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AIRCRAFT TRANSPARENCIES AND ASSOCIATED EQUIPMENT

GENERAL AND TECHNICAL INFORMATION

BY COMMAND OF THE DEFENCE COUNCIL

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CONTENTS

Chapter 1-1

GENERAL INFORMATION

CONTENTS

INTRODUCTION

1 This chapter provides general information on aircraft transparencies and defines the terms used. An introduction to the main materials, optical and constructional requirements is included. Table 1 details the terms and abbreviations used throughout this publication.

2 Aircraft transparencies vary in construction from a single ply of transparent plastic to multi-ply laminates of all plastic, plastic and glass and all glass. Transparencies can be separated into three categories based on location and the optical accuracy necessary to fulfil the design requirements. These categories are:

2.1 Forward windscreens or centre panels

2.2 Side panels or quarter lights

2.3 Cabin windows and ancillary transparent panels

TABLE 1 TERMS AND ABBREVIATIONS

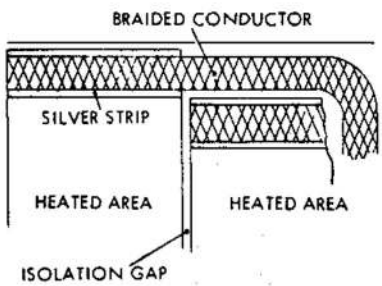
Term/abbreviation	Description	Remarks
Anti-icing	Prevention of ice formation on the exterior surface of a transparency	
Anti-misting	Prevention of condensation on the interior surface of a transparency	
As-cast acrylic	Acrylic sheet (polymethyl methacrylate) manufactured by casting technique to the requirements of the American specification MIL-P-8184 C and British specification DTD 5592.	
Bird-proof transparency	A transparency which, after impact by a bird of a quoted weight and speed will not necessitate abandonment of the aircraft through damage or crew injury, although replacement may be necessary before the next flight.	
Braided conductor	Part of busbar which extends from silver strip into supply terminal block.	
Busbar	Used to feed electricity to the heating film. Flat wire braided of tinned copper tape conductor in contact with a silver strip which distributes current to the film.	
Canopy	A transparency formed into a structure with a metal or composite framework to enclose the cockpit area and in certain cases the windscreen, e.g. the F16 aircraft.	

TABLE 1 TERMS AND ABBREVIATIONS (continued)

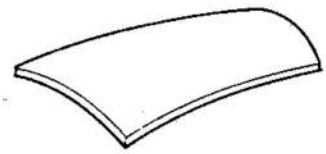
Term/abbreviation	Description	Remarks
Crazing	The formation of a multiplicity of fine cracks, which extend in a network over or under the surface of the plastic, or indeed through it. Crazing may be caused by mechanical stresses, by the action of chemical reagents, or by prolonged solar exposure. Solvent crazing may occur if the plastic is exposed to the action of certain liquids or their vapours (see Chap. 2-1).	
Delamination	A breakdown in adhesion at an interface between adjacent layers of materials. This can be interlayer to glass or plastic, or if the glass or plastic carries a heating film, interlayer to film or heating film to substrate. The forces causing breakdown can be shear and/or tension.	
Density of heat flow rate	Watts/m^2 required to produce design heating requirements.	
Double-curved	Transparency curved in two directions.	
H.U.D.	Head-up display.	
Heating film	Electrically conductive, transparency, metallic coating, which when energised provides heat for anti-icing and anti-misting purposes. Seen in a transparency as a light straw coloured tint. 'Hyvig', (medium thin oxide) gives a neutral tint in transmission.	
Interlayer	Layers of polyvinyl-butyral, polyurethane or silicone interposed between adjacent plies.	

TABLE 1 TERMS AND ABBREVIATIONS (continued)

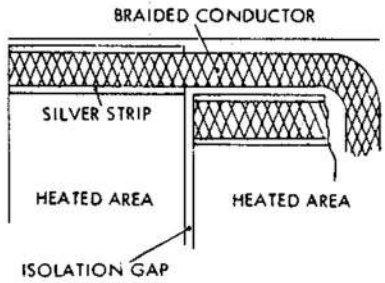
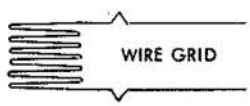
Term/abbreviation	Description	Remarks
Isolation gap	Gap electrically separating coated areas, e.g. two phases. Formed by leaving a line 0.75 to 1.0mm wide uncoated where separation is required. Virtually invisible when looking through a transparency.	
Laminate	Transparency formed from two or more sheets of transparent material, laminated together by a layer(s) of suitable interlayer material.	
Main ply or plies	One or more plies in a transparency subject to pressurisation and aero-dynamic loading and for forward facing transparencies, bird impact.	
M.D.C.	Miniature explosive detonating cord, actuated by a detonator, facilitates breakage of transparency for emergency egress.	
Monolith	Transparency formed from a single sheet (ply) or transparent rigid material.	
Outer ply	Outer surface of a transparency. Not normally load bearing.	
Resistivity	The resistivity of a given coating (heating film) represents the busbar to busbar resistance over the area of the element. Resistivity is expressed in ohms per square unit and is a convenient measure of the characteristics of a given coating.	
Sensing element - wire grid	Thermally sensitive wire grid with a positive temperature co-efficient. Used in conjunction with an external temperature control system.	

TABLE 1 TERMS AND ABBREVIATIONS (continued)

Term/abbreviation	Description	Remarks
Sensing element - thermistor	Thermally sensitive semi-conductor with a negative temperature co-efficient. Used in conjunction with an external temperature control system.	
Single curved	Transparency curved in one direction only.	
Transparencies	General term referring to all forms of aircraft glazing, i.e. front windscreen, quarter lights, windows, canopy, etc.	
Stretched acrylic	Acrylic sheet produced by hot stretching bi-axially or multi-axially as-cast material, to impart superior craze and crack propogation resistance. Produced to the requirements of British specification DTD 900-6050 and American specification MIL-P-25690A.	
Windscreen	A transparency through which the flight deck/cockpit forward vision is made.	
Wire heating element	Electrically conductive fine wire applied to an inter-layer in a regular grid pattern. When energised produces heat for anti-icing and/or anti-misting purposes.	
Wraparound	One piece profiled windscreen.	

Optical Definition - Forward windscreens or centre panels

3 Forward windscreens or centre panels must have a very high degree of optical accuracy to provide a superior standard of visual clarity for the aircrew permitting accurate location and recognition of other aircraft. On aircraft the windscreen surface is classified into areas of vision according to their optical effect on the efficiency of the aircrew. For example:

3.1 A super critical area where optical distortions and defects must be kept within limits specified to Def. Standard 00.970 and through which a head-up display (H.U.D.) may be presented.

3.2 A critical area which is used during normal flying and taxying manoeuvres but where optical requirements are slightly less stringent than for the super critical area.

3.3 A non-critical area comprising the remaining area of the windscreen or front panel where vision may be partially obstructed by ancillary items, e.g. anti-glare shield, anti-icing equipment.

Optical Definition - Side panels or quarter lights

4 The optical accuracy of these transparencies may be less than for forward windscreens or centre panels however, depending on the aircraft application, a high degree of optical accuracy may still be required when they form part of the aircraft canopy or for helicopter cockpits. For certain aircraft applications the side panel or quarter light areas may be classified into areas of vision according to their optical requirements.

Optical Definition - Cabin windows and ancillary transparent panels

5 In general the optical accuracy of cabin windows and ancillary panels is less than that for the previous categories however in certain applications such as reconnaissance camera panels, a much higher optical accurancy will be required.

OPTICAL QUALITY

6 The qualities of an aircraft transparency necessary for satisfactory operational use can be separated into three groups; the first group includes the qualities essential for clear uninterrupted vision, namely optical resolution, optical transmission and haze or halation. The second group involves optical deviation which may affect the accuracy of vision for safe handling and weapon sighting. The third group includes those qualities which, unless controlled may result in eye fatigue; these are binocular deviation leading to image distortion, double imaging, minor scratches and inclusions.

7 The extent to which the above groups affect the operational efficiency of the aircrew is dependant on the category of the transparency (para 2), however in general all qualities are necessary and it is the limits to which the specific optical quality is maintained which determines the category of the transparency. A brief description of each optical quality is given in para 8 to 15.

8 Optical resolution: This may be defined as the ability to distinguish clearly between two objects which subtend by a small angle at the eye. For reconnaissance and search duties it is essential that the transparency does not impair the observers view and prevent two targets close together from being clearly identified.

9 Haze or halation: A hazy panel blurrs the details, reduces black to grey and generally dims outlines. A slight coating of dirt or fine scratching scatters the light and may make it impossible for the pilot to see when flying towards the sun, even when he wears anti-sun goggles. Scratches, dirt, oil and particles of paint all impair the clarity of a transparency and causes haziness, dazzle or halation.

10 Optical transmission: The amount of light passing through a transparency will be reduced by surface reflection, the angle at which the light passes through the transparency and absorption or reflection by the layers in a composite transparency. Although these factors are largely considered at the design stage of the transparency, a deterioration in the layers of a composite

transparency, especially when de-icing equipment is incorporated into the layers, can reduce the transmission of light through the transparency.

11 Optical deviation: When light passes through the transparency, any error in parallelism between the two surfaces of the transparency will cause the rays of light to be displaced. This may cause the aircrew to misjudge the position of another aircraft and, for weapon sighting this optical deviation can have a marked effect on the weapon accuracy. When undertaking repair procedures on the transparency it is essential that the parallelism between the two surfaces of the transparency is maintained.

12 Distortion: Over the area of a transparency local variations or deviations can occur. These deviations result in the distortion of an image and the effects are especially apparent when viewing straight line forms. For forward facing transparencies the distortion must be strictly limited, especially in the area associated with weapon sighting.

13 Binocular deviation: When viewed through a transparency, both the pilots eyes should observe an identical image. Any small defect in the transparency may result in one of the pilots eyes having a slightly distorted view of the image. Although the eye can correct for some difference, a measure of eye strain is involved which increases as the image difference observed by the eyes becomes greater.

14 Double imaging: Aircraft transparencies usually comprise of multilayers of material which can include an air interspace or heating film each of which may cause a reflection from its surface. The reflections are not always apparent until the contrast from the image becomes high, for example when observing airfield lights during an approach, when these reflections or double images become visible. This effect is a feature of the transparency design, i.e. the thicker the transparency the higher the possibility of double imaging, and can only be overcome by fine quality control at the design and manufacturing stage.

15 Minor scratches and inclusions: All materials used for aircraft transparencies are susceptible to minor scratches, chipping and damage due to impact. The level to which these affect the visibility depends upon the area of vision affected (i.e. weapon sighting or head-up display area) and the extent of the defect. The level at which the optical performance of the transparency becomes unacceptable must be assessed on a specific basis by the aircrew.

MATERIALS

16 The materials used for aircraft transparencies are selected for their physical and mechanical properties compatability with ambient conditions during flight combined with the essential requirement of high optical quality. There are three groups of material in current use in the construction of transparencies which are selected as a single sheet (ply) or as a laminate comprising of several plies of material, depending on the aircraft application, i.e. simple transparencies fitted to non-pressurised aircraft with limited performance or laminated transparencies fitted to pressurised aircraft with all-weather capability. The material groups are glass, acrylics and polycarbonates.

Glass

17 Glass is a hard brittle material having an outstanding quality of transparency. To relieve internal stresses the glass is annealed. In this condition it is at its lowest strength. The annealed glass is then thermally or chemically processed to increase its strength. A further treatment is usually applied to the glass to create a compressive outer skin. This can be created by a chemical process or by heat treatment, sometimes utilising a high energy laser. The safety factors required on glass components are very much higher than for other materials and therefore glass is normally used in a laminate transparency together with a transparent material such as acrylic which does not require such a high factor of safety.

Acrylics

18 Acrylics (polymethyl methacrylate) are a range of plastics known under such trade names as 'Perspex', 'Oroglass 55' and 'Plexiglass 55' which are widely used for aircraft transparencies. The material can be produced in two forms:

18.1 As-cast acrylic; acrylic sheet manufactured by casting techniques.

18.2 Stretched acrylic; acrylic sheet produced by hot-stretching, bi-axially or multi-axially, as-cast material to impart superior 'craze' and 'crack' propogation resistance.

19 Acrylics have outstanding weather resistance but are seriously affected by certain materials including solvents, de-icing fluids, plasticisers and exudates from rubber. It is therefore essential that reference is made to Chap 2-1 to determine the safe materials that can be used with the acrylic transparency. The material is tough although it has a relatively soft surface when compared with glass, thus making it prone to scratch and impact damage. On some windscreens the material is used in conjunction with a toughened glass outer ply, interspaced with a layer of polyvinyl-butyral (vinyl), silicone or polyurethane.

Polycarbonates

20 Polycarbonates are a range of thermoplastics which possess similar properties to acrylic materials but with the addition that its toughness and impact strength over a wide temperature range are far greater than that of acrylic. Its surface is, however, relatively soft when compared with glass, thus making it prone to all contact damage. Repolishing a polycarbonate is not possible using conventional polishing technqiues. The material has good impact properties making it a suitable material for aircraft transparances, provided it is protected on all surfaces and edges.

21 Polycarbonates are seriously affected by certain materials including solvents and some de-icing fluids therefore it is essential to refer to Chap 2-1 to determine the safe materials that can be used with a polycarbonate transparency.

CONSTRUCTION

22 Transparency construction varies considerably with different aircraft types and the location of the transparency on the aircraft. The transparency is designed to accommodate specific aircraft requirements such as de-misting and de-icing, bird impact resistance, optical considerations and the method of transparency mounting. The construction can compromise a single ply of material or a multi-ply laminate of the same or differing materials. Typical examples are shown in Fig 1.

23 An interlayer material such as polyvinyl butyral (vinyl) is interposed between laminates on multi-ply transparencies to bond the laminates together.

De-misting and de-icing

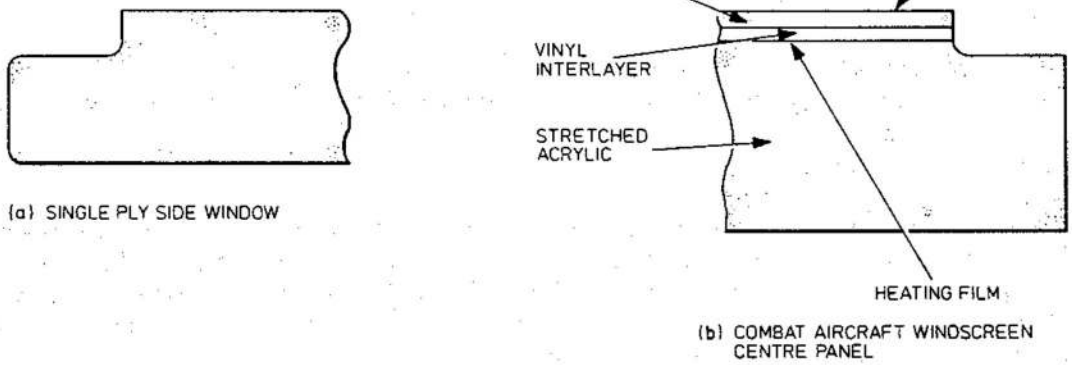
24 The method of de-misting and de-icing must be taken into consideration in the construction of the transparency. In particular, two methods of de-misting and de-icing; electrical heating and dry-air sandwich, affect the construction of the transparency. For detailed information on all de-misting and de-icing techniques refer to Chap 1-2.

25 Electrically heated transparencies use a wire element, grid or transparent conductive film sealed into the multi-ply laminate to provide the de-misting and de-icing. The wire, grid or film is within the laminate to provide electrical insulation and protection against damage, and is positioned relative to the heating requirements. Electrical supplies are fed via busbars, forming continuous strips along the heated area. Typical constructions of transparencies incorporating electrical heating are shown in Fig 2.

26 Dry-air sandwich type transparencies utilise an air space between two plies of the transparency. The air space is kept completely dry, thereby preventing misting between the plies. The space is vented through a desiccant such as silica gel. The air space acts as a thermal barrier thus insulating the inner transparency from the outer and preventing the formation of condensation visible as misting on the inner face of the component.

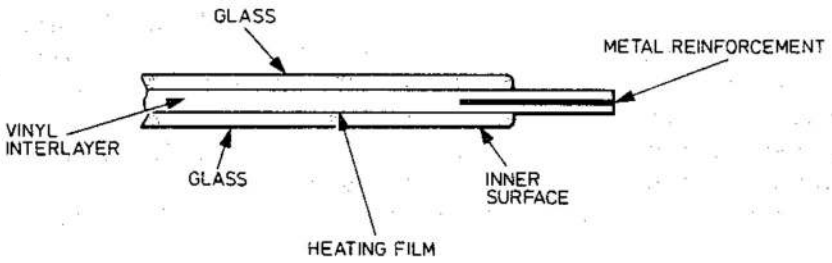
Bird impact proofing

27 The possibility and dangers of collision with birds is of major importance and the selection of materials and the design of the transparency is vital. Where weight is not critical, material is selected that is strong enough to bounce the bird off with relatively little deformation of the transparency or the aircraft structure. In critical weight cases, the transparency and structure are designed to deflect and absorb the energy. The extent of deflection permissible is controlled by the position of internal instrumentation such as the Head-Up Display, Gunsights, etc - and in extreme cases the clearance between the head of the crew member and the transparency. It is a requirement that no bird remains enter the cockpit following a strike at high speed and that the crew are not injured by broken facing plies.

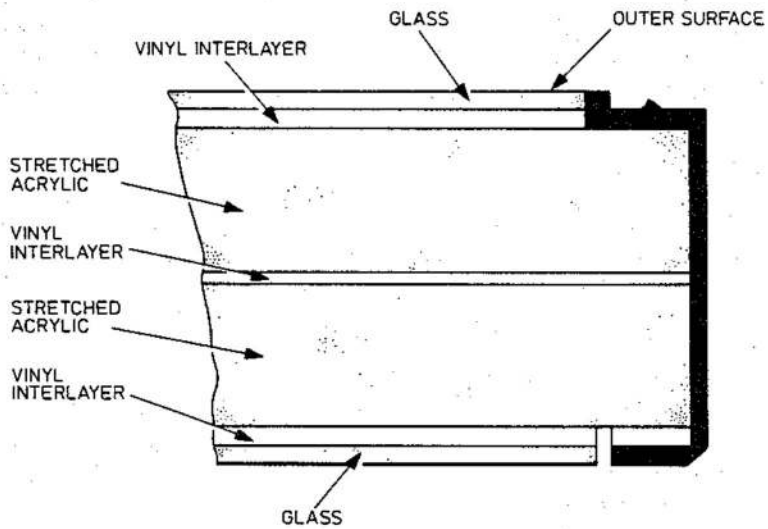


(a) SINGLE PLY SIDE WINDOW

(b) COMBAT AIRCRAFT WINDSCREEN CENTRE PANEL

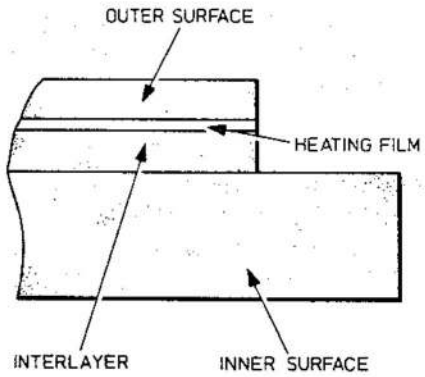


(c) HELICOPTER PILOT'S WINDOW

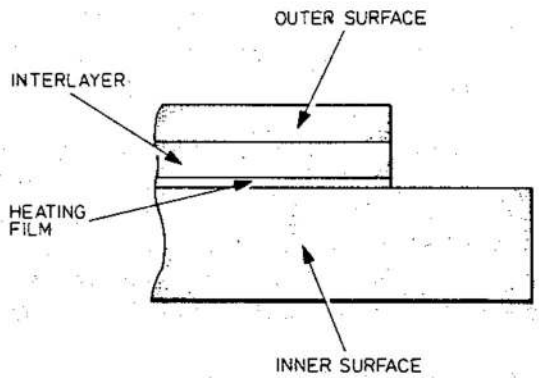


(d) TRANSPORT AIRCRAFT FLIGHT DECK TRANSPARENCY

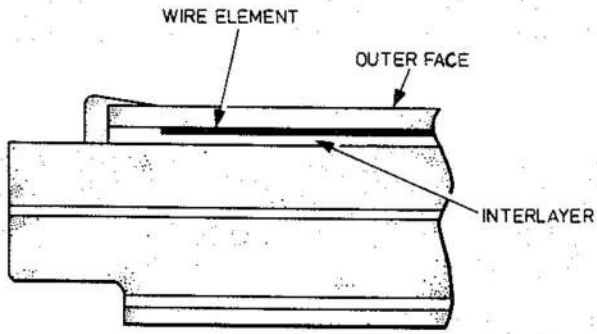
Fig 1 Typical transparency constructions - sectional views



(a) ELECTRICAL HEATING FILM (DE-ICING)



(b) ELECTRICAL HEATING FILM (DE-MISTING)



(c) WIRE ELEMENT DE-ICING

Fig 2 Transparency construction with integral electrical de-misting and de-icing facility

Transparency mounting

28 Transparencies are mounted in the aircraft structure by one of a number of different methods. Each design must consider the relative movement that must be allowed between the transparency materials, the aircraft structure and any elastomeric sealants. The choice of design must consider the transparency material and the design requirements with particular reference to bird impact and fail safe.

29 For glass transparencies either a clamped construction is employed or the extended interlayer design as shown in Figs 3a and 3b respectively. Both designs are suitable for non-pressurised or pressurised aircraft.

30 For acrylic designs (including glass faced), both the clamped construction, Fig 3a, and the bolted-in construction, Fig 3c, are used where all bolt holes through the acrylic are bushed within an elastomeric material. For canopies of high performance aircraft a third method is also optional as shown in Fig 3d, where the canopy is bonded to a fibre reinforced edge attachment through which the bolts pass.

Emergency escape facilities

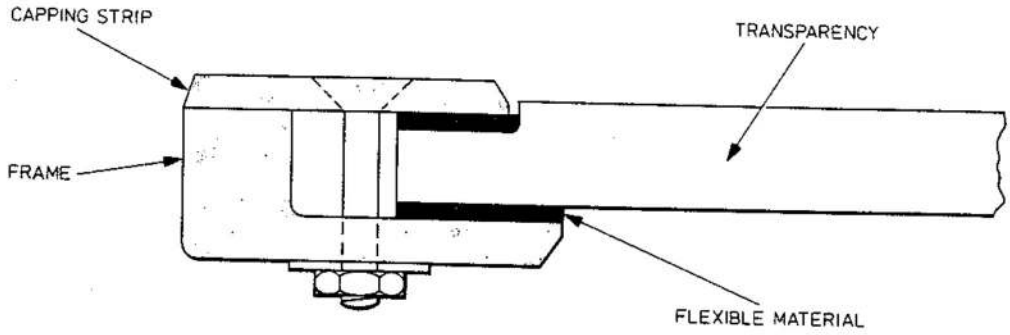
31 A suitable system for the escape of aircrew from an aircraft in flight or on the ground must be available. This comprises an effective method of removing the aircraft canopy or transparency panel to effect an adequate escape path. This can take the form of a manual release (typically used on cabin and helicopter cockpit windows), an explosive or gas assisted device to jettison the aircraft canopy from the aircraft, or a miniature detonating cord (MDC) or linear cutting charge (LCC) attached to the inner surface of the transparency or canopy to fragment the transparency and allow escape. Refer to AP110A-0102-1 for details of MDC and LCC systems.

WARNING ...

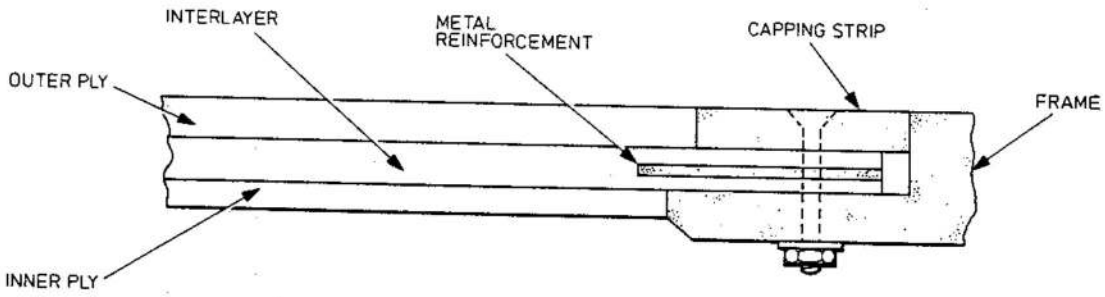
THE JETTISON DEVICE AND MINIATURE DETONATING CORD (MDC) OR LINEAR CUTTING CHARGE (LCC) ARE POTENTIAL SOURCES OF DANGER AND INADVERTENT OPERATION CAN CAUSE FATAL INJURY. BEFORE CARRYING OUT ANY WORK ON THE TRANSPARENCY ENSURE THAT THE RELEVANT SAFETY PINS ARE FITTED.

DAMAGE TO TRANSPARENCIES

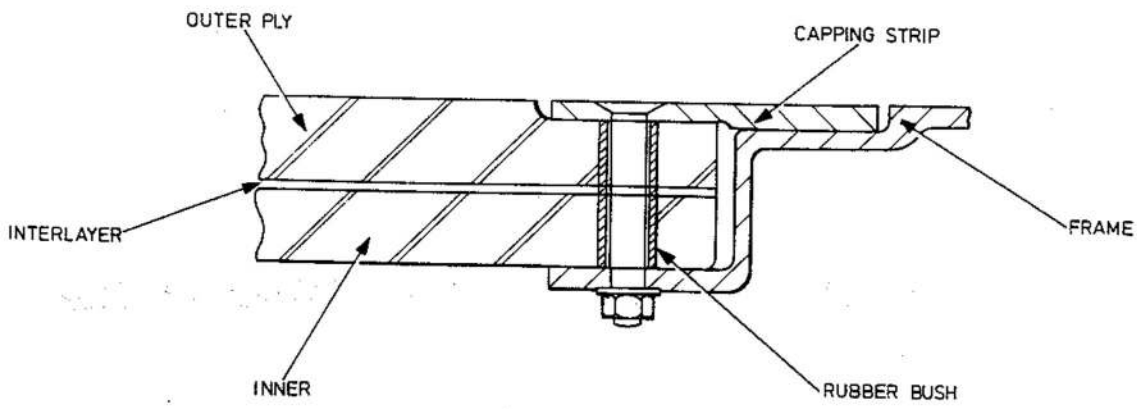
32 Detailed information on the types of damage, damage evaluation and the determination of the extent of the damage are given in Chap 2-1. When repairs are recommended, refer to Chapter 4-1 together with the relevant Aircraft Servicing Manual.



(a) FRICTION MOUNTING

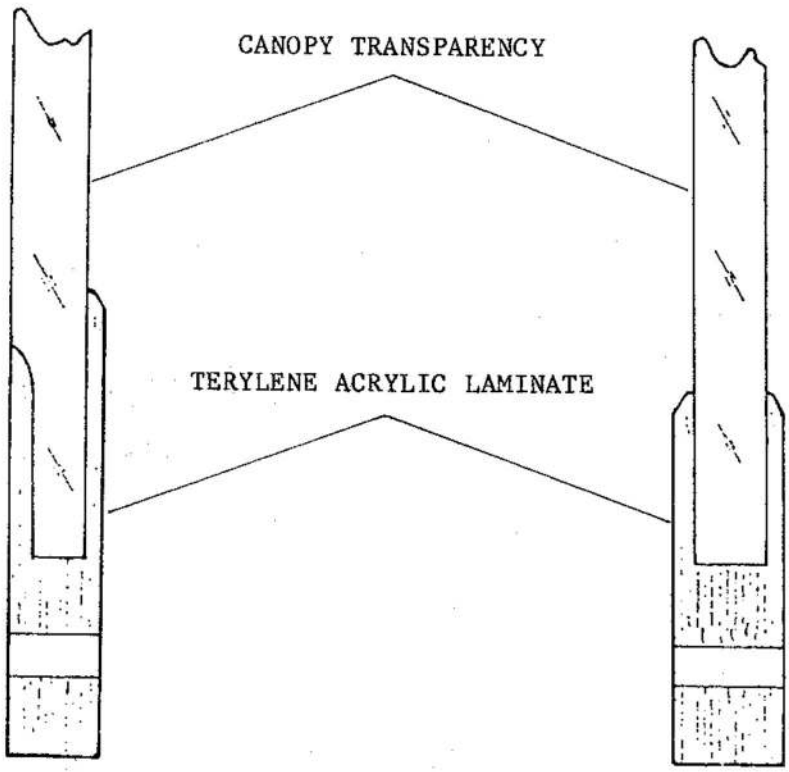


(b) EXTENDED INTERLAYER



(c) ALTERNATIVE MOUNTING WITH RUBBER BUSHED BOLT HOLES

Fig 3 Typical transparency mountings (continued overleaf)



BUILT UP FLUSH

BUILT UP SYMMETRICAL EDGE

Fig 3d Typical transparency mountings

Chapter 1-2

DE-MISTING, DE-ICING AND RAIN REMOVAL EQUIPMENT FOR AIRCRAFT WINDSCREENS

CONTENTS

Introduction

1 De-misting of aircraft windscreen transparencies can be carried out by one of the following methods:

1.1 Electrical heating

1.2 Dry-air sandwich (silica gel)

1.3 Hot air distribution system

2 De-icing of aircraft windscreen transparencies can be carried out by one of the following methods:

2.1 Electrical heating

2.2 Fluid sprays and windscreen wipers

2.3 Hot air distribution system

2.4 Local application of de-icing fluids

Note.....

Rain repellents are used in the absence of windscreen wipers to improve visibility by preventing the formation of moisture on the windscreen surface.

ELECTRICAL HEATING

3 Electrically heated transparencies utilise the heating effect of an electric current passing through a wire element or grid or a transparent conductive film sealed into a laminated transparency assembly. Information relating to a particular aircraft is given in the relevant aircraft servicing manual but general information on the two types of electrical heating is given in para 5 to 7 inclusive.

4 The operation and temperature of the electrical heating device is usually controlled and monitored from an external control unit. The temperature is monitored via sensing elements in the transparency assembly. The elements can be either a thermistor (thermally sensitive semi-conductor) or a wire grid type.

Wire element heating (Fig 1)

5 To provide the heat required for de-misting and de-icing an electrically heated wire element or grid is embedded within the transparency laminate in a position relative to the heating requirements. Electrical supply to the wire element or grid is fed from busbars along opposite edges of the heated area with flat, braided wire conductors leading from each of the busbars to an input terminal block.

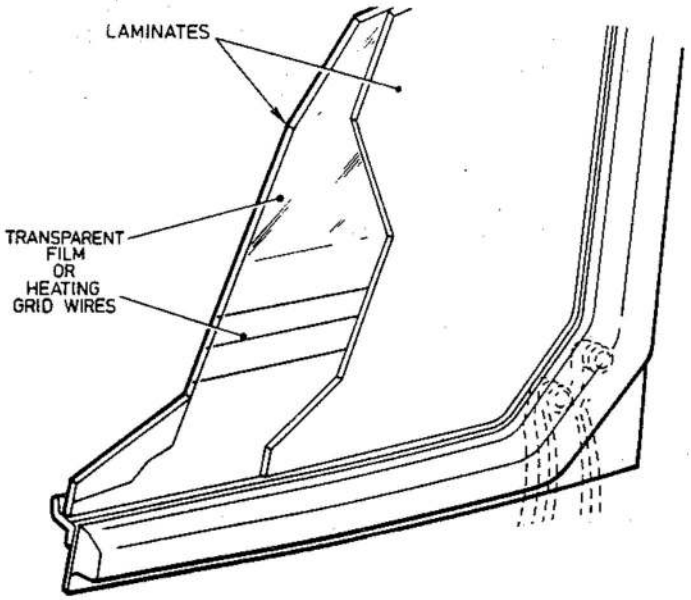


Fig 1 Typical electrical heating arrangement

Film heating

6 The heating element is a thin layer of transparent conductive coating (e.g. Lucas S3 or 'Hi-Viz') which is deposited by evaporation or sputtering onto a transparent plastic or glass sheet. This sheet then forms one of the layers (ply) in a laminate comprising a number of sheets of transparent plastic or glass interposed by layers of Polyvinyl Butyral (PVB) (vinyl) or other interlayer material. The conductive film is located within the laminate

to ensure electrical insulation and provide protection against damage, and is positioned relative to the heating requirements. To maintain uniformity of light transmission, small unheated areas of the transparency may also be coated with the film but these areas are isolated from the electrical supply.

7 Electrical supplies are fed via busbars, forming continuous strips along opposite edges of the heated area, which are connected directly to the conductive film. Flat braided wire conductors leading from a terminal block are laid along the full length of the busbars to accommodate the current requirements. The terminal block provides for connection of the aircraft electrical system to the transparency and is designed to prevent ingress of moisture to the conductive film.

DRY-AIR SANDWICH (SILICA GEL)

8 The dry-air sandwich transparency is a hollow panel or canopy in which the interspace serves to insulate the inner face from the outer. This design prevents mist forming on the inner surface of the transparency. A complete dry-air sandwich windscreen unit is shown in Fig 2. A valve is fitted to seal the space while the windscreen is in storage, or during servicing. When the windscreen is fitted to an aircraft, the valve is depressed by the connecting pipe, so allowing the interspace to 'breathe' into the cabin and equalise pressure changes resulting from changes of altitude in flight.

9 To prevent condensation in the interspace, complete dryness of the air is necessary and is achieved by the use of a desiccant such as silica gel. a small quantity of desiccant, contained in a porous tube, may sometimes be fixed to the bottom of the inner edge. As a further precaution, the outside edges of the spacers are sealed to prevent any possible ingress of moisture. The external silica gel container is open to cabin atmosphere; the desiccant which is coloured blue when dry, has to be examined periodically and renewed when it becomes pink. Some installations use transparent desiccant containers, others have containers incorporating an inspection window.

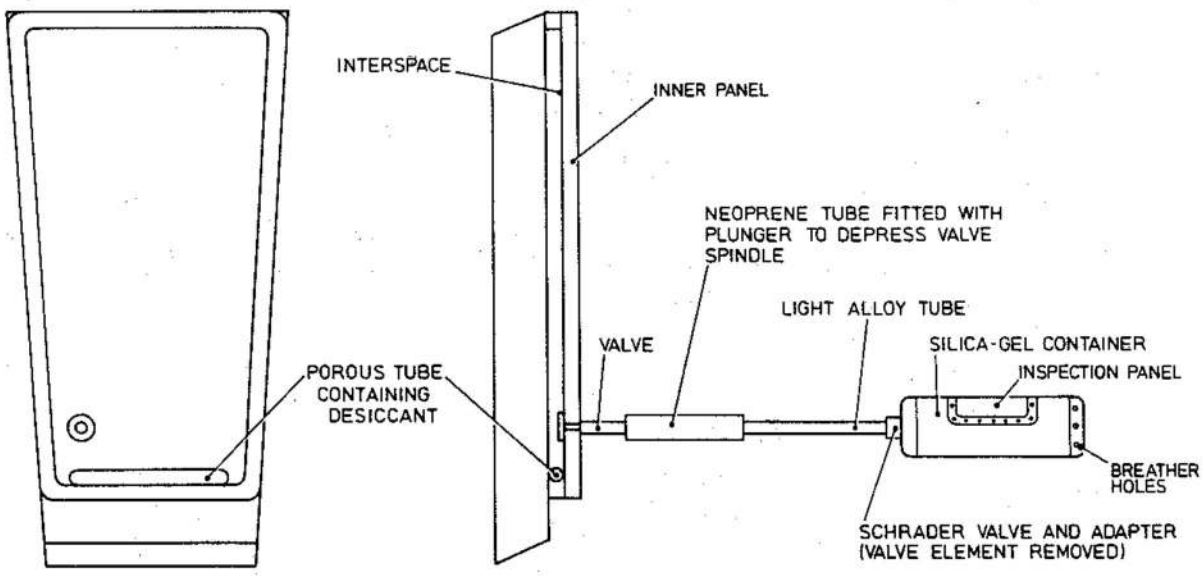


Fig 2 Typical dry-air sandwich (silica gel) system

RAIN REPELLENTS

10 A film of rain repellent applied to a windscreen prevents moisture from wetting the surface of the glass, the moisture forming into globules which are easily blown off the surface by the action of the air flow during flight. On untreated screens where wetting action occurs a film of moisture may build up due to the air flow, rendering vision almost impossible. Many rain repellents are silicone based to provide the required characteristics. At low forward speeds there is insufficient air flow to remove the moisture globules and the treated area may therefore have poor visibility. It may be decided by the Engineering Authority or local management to leave part of the windscreen untreated for improved vision during taxying.

EXTERNAL FLUID SPRAYS

11 The windscreen de-icing spray equipment, shown diagrammatically in Fig 3 and 4, comprises a de-icing fluid tank mounted in the cockpit and connected by a pipe-line to a hand-operated pump. The delivery side of the pump is coupled to a spray device arranged in front of the windscreen. The capacity of the de-icing tank varies, and is based on the requirement of $2\frac{1}{2}$ pints per hour for the estimated maximum period during which icing conditions are likely to be encountered. Some aircraft systems have a mechanical power driven pump or a pressurised reservoir in the supply system in lieu of the hand pump. These systems are remotely controlled, usually electrically, and de-icing system pipelines are not routed through the cabin thus eliminating danger from fumes in the event of leaks.

CAUTION...

Ensure that de-icing fluid is suitable for the transparency material. 'Crazing' can be caused by using de-icing fluid on certain materials used for aircraft transparencies (ref Chap 2-1). Only the correct fluid as stipulated in the aircraft servicing manual is to be used.

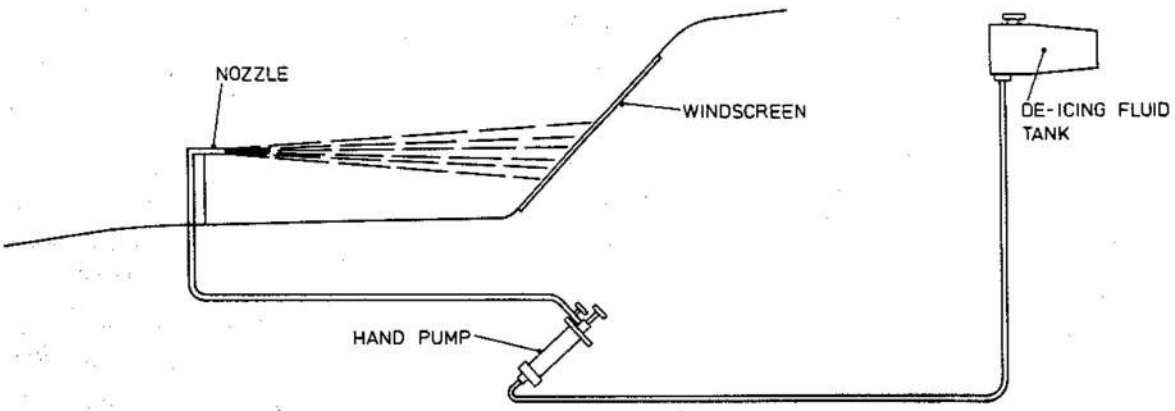


Fig 3 Windscreen de-icing spray equipment (nozzle type)

Spray devices

12 Two types of spray device are in service. The type shown in Fig 3 is used in conjunction with a windscreen wiper. The de-icing fluid is delivered from a single nozzle at the end of an upright pipe positioned approximately 2 ft in front of the windscreen. The exact position of the nozzle varies with the type of aircraft and is determined experimentally to give the best distribuiton of fluid over the screen.

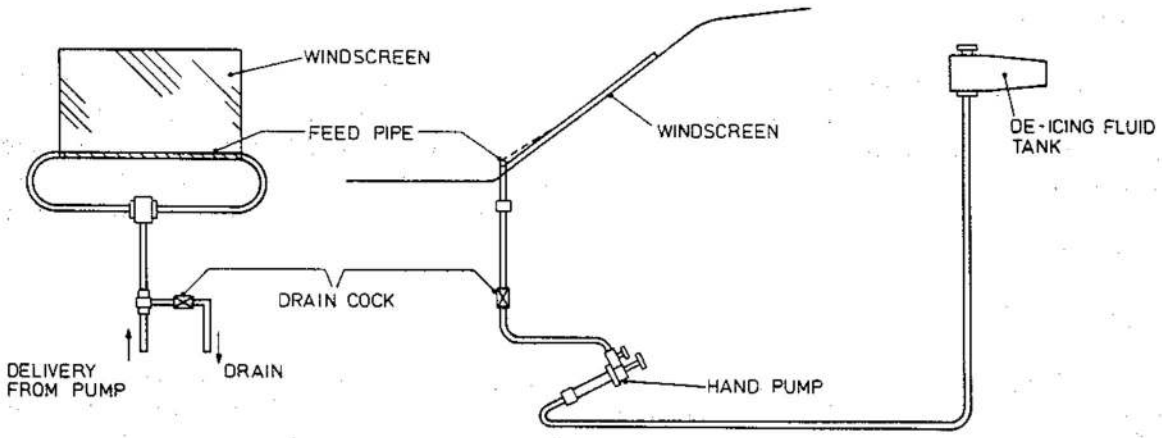


Fig 4 Windscreen de-icing spray equipment (apertured tube type)

13 In the type shown in Fig 4, the de-icing fluid is fed into both ends of a pipe at the base of the windscreen. The fluid emerges through a series of small holes along the upper surface of the pipe. A drain cock in the delivery pipe is accessible to the pilot, who drains the pipe before take-off. In both arrangements the pressure provided by the pump is only sufficient to cause the fluid to trickle from the nozzle or holes, from where it is distributed over the screen by the air stream.

Leakage of de-icing fluid

14 Owing to its toxic nature, the presence of alcohol based fluid (particularly where it may be vaporised by heating pipes or hot air supply) is a source of potential danger, especially to aircrew, and may possibly lead to loss of control. Steps should therefore be taken during routine servicing to ensure that no alcohol based fluid is spilled in the aircraft cabin. Such items as the fluid tank fillercap, pipes, pipe unions and glands of the de-icing pump must all be examined to ensure they are leak-proof. In addition, it should be ensured that the fluid directed at the windscreen cannot enter the cabin through openings in the cowlings or aircraft skin. After routine servicing, the drain-cock, when fitted, must be closed. The regulator must be ON before actuating the pump, to ensure that excessive pressure is not placed on pipe joints, which may cause them to leak.

Local application of de-icing fluids

15 Only fluids specified in the aircraft servicing manual are to be applied to transparencies to dissipate or prevent the formation of ice on the aircraft whilst on the ground.

Hot air distribution system

16 Hot air drawn from the air conditioning system may be used for windscreen de-misting, de-icing or rain dispersal. High temperature, high pressure air directed through a fish tail distributor at the base of the windscreen external face may be used for de-icing or by the blast effect, for rain dispersal. Inside the aircraft, low pressure, medium temperature air directed through perforated distributor pipes arranged around the edges of a transparency may provide de-misting of important components such as windscreen, bomb aimers windows or camera ports.

RAIN REMOVAL

17 Rain removal from aircraft windscreens is essential to prevent a build-up of moisture on the outer surface of the screen, rendering vision almost impossible. Rain repellents (para 19) are normally applied to the surface of the windscreen so that any moisture globules on the screen will easily be blown-off the surface by the passing air flow. On low speed aircraft, e.g. helicopters, rain removal is assisted by motorised wiper blades.

Windscreen wipers

18 Transparency materials are considerably weakened by surface scratches, therefore it is important that windscreen wipers are only operated on a wetted surface. When windscreen wipers are used for de-icing they are invariably used in conjunction with external fluid spray. Windscreen wipers are operated by either electric, hydraulic or pneumatic systems.

Rain Repellents

19 The rain repellent currently in use by the Services is the pre-flight application type RR990. It is unaffected by windscreen heating, but use in conjunction with a wiper system is not recommended.

CAUTION...

Rain repellent RR990 is an eye and skin irritant. Relevant safety precautions must be observed.

20 Due to the wetting action of water on glass, and to a much lesser extent on perspex, rain spreads to form a film on the windscreens. At higher speeds the air stream can cause a considerable build-up of water. This layer of water is of uneven thickness causing refraction of light rays, resulting in distorted or false images. Windscreen wipers reduce this build up but in heavy rain blurring will occur between sweeps of the blade.

21 In order to prevent this build-up of water a thin film of water repellent (similar to silicone polish) is applied to the windscreen. This film prevents moisture or rain from wetting the glass. As a result the moisture forms droplets on the surface which are easily blown off the windscreen by the slip-stream, giving a virtually undistorted field of vision.

22 Due to the prevention of moisture spread, i.e. rain droplets, rain repellent reduces the build-up of dirt film and salt spray; it also effectively reduces the deposit of hoar frost. At very low speed repellents are less effective due to reduced air flow and it may be necessary to use windscreen wipers whilst taxying. Use of windscreen wipers under flight conditions is to be discouraged as continual use will shorten the life of the repellent surface.

23 Rain repellents are affected by certain fluids such as fuels and some de-icing fluids, which may damage the repellent film and cause impairment of vision. It is therefore important that no fluids other than those authorised for use on windscreens treated with rain repellents are to come in contact with treated surfaces. Under no circumstances must de-icing fluid AL8 be used on treated surfaces. In all cases rain repellents must be used in strict compliance with the manufacturer's instruction. Application of the pre-flight type must be recorded in the aircraft Form 700.

Pre-flight application, type RR990

24 The pre-flight application, type RR990 (33C/2203490) is supplied in kit form comprising, glass cleaner, plastic cleaner rinse, rain repellent and application tissues. Application must be made under dry conditions, if necessary it is to be applied while the aircraft is parked under cover. It is also important to ensure that the repellent is applied evenly over the windscreen. The frequency at which the repellent is to be applied will vary with aircraft type and operating conditions.

Note...

Refer to the relevant care and maintenance chapter in this publication for the correct application of pre-flight rain repellent.

Chapter 2-1

GENERAL CARE AND MAINTENANCE

CONTENTS

Introduction

1 The condition of aircraft transparencies during an operational flight has a very great effect on the visual location and recognition of other aircraft and objects, and with the increased use of head-up displays, the condition of the transparency becomes even more critical. The optical quality and standard of cleanliness of all transparencies must therefore be very high. The care and maintenance of the aircraft transparency is the responsibility of the ground crew who must be familiar with the different materials and procedures to be used and also their limitations on certain transparency materials. No routine maintenance checks are required on transparencies but routine cleaning, polishing and inspection should be undertaken at regular intervals.

2 This chapter provides a general introduction to the products and procedures to be used and their limitations. For detailed information on the care and maintenance of specific types of transparency refer to Chap 2-2 and 2-3 and the relevant aircraft servicing manual.

DAMAGE TO TRANSPARENCIES

3 Damage to transparencies can be defined as follows:

4 Physical damage: Great care must be exercised when handling or working in the vicinity of aircraft transparencies, especially those produced in plastic materials, as the surface is easily scratched or damaged. Causes of physical damage are as follows:

4.1 Contact or impact with any hard object

4.2 Contact with a rough material such as cloths and clothing

4.3 Contact with dirty hands

4.4 Movement of protective covering materials

4.5 Contact with abrasive materials (i.e. unauthorised polishes, etc)

5 Crazing: Crazing is the formation of stress induced cracks which extend in a network over or through the transparency and can be caused by either mechanical stresses in the material, by the action of a chemical reagent or by prolonged solar exposure. Crazing is usually confined to transparencies manufactured from plastic materials.

6 Mechanical stress crazing is usually caused by local stresses around the mounting points of the transparency, although crazing may also be caused when the transparency is subjected to an impact, which, although insufficient to shatter the material, momentarily deforms it.

WARNING...

DO NOT CHECK THE SURFACE TEMPERATURE OF A CRAZED TRANSPARENCY WITH THE BARE HAND. A LETHAL VOLTAGE MAY BE PRESENT ON THE HEATING FILM OR GRID.

7 Crazing caused by exposure to certain chemicals or their vapours can have a serious effect on the structural strength of the transparency as well as the optical quality. The solvents used in aircraft paint schemes and thinners are severe crazing agents and the transparency must be protected during servicing. It is essential that harmful chemicals are not used or stored in the vicinity of plastic transparencies. Refer to Table 1 and 2 for the safe and unsafe materials for contact with plastic transparencies.

8 Delamination: Delamination is the breakdown in adhesion usually due to ingress of moisture at the interface between material layers. Delamination may start around the edges of the panel and extend inwards as more air is admitted between the laminations. Delamination can also occur around sensors and unheated areas. Delamination affects the strength and optical effectiveness of the transparency and also the de-icing and de-misting properties.

The extent of permissible areas of delamination is generally given in the Aircraft Servicing Manual. Where information is not available, a general guide is that delamination must not extend beyond 20 to 40mm ($\frac{3}{4}$ to $1\frac{1}{2}$ in) from the edge of the transparency however this may be reduced if vision is impaired. In stretched or pressed acrylic delamination can also occur as separation of the adhesion layers. It is caused by ingress and egress of moisture from material edges or bolt holes.

9 Cracks: Cracks are serious defects which, depending on their location and the transparency material, may result in considerable strength reduction, impaired visibility and possible loss of cockpit pressure. It is recommended that the transparency is replaced when cracks are evident. For unpressurised aircraft some allowable cracking may be authorised, refer to the Aircraft Servicing Manual for limitations.

10 Bubbling: Small bubbles occurring within the vinyl interlayer of electrically heated transparencies are not delamination nor are they structurally dangerous. They are usually due to overheating conditions, the bubbles being formed by a gas or water vapour liberated from the vinyl. Where vision is seriously impaired, the transparency must be replaced. Bubbling may indicate a defective control system for the de-icing heating device or localised non-uniformity in the heating medium itself.

11 Discolouration: Electrically heated transparencies are transparent to direct light but normally have a distinctive colour when viewed by reflected light. This apparent discolouration is due to the heating film and may vary slightly between transparencies. Only black or brown discolouration, when viewed normal to the surface should be regarded as a possible defect. The cause of such discolouration may be a burn-out of the heating film or a carbon deposit between a busbar and the heating film due to overheating.

EXAMINATION OF TRANSPARENCIES

12 Transparencies must be examined for damage and defects as part of the regular care and maintenance procedures and any damage evaluated to determine the effect on the operational characteristics of the transparencies. The implications of damage sustained by a transparency depends on the area of vision zone in which it occurs and the main criteria in evaluating this damage will be the effect on optical quality and structural integrity. The types of damage likely to be sustained by a transparency are defined in para 13 to 21.

Notes...

(1) Refer to the Aircraft Servicing Manual for vision zone areas.

(2) For repair information specific to the category of damage detailed in para 13 to 21, refer to Chap 4-1.

Scratches

13 The depth of a scratch can be determined by carrying out a comparison check using a x 10 magnifying glass, a set of feeler gauges and a set of reference scratches. The scratches should fall into one of the three categories:

13.1 Superficial scratches; a light hairline scratch, less than 0.05mm in width that cannot be detected with a finger nail.

13.2 Moderate scratches; a scratch with a width greater than 0.05mm and with a depth not exceeding 0.2mm and less than 10mm in length. The scratch can be detected with the finger nail.

13.3 Deep scratches; a scratch similar to a moderate scratch but with a depth exceeding 0.2mm.

Note...

Before assessing scratches they should be lightly polished with the recommended materials (Chap 2-1) to remove any external ridges created on the scratch edges.

14 An alternative method for assessing the approximate depth of scratches is by using millimetre graph paper as follows (Fig 1):

14.1 Place a sheet of millimetre graph paper on the transparency so that a graph line coincides with an outer edge of the scratch.

14.2 From the opposite side of the transparency examine the scratch at an angle of approximately 45 degrees to determine its widest point.

14.3 The apparent width of a scratch can be determined, to an acceptable degree of accuracy, using a x10 magnifying glass. The approximate depth of the scratch is obtained by multiplying the apparent width by a factor of 2.

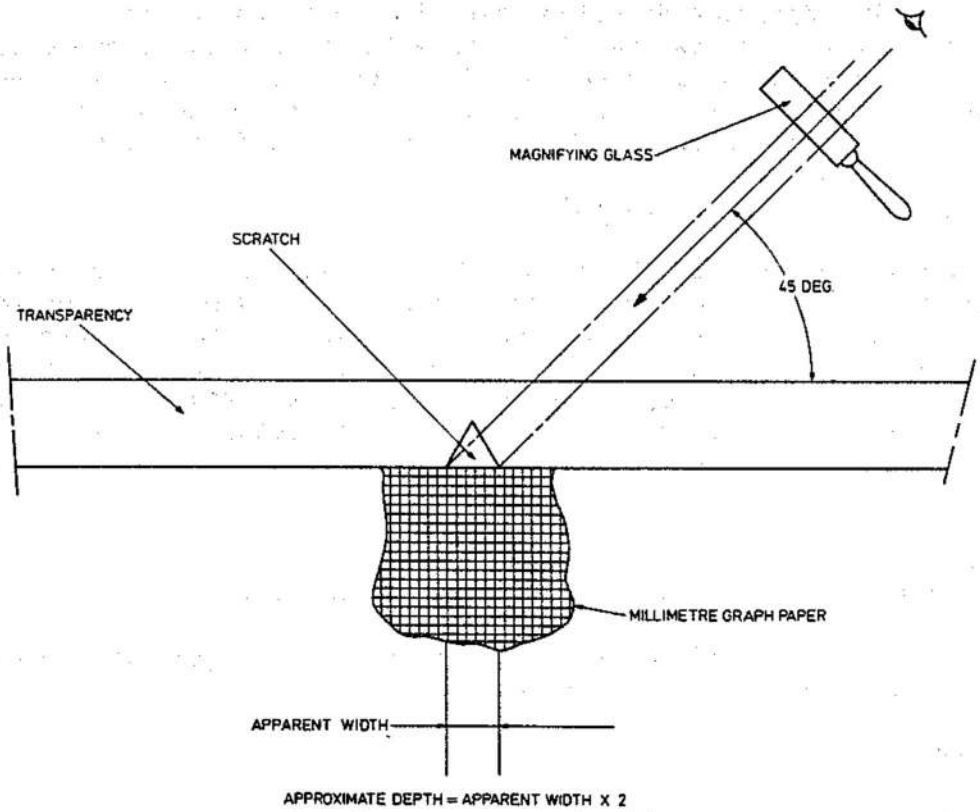


Fig 1 Assessing scratch depth

Abrasions

15 An abrasion is defined as a dulling of the surface caused by numerous concentrated superficial scratches (para 13.1).

Crazing

16 The depth of crazing in a transparency can be assessed using millimetre graph paper, a x 10 magnifying glass and a suitable light source as follows (Fig 2):

16.1 Place the edge of the graph paper so that the edge of the paper coincides with the edge of the craze.

16.2 From the same side of the transparency view the craze through the magnifying glass at an angle of 45 degrees.

16.3 The approximate depth of the craze is twice the apparent depth as compared against the graph paper squares.

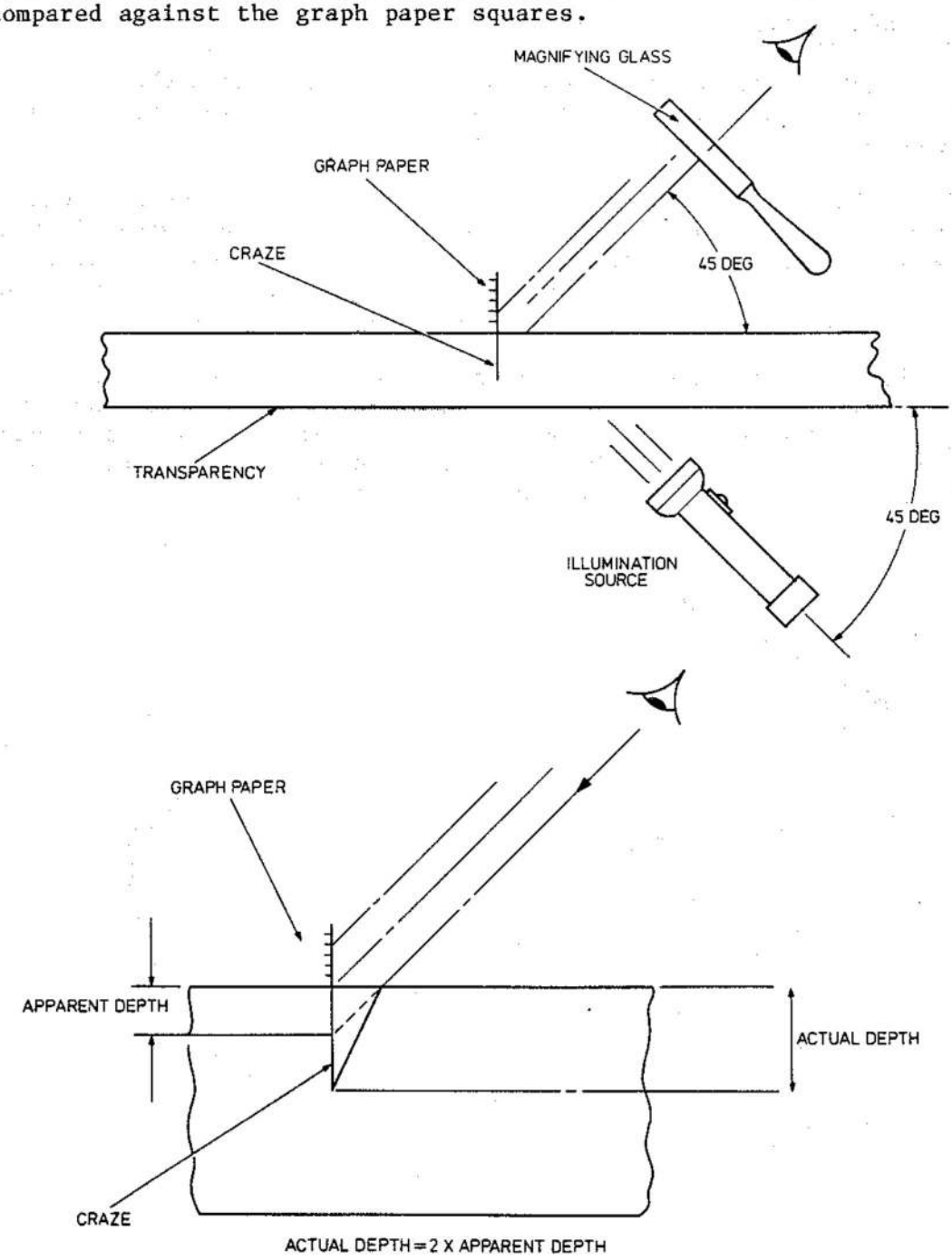


Fig 2 Assessing depth of crazing

Gouges

17 The size of a gouge can be ascertained by placing a sheet of millimetre graph paper under the transparency and counting the number of squares covered by the gouge. A depth gauge is used to measure the depth of the gouge. The gouges should fall into one of the following two categories:

17.1 Negligible gouges; this is defined as a gouge of less than 1mm diameter.

17.2 Minor gouges; this is defined as a gouge with a depth not exceeding 1mm and a width not exceeding 3mm and a maximum area of 25mm^2.

Surface or edge chips

18 The size of a chip can be ascertained using a similar method as detailed in para 16. The effect of chipping is dependent on the location of the chipping on the transparency as follows:

18.1 Surface chips: A surface chip is defined as a smooth particle removed by impact. These are sometimes accompanied by internal splitting which is indicated by a whitened area. A negligible surface chip is less than 1mm diameter. A minor surface chip is less than 1mm in depth and not exceeding 3mm in width and not exceeding an area of 25mm^2.

18.2 Edge chips: An edge chip is a smooth shell-shaped piece missing from a panel edge, usually caused by accidental damage. The acceptable size of an edge chip is dependent on its location and is usually expressed by the dimensional limits shown in Fig 3. Refer to the relevant Aircraft Servicing Manual for specific dimensional limits.

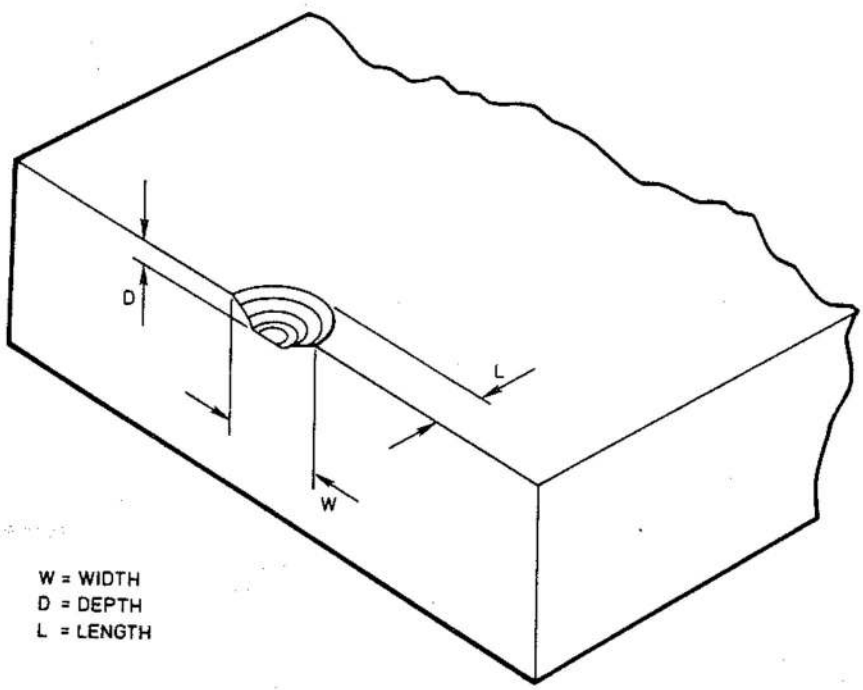


Fig 3 Typical edge chip

Distortion

19 The significance of distortion will vary with the transparency and the area of vision zone affected. Distortion can be assessed using one of the following methods:

19.1 Using a photograph of a grid board taken through the transparency, select the grid line on the photograph with the greatest curvature. Draw a line tangential to this apparent grid line so as to make the largest possible angle with the true grid line. Measure the angle between the tangetial line and the true grid line.

19.2 Using a projector and a film slide of a grid board, capable of projecting a grid pattern with 25mm pitch onto a screen with horizontal and vertical arms to provide a datum and means of measuring the distortion (e.g. a draughting head similar to that used on a drawing board). Set up the projector and screen to obtain an image of 25mm pitch with horizontal and vertical lines (a plumb-bob can be used for the vertical datum). Position the transparency so that the projector lens is at the pilots eye position and the image passes through the area under investigation. Refocus the image on the screen and measure the slope of the tangent to any distorted line.

Note...

As an alternative method to the above an approximate visual assessment can be made by viewing a grid board positioned in front of the transparency. Any distortion can be observed from behind the transparency which will be identified by an apparent distorted line on the grid board.

Delamination

20 The permissible areas of delamination are given in the Aircraft Servicing Manual. The extent of delamination can be visually identified around the edges of the transparency and may form as a smooth edge around the boundary of the transparency or as a rough edge characterised by irregular, sharp or jagged boundary edges. If moisture penetrates the delaminated plies, the area may appear 'cloudy'. In doubtful cases, delamination can be confirmed by carrying out a reflection test by means of a flaw detector using a light beam. The beam is directed onto the surface of the transparency and the reflection observed on a ground glass screen. There must be two sharply defined lines, representing the top and bottom surfaces of the transparency. Any delamination present will produce an additional line and its proximity to either of the other two reflected lines will be helpful in determining which of the plies has separated. Service delamination should not be confused with controlled delamination where release tapes are built into the edges of panels to permit flexing in service.

Heating device failure

21 Failure of the heating film or wire grid in transparencies other than Polyvinyl Butyral (PVB) can profoundly affect the structural integrity of the transparency and operational capability of the aircraft due to lack of de-icing or de-misting. Details of specific checks for heating elements, film

and sensing elements are contained within the Aircraft Servicing Manual but the following procedures cover general information on testing common to all aircraft.

22 The serviceability of heating elements, film and sensing elements can be checked by carrying out insulation and resistance checks as detailed in para 23 to 25. The following test equipment will be required for a typical installation:

22.1 Insulation resistance tester

22.2 Ohmmeter

22.3 Wheatstone bridge or test meter of similar accuracy

Resistance check - temperature sensing elements

23 This check is intended primarily as a continuity check and the actual measured resistance is unimportant provided that it falls within the limits of resistance corresponding to the appropriate range of ambient temperature given in the aircraft manual.

CAUTION...

Do not apply voltages in excess of 3 volts to wire grid or thermistor temperature sensing elements. Voltages in excess of 3 volts may damage sensing element.

23.1 Where applicable disconnect aircraft electrical leads from sensing element terminals.

23.2 Using the ohmmeter check that the resistance of each sensing element (in turn) is as specified for the appropriate temperature range.

Resistance check - heating film or element

24 This check is specific to particular aircraft transparencies and details will be contained within the relevant publication or associated engineering documents.

Insulation resistance checks

25 Proceed as follows:

25.1 Where applicable disconnect aircraft electrical leads

25.2 Using an insulation resistance tester and maintaining the test voltage for five seconds check:

25.2.1 The insulation resistance between sensing elements

25.2.2 The insulation resistance between each sensing element (in turn) and heating element.

25.2.3 The insulation resistance between each sensing element (in turn) and aircraft structure or simulated aircraft structure (metal plate).

25.2.4 The insulation resistance between heating element and aircraft structure or simulated aircraft structure (metal plate).

26 On completion of any checks, where applicable, reconnect aircraft electrical leads.

PRECAUTIONS AGAINST DAMAGE

27 To prevent damage to transparencies during cleaning and maintenance operations it is essential that the following precautions are observed:

27.1 Do not apply fluids or materials to the transparency that may result in damage to the transparency material. Only the safe materials detailed in Table 1 and the Aircraft Servicing Manual must be used.

27.2 Do not use hazardous fluids or materials in the vicinity of a transparency. These fluids or materials may give off vapours that may result in damage to the transparency material. Table 2 lists materials which are prohibited and must not be used on transparencies.

27.3 When working in the vicinity of a transparency, do not touch or allow equipment to come into contact with them.

27.4 Always use an aircraft type specific cover when available. If conditions dictate the use of covers and the correct type are not available, ensure any substitute cover has no rough internal surface and is free from potentially damaging features, such as clips, hooks or eyelets. Prior to fitting any cover examine the internal face of the cover to ensure freedom from grit, discarded locking wire fragments, spilled oil or other potential source of transparency damage.

27.5 When fitting a transparency cover never drag it over the surface of the component, always lift the cover into position. If flannelette covers are available these should be used alone during dry conditions, the waterproof cover should be fitted when rain or frost is likely. Policy regarding when covers shall be used will be determined by unit engineering management. Rough canvas covers or tarpaulins should not be used without some internal protective layer such as a blanket even as temporary weatherproofing.

27.6 Always determine the material from which the transparency is made or surfaced before commencing maintenance work on the transparency. It should be noted that the inner and outer surfaces of the transparency may differ, which may require a different maintenance technique, fluid or material. The transparency material is given in the relevant Aircraft Servicing Manual.

SAFE MATERIALS

28 Table 1 details the fluids and materials that are safe for direct contact with transparencies currently in service and manufactured from acrylics, polycarbonates or glass. It is essential that no other fluids or materials are used on or in the vicinity of aircraft transparencies. Cleaners and polishes of a more abrasive nature than those given in Table 1 must not be used or the optical quality of the transparency may be seriously damaged.

TABLE 1 SAFE MATERIALS FOR CONTACT WITH AIRCRAFT TRANSPARENCIES

Description	Ref No	Notes
Chamois leather (400 x 400mm)	32B/1327703	2
RR990 rain repellent (pre-flight)	33C/2203490	
Mild detergent (Tepol)	33D/2204958	
Polishing cloth, blue (DTD763A)	33D/2242030	
Polishing cloth, white (DTD763A)	33D/9233882	
Cotton wool, photographic grade	14B/4693905	
Cream, anti-static for aircraft canopies (1 litre)	33D/514	1
Polish, perspex ICI No 2	33D/513	1
Fluid, windscreen washing	33D/2245036	
Micro-mesh abrasive, grade 1500)	33J/-	1
Micro-mesh abrasive, grade 1800)	33J/-	1
Micro-mesh abrasive, grade 2400) Rolls, 50ft x 6in	33J/0340509	1
Micro-mesh abrasive, grade 3200) for major	33J/-	1
Micro-mesh abrasive, grade 3600) servicing	33J/0340508	1
Micro-mesh abrasive, grade 4000) units only	33J/2339830	1
Micro-mesh abrasive, grade 6000)	33J/-	1
Micro-mesh abrasive, grade 8000)	33J/84	1
Micro-mesh abrasive, grade 12000)	33J/-	1
Micro-mesh abrasive, kit, unit repairs	33J/86	1
Cream, anti-static 500 millilitre (P.W. Products)	33J/85	1
PR-1422-BT2 sealer	33H/2203813	2
PR-205 sealer	33H/2245082	2
PR-1422 ½ sealer	33H/2203110	2
PR-1221 BT sealer	33H/2201295	2
White spirit (B.S. 245)	34D/9427564	2
Masking tape (B.S. 2J11)	32B/various	
Protective paper	32B/1255307	
Chinagraph pencil	Various HMSO codes	

Notes...

1) For use on acrylic only

2) For use on glass only

PROHIBITED MATERIALS

29 Table 2 details the fluids and materials that are strictly prohibited from contact with aircraft transparencies in current service. Serious damage may result if the transparency material, especially plastic materials, are exposed to the action of these fluids and materials including their vapours. Table 2 details the more common of the prohibited materials however certain less common materials may be excluded. As a general rule the following categories of materials or their vapours are prohibited from contact with transparencies:

29.1 All paints and thinners

29.2 All paint removers

29.3 All sealants (other than those specified for transparencies)

29.4 All aromatic hydrocarbons

29.5 All jointing compounds

29.6 All thread locking compounds

29.7 Trichlorethylene

29.8 Petrol

29.9 Acids

29.10 Ether based liquids

29.11 Ketones (e.g. MEK)

29.12 Hydraulic fluids

29.13 Adhesives (other than those approved by the Aircraft Design Authority)

29.14 All primers (e.g. Bostick and PRC)

29.15 All cleaners (other than those specified for transparencies)

29.16 All polishes (other than those specified for transparencies)

29.17 All abrasive materials and fluids (other than those specified for transparencies)

TABLE 2 PROHIBITED MATERIALS FOR AIRCRAFT TRANSPARENCIES

Material	Remarks
Acetone (and all Ketones)	See notes 1 and 2
Ammonia	
Amyl acetate	
Aromatic hydrocarbons (e.g. Benzine, paraffin)	
Butyl acetate	See note 2

TABLE 2 PROHIBITED MATERIALS FOR AIRCRAFT TRANSPARENCIES (Continued)

Material	Remarks
Carbon tetrachloride	See note 1
Cellulose finishers, primer and thinners	
Chromic acid	
Cresols	See note 1
Deoxidine	
Ethyl alcohol and de-icing fluid	
Ethylene dichloride	See notes 1 and 2
Evostick	
Gasolene	
Glacial acetic acid	See notes 1 and 2
Hydraulic fluids	
Jointing compounds (e.g. Celloseal QH)	
Kerosene	
Methol alcohol	
Methylated spirit	
Paint solvents	
Petrol	
Plasticisers	
Rust removing solutions	
Solvent based rubber adhesives	
Synthetic (ester based) oils and greases	
Synthetic finishing materials	
Tautening dopes	
Thread locking compounds (e.g. Loctite)	
Toluene (methylbenzene toluol)	See note 2
Trichlorethylene	See note 1

Notes...

1) Polymethyl methacrylate is dissolved by these liquids

2) Polycarbonate is dissolved by these liquids

CLEANING AND POLISHING

30 The techniques used for cleaning and polishing will vary depending on the transparency material and location. Reference should be made to the relevant chapter in this publication for specific care and maintenance information. The purpose of cleaning and polishing is to remove accumulations of dirt, dust, insect debris, etc, from the surfaces of the transparency and to polish the transparency surfaces to provide optimum optical quality. Under no circumstances should any attempt be made to eliminate any damage however slight, by local polishing. For damage rectification, reference should be made to chapter 4-1 of this publication.

31 Before commencing work, the transparency material must be determined by reference to the Aircraft Servicing Manual as this may affect the cleaning and polishing technique used. It should be noted that the material on the inner and outer surfaces of the transparency may differ and this must be taken into account when deciding on the technique to be employed.

32 The location and optical requirements of the transparency must also be determined before cleaning and polishing; for example, a super critical area on a forward windscreen, where a HUD is displayed may require a different technique from that of a side panel or cabin window. Reference should be made to the relevant chapter in this publication for specific care and maintenance information.

Removal of coarse dirt

33 Coarse dirt such as grit, and mud splashes, oil mixed with dust, etc, should be rinsed off the transparency with clear water. The transparency must not be rubbed in any way as this will produce scratches. The water should be allowed to run down the transparency until all traces of coarse dirt have been removed. Grease, etc may be removed by carefully swabbing the surface of the transparency with photographic grade cotton wool swabs saturated with a solution of clean water and mild detergent (refer to Table 1). Take the utmost care to avoid damage to the transparency and discard the swabs after each application. If time permits, allow to air dry. Otherwise, dry by dabbing with clean swabs. On glass transparencies, the surface can be wiped with a chamois leather to remove water. In order to prevent dirt and grit from being picked-up by polishing cloths, it is necessary to periodically clean the frame surrounding the transparency.

Cleaning

34 When all coarse dirt and other abrasive materials have been removed from the transparancy, any residual surface dirt can be removed using a recommended cleaning material (refer to Table 1). The cleaning material should be applied to the transparency surface using clean photographic grade cotton wool swabs, spreading the cleaner evenly and discarding the swabs after each application.

CAUTION...

When cleaning the inner surface of a transparency, use minimum quantities of water applied with a moistened swab; protect adjacent instrumentation and miniature detonating cord (MDC) from water ingress.

Polishing

35 It is essential that a high standard of cleanliness is maintained throughout the polishing procedure, especially with plastic transparencies, to prevent traces of abrasive dust or dirt contaminating the polishing cloths and scratching the transparency. The polishing procedure will vary and reference should be made to the relevant chapter in this publication for specific instructions. The following general precautions must be observed when polishing:

35.1 Only light, hand pressure should be applied when polishing.

35.2 Renew polishing cloths frequently so that clean working surfaces are maintained at all times.

35.3 Ensure all dirt, etc has been cleaned from the transparency surface before commencing polishing.

35.4 Avoid the accumulation of cleaning or polishing materials in recesses or at the frame abutments.

36 Materials for cleaning transparencies may be demanded as follows:

36.1 Polish, Ref No 33D/514 (ICI Polish perspex No 2)

36.2 Cloths, polishing coloured WHITE, Ref No 33D/9233882 (DTD 763A)

36.3 Cloths, polishing coloured BLUE, Ref No 33D/2242030 (DTD 763A)

36.4 Fluid, windscreen washing, Ref No 33D/2245036

Note...

Refer to Table 1 for alternative polishes when working on the inner surface of the transparency.

37 The polishing procedure is as followed:

37.1 Clean the transparency (para 33 and 34).

37.2 When the transparency is dry, polish the surface with a clean WHITE polishing cloth using light hand pressure.

37.3 Apply the polish to the transparency using clean BLUE application cloths. Use sufficient polish to keep the surface moist, applying the polish frequently and in small quantities. Each application cloth must be only used once, then discarded.

Note...

Ensure the container of polish is thoroughly shaken before use.

37.4 Allow the transparency to dry then polish lightly using clean WHITE polishing cloths, until all traces of polish have been removed. The cloth must be discarded when it becomes soiled.

37.5 The cloths must be kept in their polythene bags until required for use. Ensure that the cap on the polish bottle is screwed firmly back in place.

HANDLING AND TRANSPORTATION

38 In most instances, damage to transparencies is caused during handling or transportation or when the aircraft is being serviced. It is therefore necessary to emphasise the need for great care to be taken when transparencies are in transit or during aircraft servicing, to prevent damage to the delicate surfaces of the transparency materials, especially plastics.

39 The following precautions should be observed by all service personnel:

39.1 Avoid handling transparencies; do not grip a transparency when entering an aircraft and whenever possible, lift transparencies by the framework.

39.2 Do not lean on transparencies.

39.3 Do not place tools on an aircraft transparency or position tools in an unsafe position where they may fall onto the transparency.

39.4 Do not pull covers over the aircraft transparency; the cover must always be lifted into position.

39.5 Do not remove the protective paper from new transparencies until installation into the aircraft is complete.

39.6 Always rest a transparency on suitable padded supports, ensuring the padding is clean, dry and free from abrasive material.

39.7 Ensure the electrical components of the de-misting and de-icing system where fitted are protected from accidental damage.

40 Transparencies are often seriously damaged during transportation by being loaded and unloaded carelessly and, by being left unsecured whilst in transit allowing them to move and contact other objects. Whenever possible the transparencies should be transported in the original packaging. If this is not available, paper coverings should be placed over the transparency and the component packed in soft packaging material. Avoid plastic materials, e.g. foams.

STORAGE

41 Transparencies should be stored in a cool, dry and well ventilated environment in their original packaging when available. Keep away from processes that could give off vapours which may have a detrimental effect on the transparency material (refer to Table 2), or abrasive materials that may damage the optical surface of the transparency.

Chapter 2-2

CARE AND MAINTENANCE OF GLASS WINDSCREENS AND GLASS WINDOWS

CONTENTS

CAUTION...

Prior to commencing maintenance work on aircraft windscreens and glass windows, determine the windscreen or window material and refer to Chapter 2-1 (Tables 1 and 2) for the materials that can safely be used on the specific material and also the prohibited materials that must not be used.

Introduction

1 This chapter details the care and maintenance procedures for aircraft windscreens and glass windows, including windscreen wipers and rain removal methods. The types of transparency covered by this chapter are as follows:

1.1 Multi-ply plastic and glass with glass outer layers.

1.2 Multi-ply plastic and glass with glass on outer surface only.

1.3 Multi-ply glass only.

2 The condition of aircraft windscreens and glass windows during an operational flight has a very great effect on the visual location and recognition of other aircraft and objects. The forward transparency or windscreen is the most important transparency, as the pilots main sightings and weapon aiming is made through the front windscreen. The correct care and maintenance of the transparency by the ground crew is therefore of utmost importance to the effectiveness of the in-flight operations.

PRE-MAINTENANCE CHECKS

3 Prior to commencing any preventive maintenance work on an aircraft windscreen or glass window check the following:

3.1 The type of transparency material; refer to the relevant Aircraft Servicing Manual.

3.2 The substances that can safely be used on the transparency material; refer to Chap 2-1, Table 1.

CAUTION...

Check the transparency material on any adjacent transparencies; the substances to be used may not be suitable for all types of transparency.

3.3 The prohibited substances that must not be used on the transparency material; refer to Chap 2-1, Table 2.

3.4 Determine from the Aircraft Servicing Manual if the windscreen incorporates a super-critical area of vision for H.U.D.; great care must be taken not to scratch this area.

MAINTENANCE

4 The following maintenance procedures must be carried out at regular intervals to ensure the windscreen or glass window remains in a serviceable condition.

Cleaning

5 Prior to examination or polishing all surface debris such as dirt, grit, etc, must be removed from the surface of the transparency as follows:

5.1 Remove coarse dirt, etc, from the outer surface of the transparency as detailed in Chap 2-1, para 33.

5.2 Clean the inner and outer surfaces of the transparency as detailed in Chap 2-1, para 34.

CAUTION...

When cleaning the inner surface of the transparency, use minimum quantities of water applied with a moistened swab; protect adjacent instrumentation, etc, from water ingress.

5.3 Dry the surfaces of the transparency with a clean chamois leather.

5.4 Where windscreen wipers are fitted, clean the wiper blades with a damp cloth.

Examination

6 Visually examine the windscreen or glass panel for the following:

6.1 Scratches.

6.2 Abrasions.

6.3 Crazing and cracking, especially around the transparency mounting points.

6.4 Gouges.

6.5 Surface or edge chips.

6.6 Distortion.

6.7 Delamination.

6.8 Heating device failure.

6.9 Windscreen wiper blade damage or wear (where fitted).

6.10 Deterioration of sealer around windscreen.

6.11 Detachment of miniature detonating cord (MDC).

Note...

Weather sealer provided around the periphery of windscreens must be inspected for evidence of erosion, lack of adhesion, separation or holes. The obvious purpose of maintaining an effective weather sealer is to protect the windscreens against moisture entry and the delamination or electrical problems associated with moisture penetration. When new sealer is required, the damaged material should be removed, the area cleaned, and new material applied in the manner prescribed in the relevant Aircraft Servicing Manual and Chap 4-1. Damaged material should always be removed with a plastic tool that will fit, without binding, in the gap between windscreen and frame.

7 The types of damage and the methods for determining the extent of any damage are detailed in Chap 2-1. Reference must be made to the relevant Aircraft Servicing Manual and/or Chap 4-1 of this publication to determine the serviceability of a windscreen or glass panel with visible damage or defects. Repair procedures for certain types of damage are included in Chap 4-1.

Polishing

8 Following cleaning and examination, a serviceable transparency must be polished using the procedure detailed in Chap 2-1, para 35.

Rain repellent (pre-flight)

9 The frequency with which pre-flight rain repellent is applied to glass windscreens will vary with aircraft type and operating conditions.

10 Pre-flight rain repellent, type RR990 (33C/2203490) is supplied in kit form comprising, glass cleaner, plastic cleaner rinse, rain repellent and application tissues. Application must be made under dry conditions, if necessary it is to be applied while the aircraft is parked under cover. It is important that the repellent is applied evenly over the windscreen. The following method is to be used when making applications on glass windscreens using the application tissues supplied in the kit:

10.1 Clean and polish the windscreen (para 5 to 8 inclusive)

10.2 Rinse the surface with plastic cleaner rinse.

10.3 Wipe the windscreen using a chamois leather (32B/1327703) until thoroughly dry.

10.4 Apply the rain repellent using a small quantity at a time on a clean folded application tissue. Do not soak the tissue. Ensure the rain repellent container is securely closed after application.

10.5 Polish the windscreen using clean tissues.

AUXILIARY EQUIPMENT

11 Maintenance work on windscreen auxiliary equipment must be carried out at regular intervals to ensure satisfactory operation. The equipment is as follows:

11.1 De-misting system.

11.2 De-icing system.

De-misting system

12 The de-misting system will be either an electrically heated, a dry-air sandwich system or an air distribution system (ref Chap 1-2). For electrical systems, maintenance comprises a functional check of the system. For the dry-air sandwich system, the silica gel container must be cleaned, dried and replenished with a quantity of silica gel crystals. Refer to the relevant Aircraft Servicing Manual for specific instructions.

De-icing system

13 The de-icing system will be either an electrically heated, an external fluid spray system or an air distribution system. For electrical systems, maintenance comprises a functional check only. For the external fluid spray system, operate the system and check that a quantity of de-icing fluid is applied to the windscreen. The level in the de-icing fluid tank must be checked at regular intervals. Top-up with the recommended de-icing fluid (as detailed in the Aircraft Servicing Manual) if necessary.

Chapter 2-3

CARE AND MAINTENANCE OF PLASTIC CANOPIES, TRANSPARENT PANELS, WINDOWS AND CUPOLAS

CONTENTS

CAUTION...

Prior to commencing maintenance work on plastic canopies, transparent panels and windows, determine the transparency material and refer to Chapter 2-1 (Tables 1 and 2) for the materials that can safely be used on the specific material and also the prohibited materials that must not be used.

Introduction

1 This chapter details the care and maintenance procedures for aircraft plastic canopies, transparent panels, windows and cupolas. The types of transparency covered by the chapter is as follows:

1.1 Moulded plastic canopies.

1.2 Single ply cockpit or cabin windows.

1.3 Multi-ply composite panels.

2 The condition of these types of transparency during an operational flight has a great effect on the operational effectiveness of the aircrew and aircraft systems. The condition of a plastic canopy of side and rear windows especially, can effect the visual location and recognition of other aircraft and objects by the pilot or aircrew. The correct care and maintenance of these transparencies by the ground crew is therefore of utmost importance to the effectiveness of in-flight operations.

PRE-MAINTENANCE CHECKS

3 Prior to commencing any preventive maintenance work on an aircraft plastic canopy, transparent panel or window check the following:

3.1 The type of transparency material; refer to the relevant Aircraft Servicing Manual.

3.2 The materials that can safely be used on the transparency material; refer to Chap 2-1, Table 1.

CAUTION...

Check the transparency material on any adjacent transparencies; the materials to be used may not be suitable for all types of transparency.

3.3 The prohibited materials that must not be used on the transparency material; refer to Chap 2-1, Table 2.

3.4 Determine from the Aircraft Servicing Manual if the transparency includes special areas of vision which may require special care during the maintenance procedures.

MAINTENANCE

4 The following maintenance procedures must be carried out at regular intervals to ensure the transparency remains in a serviceable condition:

WARNINGS...

(1) CANOPIES FITTED WITH MDC OR EXPLOSIVE JETTISON SYSTEMS SHOULD HAVE THE APPROPRIATE SAFETY DEVICES INSTALLED PRIOR TO MAINTENANCE.

(2) DURING MAINTENANCE A LOCKING DEVICE SHOULD BE FITTED TO THE OPERATING MECHANISM TO PREVENT INADVERTENT OPERATION OF THE CANOPY ACTUATING SYSTEM.

CAUTIONS...

(1) A canopy must not be left open if subject to high winds or jet blast from taxying aircraft.

(2) The front underside of a canopy is particularly vulnerable to scratching and damage when open. Ensure every precaution is taken to prevent damage.

Cleaning

5 Prior to examination or polishing, all surface debris such as dirt, grit, etc, must be removed from the outer surface of the transparency as follows:

CAUTION...

Do not rub or wipe the transparency during the removal of coarse dirt.

5.1 Remove coarse dirt, etc, from the outer surface of the transparency as detailed in Chap 2-1, para 33.

5.2 Clean the inner and outer surfaces of the transparency as detailed in Chap 2-1, para 34.

CAUTION...

When cleaning the inner surface of the transparency, use minimum quantities of water applied with a moistened swab; protect adjacent instrumentation and miniature detonating cord (MDC) from water ingress.

5.3 If time permits, allow to air dry. Otherwise, dry by dabbing with clean swabs. In order to prevent dirt and grit being picked-up by cleaning and polishing cloths, ensure the framework surrounding the transparency is also cleaned.

Examination

6 Visually examine the transparency for the following:

6.1 Scratches.

6.2 Abrasions.

6.3 Crazing and cracking, especialy around the transparency mounting points.

6.4 Gouges.

6.5 Surface or edge chips.

6.6 Distortion.

6.7 Delamination (composite panels only).

6.8 Heating device failure.

6.9 Deterioration of sealant around transparency.

6.10 Detachment of miniature detonating cord (MDC).

7 The types of damage and the methods for determining the extent of any damage are detailed in Chap 2-1. Reference must be made to the relevant Aircraft Servicing Manual and/or Chap 4-1 of this publication to determine the serviceability of a transparency with visible damage or defects. Repair procedures for certain damage are included in Chap 4-1.

Polishing

8 Following cleaning and examination, a serviceable transparency must be polished as detailed in Chap 2-1, para 35.

CAUTION...

Do not attempt to remove any damage, however by local polishing which can cause optical distortion in the transparency/material.

Rain repellent (pre-flight)

9 The frequency with which pre-flight rain repellent is applied to plastic transparencies will vary with the aircraft type and operating conditions.

10 Pre-flight rain repellent, type RR990 (33C/2203490) is supplied in kit form comprising, glass cleaner, plastic cleaner rinse, rain repellent and application tissues. Application must be made under dry conditions, if necessary it is to be applied while the aircraft is parked under cover. It is important that the repellent is applied evenly over the transparency. The following method is to be used when making applications on plastic canopies and panels using the application tissues supplied in the kit:

10.1 Clean and polish the transparency (para 5 to 8 inclusive).

10.2 Rinse the surface with plastic cleaner rinse.

10.3 Allow the transparency to air dry if time permits, otherwise dry by dabbing with clean swabs.

10.4 Apply the rain repellent using a small quantity at a time on a clean folded application tissue. Do not soak the tissue. Ensure the rain repellent container is securely closed after application.

10.5 Polish the transparency using clean tissues.

DE-MISTING AND DE-ICING

11 The de-misting system will be either an electrically heated, a dry air sandwich system or a hot air distribution system (ref Chap 1-2). The de-icing system will usually be an electrically heated film or wire grid. For electrical systems, maintenance comprises a functional check of the system. For the dry air sandwich system, the silica gel container must be cleaned, dried and replenished with a quantity of silica gel crystals. Refer to the relevant Aircraft Servicing Manual for specific instructions.

EMERGENCY ESCAPE SYSTEMS

12 The miniature detonating cord (MDC) or linear cutting charge (LCC) system must be visually inspected for damage and security. A transparency or canopy fitted with a kinked, stretched or deformed MDC or LCC must not be used. Refer to AP 110A-0102-1 for full details of MDC and LCC systems.

WARNING...

AN ESCAPE JETTISON DEVICE OR MDC AND LCC ARE POTENTIAL SOURCES OF DANGER AND INADVERTENT OPERATION CAN CAUSE FATAL INJURY. BEFORE CARRYING OUT ANY MAINTENANCE WORK ON THE TRANSPARENCY OR CANOPY ENSURE THAT THE RELEVANT SAFETY PINS ARE FITTED.

Chapter 3

SERVICING

Introduction

1 The servicing of aircraft transparencies is specific to the aircraft application, therefore refer to the relevant Aircraft Servicing Manual for specific servicing information.

Chapter 4-1

REPAIRS - GENERAL PRINCIPLES

CONTENTS

CAUTION...

Prior to commencing repair work on aircraft transparencies, determine the transparency material and refer to Chapter 2-1 (Tables 1 and 2) for the materials that can safely be used on the specific material and also the prohibited materials that must not be used.

INTRODUCTION

1 This chapter details the general principles for repairing damaged aircraft transparencies, including information on selecting the correct repair procedure with regard to the type of damage or defect sustained and the optical quality and structural integrity of the transparency.

2 The transparency must be inspected at regular intervals and any damage evaluated as detailed in Chap 2-1 to determine the type and extent of the damage; this evaluation will determine if the damage can be repaired and the repair procedure to be used. The selection of a suitable repair procedure is dependent on the following:

2.1 The extent of the damage (as defined in Chap 2-1).

2.2 The location of the transparency.

2.3 The area of vision zone in which the damage occurs.

SELECTION OF A REPAIR PROCEDURE

3 As previously stated, the selection of a repair procedure to recover an unserviceable transparency is dependent on the location of the transparency and the area of vision zone on the transparency. The following information on the selection of a suitable repair procedure is given as a general guide only, and reference must be made to the relevant Aircraft Servicing Manual for specific details.

Note...

Refer to Chap 2-1 to determine the type and extent of damage.

Forward windscreens or centre panels

4 This category of transparency must have a very high degree of optical accuracy and this must be taken into consideration during any repair work on the transparency. The transparency may be divided into areas of vision (e.g. critical, super-critical, etc) where the affect on optical accuracy by defects or damage may seriously limit the operational effectiveness of the aircraft.

4.1 Superficial scratches: On glass transparencies, superficial scratches are acceptable to aircrew approval. On plastic transparencies, these scratches can be removed using the polishing procedure detailed in para 13. Reference must be made to the relevant Aircraft Servicing Manual to determine if a super-critical area for H.U.D. presentation is incorporated in the transparency, as this area may require special attention.

4.2 Moderate scratches: On glass transparencies, moderate scratches are acceptable subject to aircrew approval. On plastic transparencies, remove scratches using the polishing procedure detailed in para 15. Check for H.U.D. display areas before commencing.

4.3 Deep scratches: On glass transparencies, deep scratches can cause the propagation of cracks; it is recommended that the transparency is replaced. On plastic transparenices, remove deep scratches using the repair procedure detailed in para 17. Deep scratches can also affect the strength of the transparency and reference must be made to the relevant Aircraft Servicing Manual to keep within the bottom limits on thickness and determine the limits to which deep scratches are permissible.

4.4 Abrasions: The repair procedures for recovering abraded transparencies are the same as for superficial or moderate scratches.

4.5 Crazing: Minor crazing is acceptable in certain areas of the forward windscreen or centre panel subject to limits in the Aircraft Servicing Manual. Any crazing must be monitored periodically. Minor crazing on plastic transparencies can be removed by the procedures detailed in para 13 or 15. The cause of crazing must be investigated i.e. solvent damage).

Notes...

(1) Use the polishing procedure (para 13) to attempt to remove any minor crazing prior to using the repair procedure (para 15).

(2) If the structural plies are affected by the crazing the transparency must be replaced.

4.6 Gouges: Negligible or minor gouges are acceptable in certain areas of the forward windscreen or centre panel subject to aircrew approval. If a gouge exceeds the limits stated in Chap 2-1 or the Aircraft Servicing Manual, replace the transparency.

4.7 Surface chips: Surface chips are acceptable providing they do not obstruct the pilots line of vision. If internal splitting is present the transparency should be replaced. If the chip exceeds 1mm depth, replace the transparency.

4.8 Edge chips: A repair procedure is not available for edge chips, if the dimensions of the chip exceed the limits given in the Aircraft Servicing Manual, the transparency must be replaced. If the chip exceeds 2mm depth, replace the transparency.

4.9 Distortion: A forward windscreen or centre panel which distorts images or vision due to defects in the construction of the transparency must be replaced.

4.10 Delamination: Delamination is acceptable subject to the limits given in the relevant Aircraft Servicing Manual. If these limits are exceeded the transparency must be replaced.

4.11 Heating device failure: The failure of the heating device other than Polyvinyl Butyral (PVB) types can effect the structural integrity of the windscreen or centre panel. The operational capability of the aircraft could be reduced through lack of de-icing or de-misting. The transparency must be replaced if the reduced operational capability becomes unacceptable.

Side panels or quarter lights

5 This category of transparency generally does not require such stringent optical accuracy as that for forward windscreens or centre panels however, if the transparency forms part of an aircraft canopy or helicopter cockpit the optical requirements may be increased. Refer to the relevant Aircraft Servicing Manual for specific details. The repair procedures for this category of transparency are the same as for windscreens and centre panels.

Cabin windows and ancillary transparent panels

6 In general the optical accuracy of these transparencies is of far less importance than for the previous two categories, the exception being where the transparency is used for photographic or reconnaissance applications where a much higher degree of optical accuracy is required. It is therefore necessary to ascertain the operational function of the unserviceable transparency to determine the extent of repair necessary. For cabin windows, etc, where the

optical accuracy is of little importance, scratches, etc, can be removed using either of the polishing procedures (para 13 or 15) or the more abrasive repair procedure (para 17) depending on the extent and depth of scratches, etc. For transparencies where the optical accuracy is of greater importance the repair procedures are the same as for side panels and quarter lights.

REPAIR PROCEDURES

7 Repair procedures must be carried out in a clean working environment with an adequate supply of clean water available. In general, all repairs should be carried out with the transparency removed from the aircraft, however if it becomes necessary to carry out the repair with the transparency installed, ensure all the relevant safety precautions regarding working on aircraft are complied with.

8 The repair procedures detailed in this publication are applicable to plastic transparencies only. There are no in service repair procedures applicable to glass transparencies.

9 When carrying-out the repair procedures ensure scrupulous cleanliness is maintained at all times. Traces of dirt or dust on any application cloths, etc will scratch the transparency. Only the materials specified in the relevant procedure must be used. Do not use polishes or materials of a more abrasive nature than specified as they may adversely affect the optical qualities of the transparency.

10 It is recommended that the repair procedures are only carried out by specially qualified service personnel who have undertaken suitable previous training in the correct polishing techniques.

11 Polishing must be carried out in straight line motions in the directions detailed in Fig 1. The direction of polishing must be moved through 90 degrees at every change of abrasive material (micro-mesh). Use light pressure only with plenty of clean water to prevent any build-up of heat. Polishing debris must be removed after each application using plenty of water. Ensure the subsequent polishing operations remove all marks left by the previous abrasive.

Note...

If necessary polish (to DTD 770A) to assist inspection of the repair area after each micromesh polishing operation.

12 The materials required are detailed in Table 1

TABLE 1 MATERIALS REQUIRED FOR REPAIR PROCEDURES

Description	Ref No
Abrasive material (micro-mesh)	) As detailed in
Cotton Wool, photographic grade	) Chap 2-1
Chinagraph pencil	) Table 1
Foam rubber block	Local manufacture

Removal of negligible damage

13 The following types of repairable damage are generally classified as negligible:

13.1 Forward windscreens or centre panels; superficial scratches, moderate scratches (not in super-critical areas of vision) localised abrasions, negligible gouges, surface chips and fine crazing (not in super-critical areas).

13.2 Side panels or quarter lights; superficial and moderate scratches, abrasions, negligible gouges, surface chips and fine and moderate crazing.

13.3 Cabin window and ancillary transparent panels; superficial and moderate scratches, abrasions, negligible gouges, surface chips and fine and moderate crazing.

Note...

Refer to the Aircraft Servicing Manual or the relevant Design Authority for specific limits of repairable damage on particular aircraft applications.

14 The repair procedure is carried out as follows:

14.1 Remove the transparency from the aircraft as detailed in the relevant Aircraft Servicing Manual and transfer to a suitable padded support jig.

CAUTION...

Ensure the precautions detailed in Chap 2-1, para 27 are complied with during the removal and transportation of the transparency to the working area.

14.2 Using a soft Chinagraph pencil, mark-out the limits of the scratch or defect to be removed and mark the repair area by drawing a square or rectangle enclosing the scratch lines. Mark-out two successively larger squares or rectangles using Fig 1 as a guide.

14.3 Clean the surface thoroughly and using grade 2400 abrasive material (micro-mesh) wrapped around a suitable foam rubber block, polish the scratch or defect using a straight-line motion, until the damage is removed. Limit the polishing to the first (smallest square or rectangle) repair area marked-out.

14.4 Clean the surface thoroughly using copious amounts of clean water.

CAUTION...

Do not wipe the transparency surface.

14.5 Using a grade 3600 abrasive material (micro-mesh) around the foam block, polish using a straight-line motion at 90 degrees to the previous polishing operation. Continue polishing until all the marks made by the previous polishing operation have been removed. Limit the polishing again to the first repair area marked-out.

14.6 Repeat the cleaning and polishing operations in the repair areas stated using the abrasive material (micro-mesh) as follows:

14.6.1 4000 grade micro-mesh, extending the polishing into the second repair area.

14.6.2 8000 grade micro-mesh, extending the polishing over the third (largest) repair area.

14.7 Clean the surface thoroughly and blot dry with clean swabs.

14.8 Polish the surface as detailed in Chap 2-1, para 35.

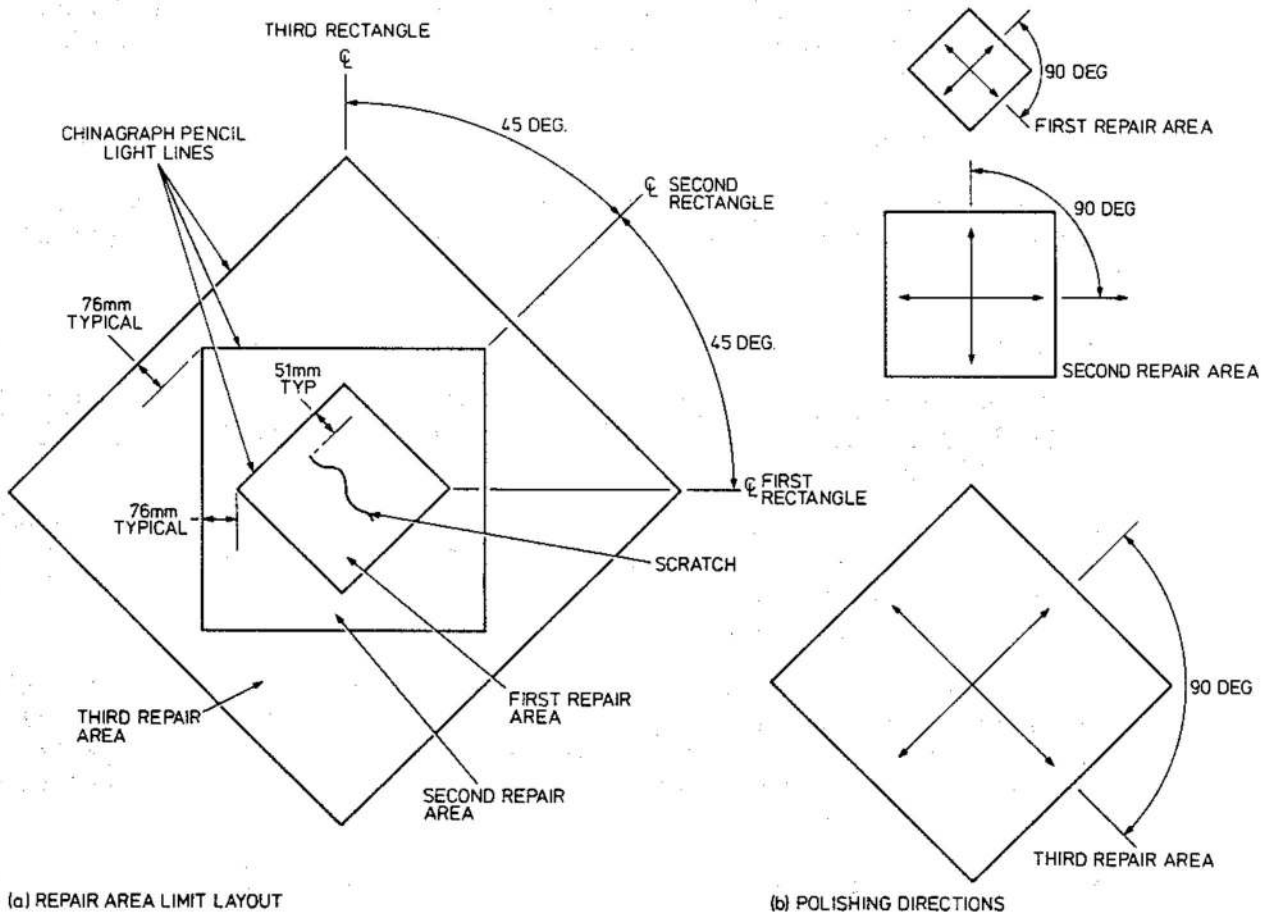


Fig 1 Transparency repairs - marking-out details

14.9 Inspect the transparency to ensure all damage has been removed. If necessary refer to the procedure for removal of minor damage (para 15) if the negligible damage cannot be removed by this procedure.

14.10 Check the thickness of the transparency in the area of the repair as detailed in para 22. The minimum thickness should be stated in the Aircraft Servicing Manual. If in doubt, refer to the Service Engineering Authority (EA).

14.11 Install the transparency in the aircraft as detailed in the Aircraft Servicing Manual.

Removal of minor damage

15 The following types of repairable damage are generally classified as minor:

15.1 Forward windscreens or centre panels; moderate scratches (not in super-critical areas of vision), abrasions, minor gouges, surface chips and fine or moderate crazing (not in super-critical areas of vision).

15.2 Side panels or quarter lights; moderate scratches, abrasions, minor gouges, surface chips and moderate crazing.

15.3 Cabin windows or ancillary transparency panels; moderate scratches, abrasions, moderate gouges, surface chips and moderate crazing.

Notes...

(1) The repair procedure for negligible damage should be carried out prior to this procedure to attempt to remove the minor damage before commencing this procedure.

(2) Refer to the Aircraft Servicing Manaual or the relevant Service Engineering Authority for specific limits of repairable damage on particular aircraft applications.

16 The repair procedure is carried out as follows:

16.1 Remove the transparency from the aircraft as detailed in the relevant Aircraft Servicing Manual and transfer to a suitable support jig.

CAUTION...

Ensure the precautions detailed in Chap 2-1, para 27 are complied with during the removal and transportation of the transparency to the working area.

16.2 Using a soft Chinagraph pencil, mark-out the limits of the scratch or defect to be removed and mark the repair area by drawing a square or rectangle enclosing the scratch limits. Mark-out two successively larger squares or rectangles using Fig 1 as a guide.

16.3 Select the lowest grade of abrasive material (micro-mesh) adequate to remove the depth of damage to be treated.

16.4 Clean the surface thoroughly and using the abrasive material (micro-mesh), selected at 16.3, wrapped around a suitable foam rubber block and polish the damage using a straight line motion until the damage or previous polishing marks are removed. Limit the polishing to the smallest square or rectangle area marked out.

16.5 Clean the surface thoroughly using copious amounts of clean water and lint free cloth.

CAUTION...Do not wipe the transparency surface.

16.6 Repeat 16.4 and 16.5 for all remaining grades up to and including step 9 on the table below. Each straight line motion must be at 90 degrees to the previous step.

Step	Micro-mesh Grade	Time/Ft^2 Mins
1	1500	3
2	1800	3
3	2400	3
4	3200	2
5	3600	2

Step	Micro-mesh Grade	Time/Ft^2 Mins
6	4000	2
7	6000	1.5
8	8000	1.5
9	12000	1.5

16.7 Polish the surface as detailed in Chap 2-1, para 35.

16.8 Inspect the transparency to ensure all damage has been removed. If necessary refer to the procedure for the recovery of transparencies with deep damage (para 17) if the minor damage cannot be removed by this procedure.

16.9 Check the thickness of the transparency in the area of the repair as detailed in para 22. The minimum thickness should be stated in the Aircraft Servicing Manual. If in doubt, refer to the Service Engineering Installation Authority.

Recovery of transparencies with deep repairable damage

Notes...

(1) The repair procedure for minor damage should be carried out prior to this procedure to attempt to remove the deep damage before commencing this procedure.

(2) Refer to the relevant Aircraft Servicing Manual or the relevant Engineering Authority for specific limits of deep damage on a particular transparency application to determine that the structural integrity of the transparency will not be affected by the damage.

17 The following types of damage generally classified as deep but repairable are:

17.1 Forward windscreens or centre panels; deep scratches or deep abrasions (not in super-critical areas of vision), minor gouges, minor surface chips and moderate crazing.

17.2 Side panels or quarter lights; deep scratches or deep abrasions, minor gouges, minor surface chips and moderate crazing.

17.3 Cabin windows or ancillary transparent panels; deep scratches, abrasions, gouges or surface chips and moderate crazing.

18 The repair procedure is carried out as follows:

18.1 Remove the transparency from the aircraft as detailed in the relevant Aircraft Servicing Manual and transfer to a suitable support jig.

CAUTION...

Ensure the precautions detailed in Chap 2-1, para 27 are complied with during the removal and transportation of the transparency to the working area.

18.2 Using a soft Chinagraph pencil, mark-out the limits of the scratch or defect to be removed and mark the repair area by drawing a square or rectangle enclosing the scratch limits. Mark-out two successively larger squares or rectangles using Fig 1 as a guide.

18.3 Carry out the repair similar to paras 16.3 to 16.7 ensuring that the procedure is commenced with a lowest grade adequate to remove the depth of damage to be treated.

18.4 Inspect the transparency to ensure all damage has been removed.

18.5 Check the thickness of the transparency in the area of the repair as detailed in para 22. The minimum thickness should be stated in the Aircraft Servicing Manual. If in doubt, consult the Service Engineering Installation Authority.

18.6 If there is evidence of damage still remaining, and the optical or thickness requirements will permit, repeat the procedure to attempt to remove the damage. If the damage cannot be removed by this procedure the transparency must be replaced.

Sealing transparencies

19 On certain glass or glass-faced transparencies, a sealer is used between the transparency and its mounting. If this sealer becomes damaged or deteriorated, or the transparency has been removed, the old sealer must be removed and new sealer inserted when the transparency is installed. The re-sealing procedure is as follows:

WARNINGS...

(1) ENSURE THE ELECTRICAL SUPPLY TO THE HEATING DEVICE IS DISCONNECTED. LETHAL VOLTAGES ARE USED FOR THE HEATING DEVICE SUPPLY.

(2) ENSURE ANY STATIC CHARGE ON THE TRANSPARENCY OUTER SURFACE IS DISCHARGED PRIOR TO COMMENCING WORK.

CAUTION...

Do not remove sealer below the level of the glass surface. Do not insert a knife or similar sharp object below the level of the glass; electrical cables may run immediately below the seal.

Notes...

(1) This procedure is applicable only to glass or glass-faced transparencies.

(2) For full details of glass transparency sealing, refer to the relevant Aircraft Servicing Manual.

20 The following compounds may be used to seal the transparency:

20.1 PR-1422-BT2 (33H/2203813) Sealer

20.2 PR-1422-½ (33H/2203110) Sealer

20.3 PR-205 (33H/2245082) Sealer

21

21.1 Remove the transparency from the aircraft as detailed in the relevant Aircraft Servicing Manual.

21.2 Clean the frame and glass transparency with white spirit (34D/9427564), then wipe dry with a clean cloth. Ensure all traces of old sealer are removed.

21.3 Apply a thin film of sealer to act as a parting agent, to the contacting edge of the glass and its mountings.

21.4 Remove any excess sealer.

21.5 Apply a heavy fillet of sealer (PR-205) to the cleaned frame, making sure to have an adequate amount of compound at any gaps or steps.

21.6 Press the glass transparency in position and tighten the mountings evenly. Use suction cups or C-clamps to hold the transparency in position.

21.7 Form a fillet with the excess sealer that extrudes from around the transparency. Ensure sufficient sealer extrudes to fill the gaps between the glass panel and the mountings.

21.8 Allow the sealer to cure in accordance with the times given in Fig 2.

21.9 Trim extruded compound flush on exterior surfaces.

Note...

Use a phenolic scraper for trimming the compound.

21.10 After trimming, wipe off excess amounts of sealer with a clean cloth soaked in white spirit (34D/9427564) then wipe dry with a dry cloth.

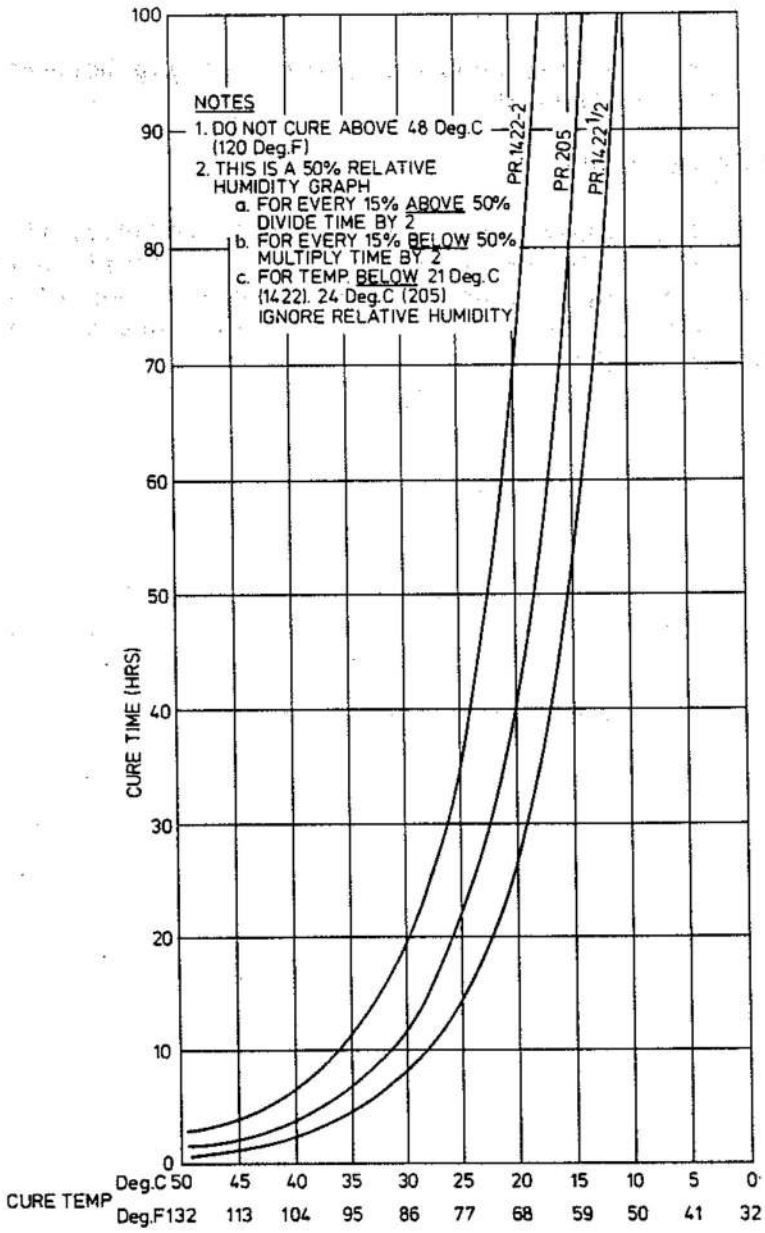


Fig 2 Sealer curing times

21.11 On transparencies that are not electrically heated, clean both surfaces with white spirit, and dry the surfaces with clean cloths. Extrude a flat ribbon of sealer, PR-1422-BT2, over the exposed vinyl edge of the bumper strip, and 1/8 in into the exterior glass.

21.12 On electrically heated transparencies, apply a bead of sealer, PR-1422-½, around the outer edge of each panel assembly where the centre vinyl panel and the outer glass panel are sealed together. The bead should not be more than 0.20 in wide and 0.06 to 0.12 in high. The seam of the two panels is approximately 1/8 in inside the window frame.

Note...

Ensure that the sealing compound covers the gap between the outer glass panel and the fuselage skin.

TRANSPARENCY THICKNESS TEST

22 On completion of a repair procedure on a transparency, the thickness of the transparency must be checked to ensure the structural integrity and optical quality of the transparency has not been detrimentally affected by the repair. The thickness is checked using a Schneider optical gauge (4A-5120-99-465-7756) or suitable technique.

Chapter 4-2

EMERGENCY REPAIRS

Introduction

1 The emergency repair of an aircraft transparency is specific to the aircraft application, therefore refer to the relevant Aircraft Servicing Manual for any emergency repair procedures. Under no circumstances should unauthorised emergency repairs be carried out. In cases of extreme emergency, local engineering management should seek the advice of the Engineering Authority.

2 Battle damage repairs (BDR), authorised by local engineering management may be implemented by reference to AP 101A-1500-0 or the Aircraft Servicing Manual, Topic 6c. They will only be carried out in combat conditions when BDR is specifically authorised.

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