IRRADIATION FOR 2 MINUTES

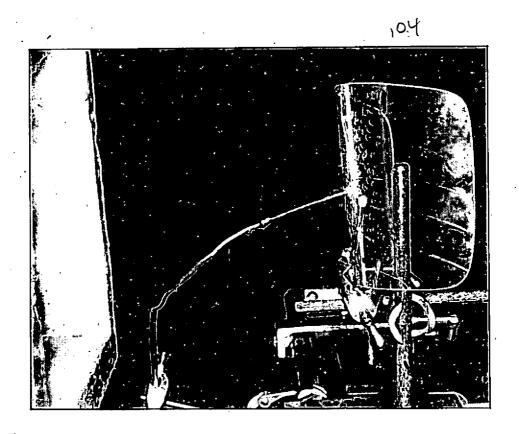


PLATE.3. SHATTERING TEST FOR GLASS VIZOR

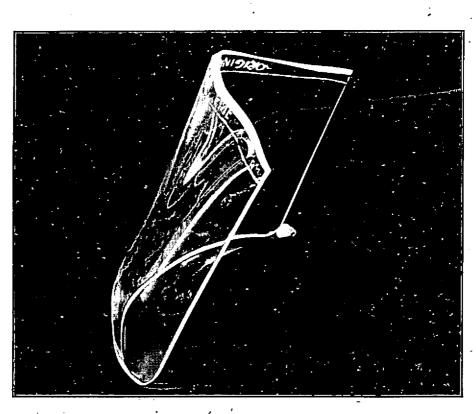


PLATE 4. DEFORMATION OF PLAIN PERSPEX VIZOR AFTER IRRADIATION

 $\mathbb{R}^{N_{1}} \times_{\mathbb{R}^{N_{1}}} \times$

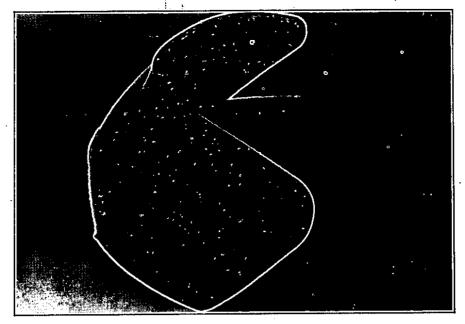


PLATE.7. DEFORMATION OF R.A.F. TYPE TINTED PERSPEX VIZOR AFTER HEATING.

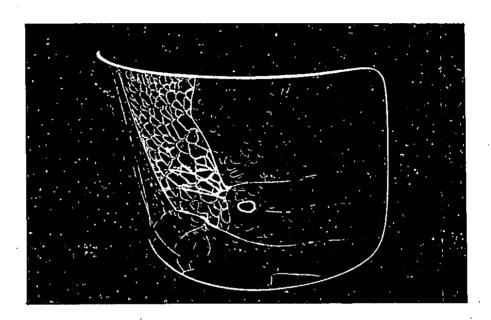


PLATE.8. THE RESULT OF SPRAYING COLD WATER ON TO LAMINATED GLASS VIZOR WHEN HOT.

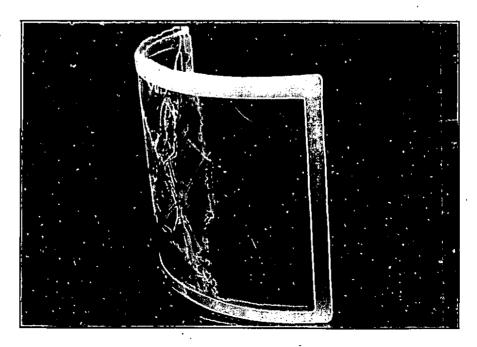
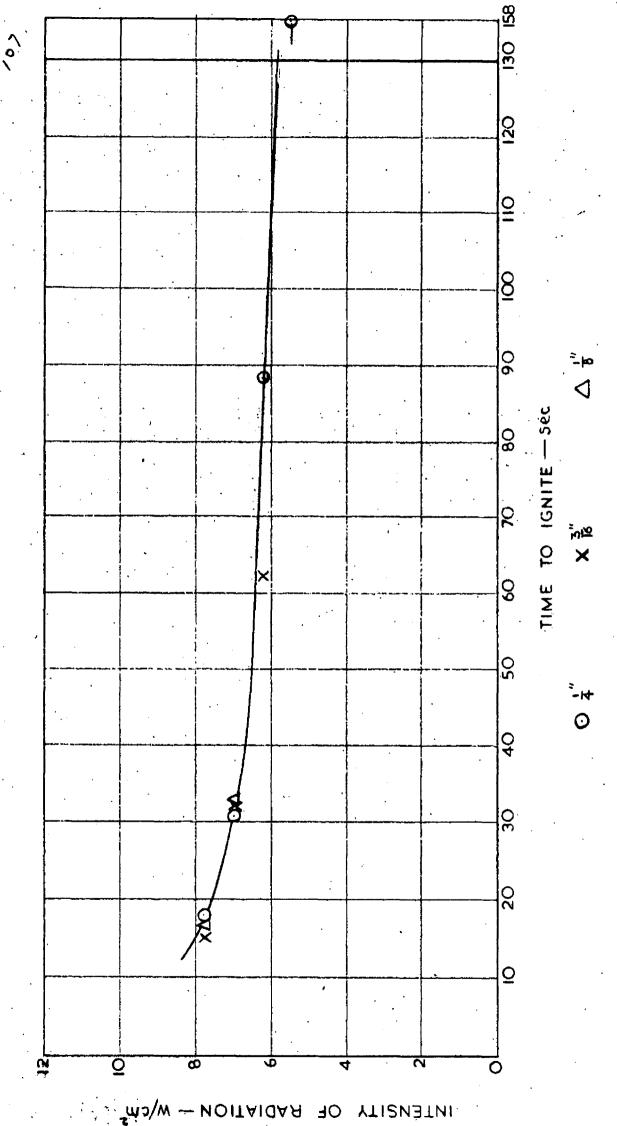


PLATE. 9. THE RESULT OF SPRAYING COLD WATER ON TO THE COMPOSITE VIZOR WHEN HOT.

1



OF PERSPEX BY RADIATION FIG.1. SPONTANEOUS IGNITION

ERODA IA