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Standard Practice for Inspection of Transparent Parts by Prism[1]

This standard is issued under the fixed designation F2108; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

1. Scope

1.1 Aerospace transparencies undergo high stresses induced by flight, environmental, or other factors. The transparency attachment points are especially subject to fatigue. These areas of fatigue are often obstructed or hidden from normal inspection. An inspector, following the techniques described in this practice, shall use a prism to view damage located near transparency bolt holes, voids, and delamination that are hidden by edge strips or frames.

1.2 The purpose of this practice is to provide acceptable methods for performing prism inspections of transparent materials with specific emphasis on aircraft windscreens and canopies. Caveats and lessons learned from experience are included to assist authors in writing tailored inspection instructions for specific applications.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Terminology

2.1 *Definitions of Terms Specific to This Standard:*

2.1.1 *coupler, n*—a liquid refractive index-matching agent or wetting agent (for example, glycerol) used to create optical contact (coupling) between the prism and transparency.

2.1.2 *delamination, n*—the separation of a laminate into its constituent parts. An edge delamination is open to the laminate's free edge. An internal delamination is contained within the laminate.

2.1.3 *edge attachment, n*—the means of fastening the side edges of a transparency to the aircraft structure. Edge attachments also include expansion joints and any other connection between the transparency and the aircraft structure.

2.1.4 *prism, n*—a transparent optical element with polished plane faces for the entrance and exit sides. Prisms use refraction or internal reflection or both to change the direction of the propagation of light.

3. Summary of Practice

3.1 Prism inspections shall be performed with the aid of a prism and a wetting agent. The wetting agent is between the prism and transparency to ensure good visibility. The examiner looks through the prism to see the area of the transparency below the prism. The exam is best done without bright sunlight, which causes glare. The examiner changes his angle of view and inspects the area seen in the prism. A trained eye can detect anomalies such as cracks, delaminations, and voids.

4. Significance and Use

4.1 Prisms are useful tools for viewing areas otherwise obstructed or hidden from normal viewing. For example, transparency bolt holes, voids, and delaminations that are covered by edge strips or frames can be seen through a prism. The prism, once put against the transparency, with a coupling agent to wet the surfaces, allows viewing of the area below where the prism is placed.

5. Apparatus

5.1 *Prism*—Material shall be of the same hardness as or softer than the transparency to avoid scratches. The angles of the prism shall be set so as to maximize the viewing area. In the case of a complex shape, the position of the inspector's head and potential interference problems shall be considered to ensure the inspector can look through the prism at the proper angles. A typical prism is a 30º–60º–90º triangle, although the prism does not need to be triangular; a simple rectagon shape is also suitable.

5.2 *Flashlight*—A high output, halogen bulb works best.

5.3 *Cover*—To allow the inspector to shade the inspection area if the inspection is done in bright sunlight.

6. Reagents

6.1 Use glycerol (USP Grade) as a coupler or wetting agent.

[1] This practice is under the jurisdiction of ASTM Committee F07 on Aerospace and Aircraft and is the direct responsibility of Subcommittee F07.08 on Transparent Enclosures and Materials.

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6.1.1 The wetting agent shall not harm the transparency (for example, cause crazing), shall be clear, and shall have a high enough viscosity to stay in place reasonably well.

6.2 Use distilled water.

7. Procedure

7.1 Use methods shall be approved by the procuring agency or parts manufacturer. One example is to use a water rinse to clean the area of the transparency thoroughly where the prism will be placed. Assure the prism is also clean. Any debris will cause scratches to the delicate optical surfaces.

7.1.1 Clean the prism with standard optical cleaning solutions appropriate for the material from which it is made. See Note 1.

7.2 If using glycerol, store it in a cool dry place, such as a refrigerator designated for chemicals, so it will be thicker. Apply several drops of coupler to the side of the prism that goes against the transparency. Ensure there is enough coupling between the prism and transparency to allow a good viewing area. (**Warning—**Do not allow the prism to slide along the transparency with no wetting agent between them or scratches will occur.)

7.3 The prism is placed on the transparency and the viewing area location as shown in Fig. 1. When moving the prism along the transparency use light pressure. Do not allow the glycerol to get on the viewing surface of the prism, as it will smear the viewing area.

7.4 A coupler is required to provide an optical path between the prism and canopy. Placing small amounts (several drops) of coupler on both the canopy and the prism tends to work best. Glycerol is a good coupler. The coupler material shall be compatible with the transparency material, the clearer and the more viscous the better. Gentle pressure between the prism and canopy keeps air out of the coupler and allows the coupler to spread farther. See Note 2.

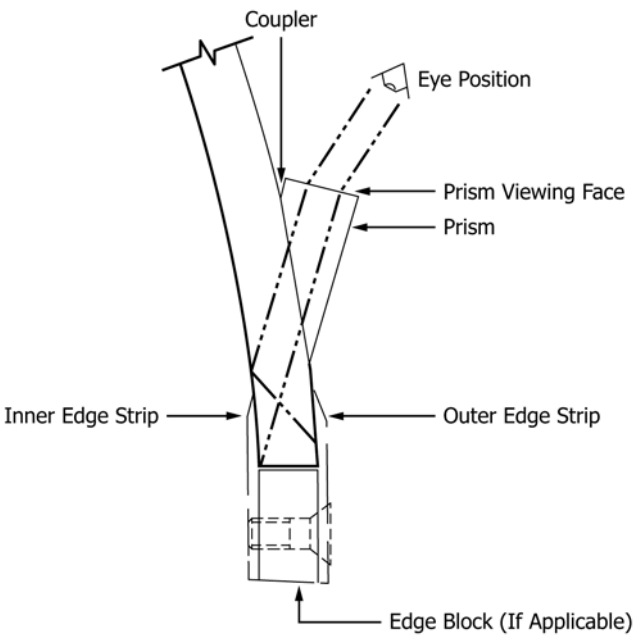

FIG. 1 Typical Prism Angles (Side View)

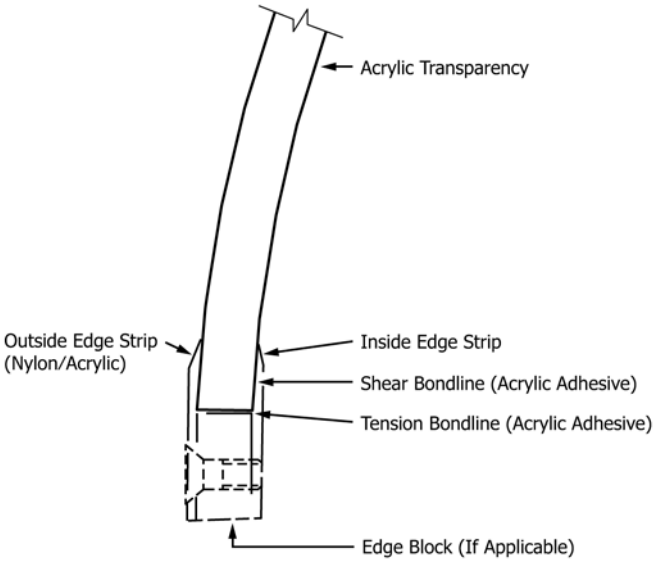

FIG. 2 Standard Nomenclature

7.5 Gently press the prism (of appropriate size and shape, as described below) to the transparency. Alter the pressure on the prism corners to remove any trapped air. To keep the prism clean, the least amount of glycerol shall be used. Hold only the edges of the prism and use gentle pressure. (**Warning—**If the coupler gets onto the viewing face of the prism, the area of interest will be blurred. Keep the prism's viewing face clean.)

7.6 A light source, such as a flashlight aids in optical clarification. This inspection technique does not work well in bright sunlight. Bright sunlight causes glare that clouds the viewing area. The inspection works best at night while using a flashlight.

NOTE 1—Any debris will cause scratches to the delicate optical surfaces.

NOTE 2—Using too much coupler will make cleanup more difficult and make it difficult to keep the prism viewing area clean.

7.7 Look through the top of the prism to view the area of interest. The prism shall be moved up or down to get the viewing area to the proper depth. When looking through the prism, change the angle of view (left to right). Begin to move the prism along the area of interest. Continue looking through the prism, altering angle of view. If an air bubble gets trapped between the prism and transparency, gently rock the prism to completely wet out the surface of the prism and transparency. If more glycerol is needed, lift the prism and add glycerol or add glycerol just in front of the prism so the prism will slide over the glycerol.

7.8 Look through the viewing area of the prism. If the view does not contain the area of interest, the prism shall be lifted slightly or moved side to side. If the area of interest cannot be brought into sight, alter the prism dimensions. Fig. 1 illustrates how the inspector's eye is able to see into the transparency. If the view is hazy, try shading the area. If the view is dark, use

a flashlight. Note, the angle of view and the angle of the flashlight shall be varied to obtain the best combination for each inspection.

7.9 After inspecting the area in sight, move the prism as required to view the entire area of interest. Add glycerol to the prism or transparency or both as needed.

7.9.1 Photographs shall be taken through the prism view to aid in documentation of findings.

8. Guidelines for Interpreting Findings in the Prism View

8.1 *Bolt Hole Inspections*—Bolt holes shall be inspected for radial cracks, inner layer delamination, and the height of a bolt hole relative to any edge strips. Figs. 3 and 4 show examples of how areas over bolt holes can look.

8.2 *Crack Inspections*—Cracks can originate from bolt holes or where edge strips/edge blocks meet the transparent portion of the transparency. Cracks, by definition, have a physical gap between the two halves. If a crack occurs while wet installing a fastener, then sealant can fill the crack. Sealant in a crack will show up as the sealant color or a brownish color. If the crack occurs after the sealant is dry or not in the vicinity of an uncured material, then the air in the gap will make the crack look opaque. Occasionally, the striations and crack direction can be seen while looking through the prism. Fig. 5 shows a side view of cracks stemming from a bolt hole. Fig. 6 shows a prism view of a crack.

8.3 *Delamination Inspections*—In multiple-layer transparencies, delamination resulting from drilling operations can be detected. Inner layer delamination can occur in monolithic materials. Because of the air gap between inner layers, the delamination appears cloudy in the prism view.

8.4 *Void/Resin-Rich Inspections*—If an edge strip is bonded to the transparency, the potential for voids and or resin-rich areas exists at the bondline. Voids and air bubbles appear clear or cloudy while resin-rich areas are dark as shown in Fig. 7. Voids, air bubbles, and resin-rich areas block the view behind it and thus break up the edge strip pattern. Fig. 8 shows both a resin-rich area (on the edge strip) and an air bubble (at the edge block bondline). Note that in Fig. 8 the resin-rich area is darker than the air bubble and that the edge strip pattern is slightly visible behind the resin-rich area but not at all visible below the air bubble. Also, the outline of the prism is seen at the edges of the figure.

8.5 *Dimensional Tolerances*—If inspecting a new transparency, a prism can assist in determining if the correct dimensions were met. For example, if the canopy is drilled and fastened to its frame in one operation, the distance from a bolt hole to the top of the edge strips on both the inside and outside can be measured. Or, if a butt block is used, the prism

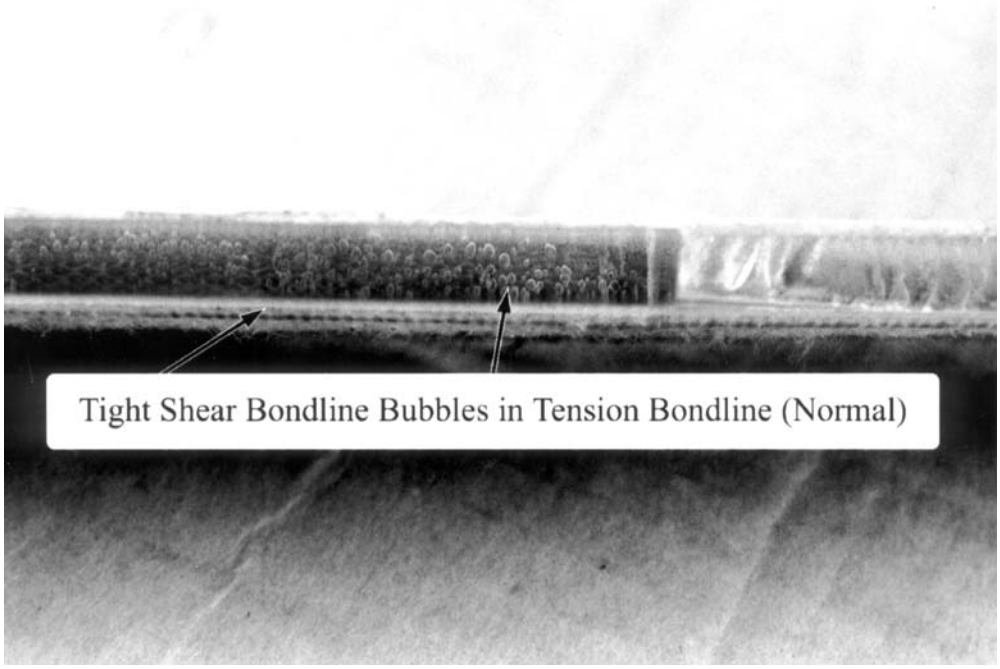

FIG. 3 Acceptable Air Bubbles (from Resin Curing)

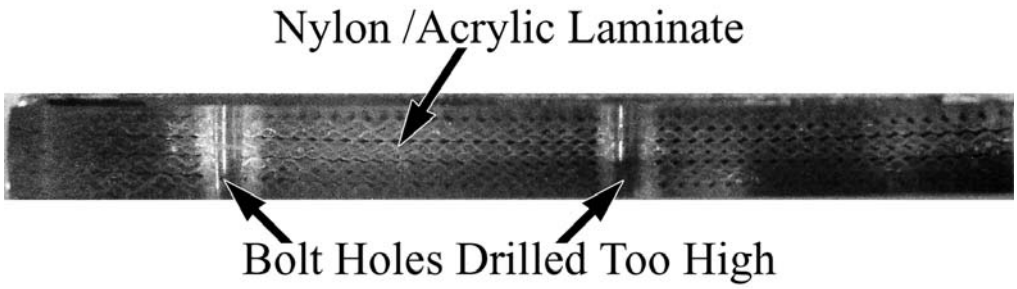

FIG. 4 View of Bolt Holes in a Nylon/Acrylic Edge Block

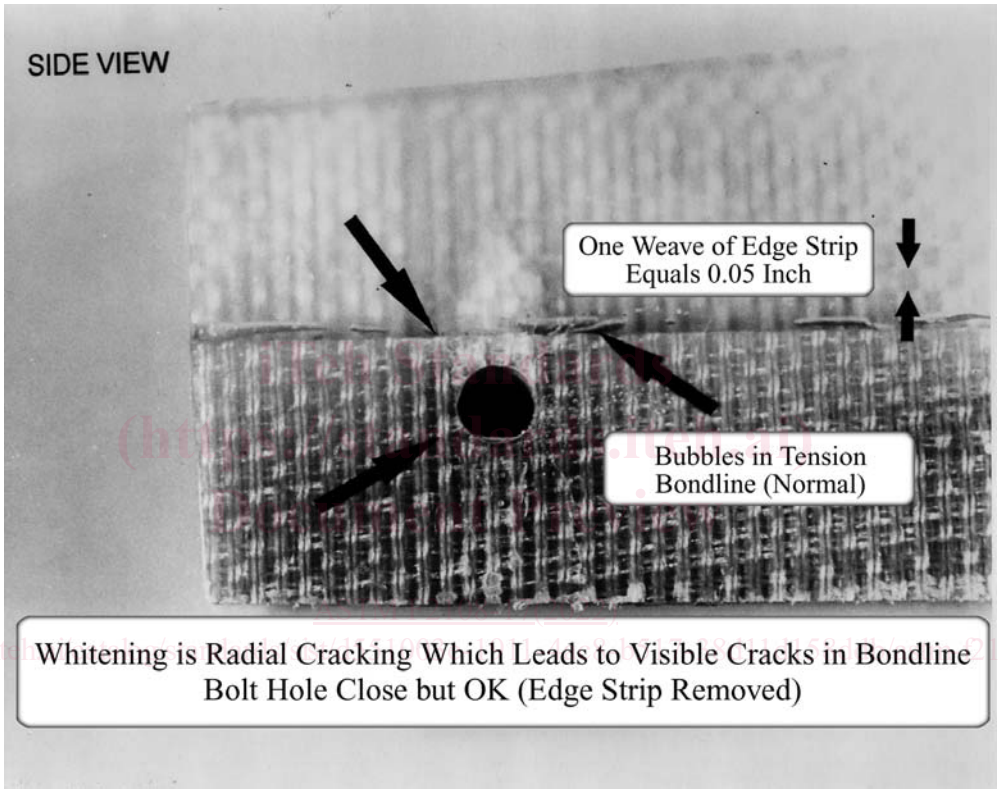

FIG. 5 Cracks Stemming From a Bolt Hole (Side View)

inspection can assure the butt block's alignment relative to the transparency and edge strips.

8.6 *Bondline Thickness*—Though the bondline thickness of a clear resin between two clear laminates cannot be easily distinguished (if at all), the bondline thickness between reinforced members of the transparency can be distinguished. For example, if both edge strips and an edge block are used, the bondline between them (appearing clear) can be determined. Also, if it were imperative for the bondline thickness to be known for a hidden area (optically noncritical), it is possible to add a dye to the resin to give a distinction between it and the laminate.

8.7 *Other Anomalies*—When comparing new transparencies versus in-service transparencies, new transparencies are typically clearer. As the transparency ages, certain areas tend to get a whitening effect. The whitening can be a result of environmental conditions such as UV exposure and thermal cycling. The whitening is an indication the transparency is weakened. Fig. 9 shows whitening at the top of an edge strip.

9. Finding Interpretations

9.1 *Flaw Size*—The length of flaws is true as viewed in the prism. The prism skews the height of flaws. To determine the flaw height, the flaw size shall be compared to something of known height. For instance, if an edge block is in the prism view, the actual height of the edge block to the apparent height gives the ratio required for determining the flaw height. Also, if the edge strip has a weave pattern of known height, this known height is also of use for flaw size computation. For bolt