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Standard Practice for Polarized Light Detection of Flaws in Aerospace Transparency Heating Elements[1]

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INTRODUCTION

Electrically conductive coatings used in aerospace transparencies for heating purposes may contain flaws resulting from imperfections of materials, imperfections of manufacturing techniques, handling damage, or contamination. Flaws may develop before, during, or after coating and processing and usually appear as hairline cracks, scratches, or pin holes. When these flaws are of sufficient size, hot spots can occur as a result of disruption and concentration of the flow of electrical current adjacent to the flaws. These hot spots may result in reduced service life of the transparency. Hot spot flaws in the transparency may also produce undesirable temporary distortion of vision during powered operation of the heater and permanent vision distortion after repeated cycling of the heater.

Polarized light is widely used to detect electrically conductive coating flaws during aerospace transparency processing.

1. Scope

1.1 This practice covers a standard procedure for detecting flaws in the conductive coating (heater element) by the observation of polarized light patterns.

1.2 This practice applies to coatings on surfaces of monolithic transparencies as well as to coatings imbedded in laminated structures.

1.3 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.4 *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 and health practices and determine the applicability of regulatory limitations prior to use.* For specific precautionary statements see Section 6.

2. Terminology

2.1 *Definitions:*

2.1.1 *transparent conductive coating*—a transparent thin film of electrically conductive material such as gold, stannous oxide, or indium oxide applied to plastic or glass which, when bounded by connecting bus-bars energized by electricity, becomes a resistance type heating element.

2.1.2 *electrically conductive coating flaw*—an electrical discontinuity in the coating, caused generally by coating cracks, pin holes, fine threads, scratches, and so forth.

3. Summary of Practice

3.1 Flaws in electrically powered conductive coatings produce local concentrations of current, which result in temperature gradients and stresses. Since glass and plastic transparencies are birefringent when stressed, flaws can be detected by optical methods, and in this case by the use of polarized light.

3.2 This practice consists of directing polarized light through a heated transparent test specimen and reading the transmitted light with a polarizing screen or filter. Diffracted light from the region of the flaw will become visible, in the form of a brighter or more intense local image, usually shaped like a butterfly.

4. Significance and Use

4.1 This practice is useful as a screening basis for acceptance or rejection of transparencies during manufacturing so that units with identifiable flaws will not be carried to final inspection for rejection at that time.

4.2 This practice may also be employed as a go-no go technique for acceptance or rejection of the finished product.

4.3 This practice is simple, inexpensive, and effective. Flaws identified by this practice, as with other optical methods,

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are limited to those that produce temperature gradients when electrically powered. Any other type of flaw, such as minor scratches parallel to the direction of electrical flow, are not detectable.

5. Apparatus

5.1 The elements of the apparatus are detailed below in their physical relationship as shown in Fig. 1. The minimum size and spacing of the elements of the apparatus are determined by the size and curvature of the part. The size of light source, light diffuser, and polarizing screen shall be large enough so that every portion of the electrically coated area of the test specimen is in the light path and is uniformly back-lit. If the test specimen is curved severely, its position may have to be adjusted during inspection so that the light path is within 20° of normal to the location being viewed. Since specimen size and curvature vary considerably, a dimensionally fixed standard is not given.

5.2 The apparatus, in the order of assembly, consists of the following:

5.2.1 *Uniform Light Source,* such as a bank of fluorescent lamps.

5.2.2 *Translucent Light Diffusion Plate,* such as milk-white glass located so as to provide a uniform light distribution.

5.2.3 *Polarizing Screen,* which converts the diffused light to polarized light.

5.2.4 *Transparent Dust Shield* (optional).

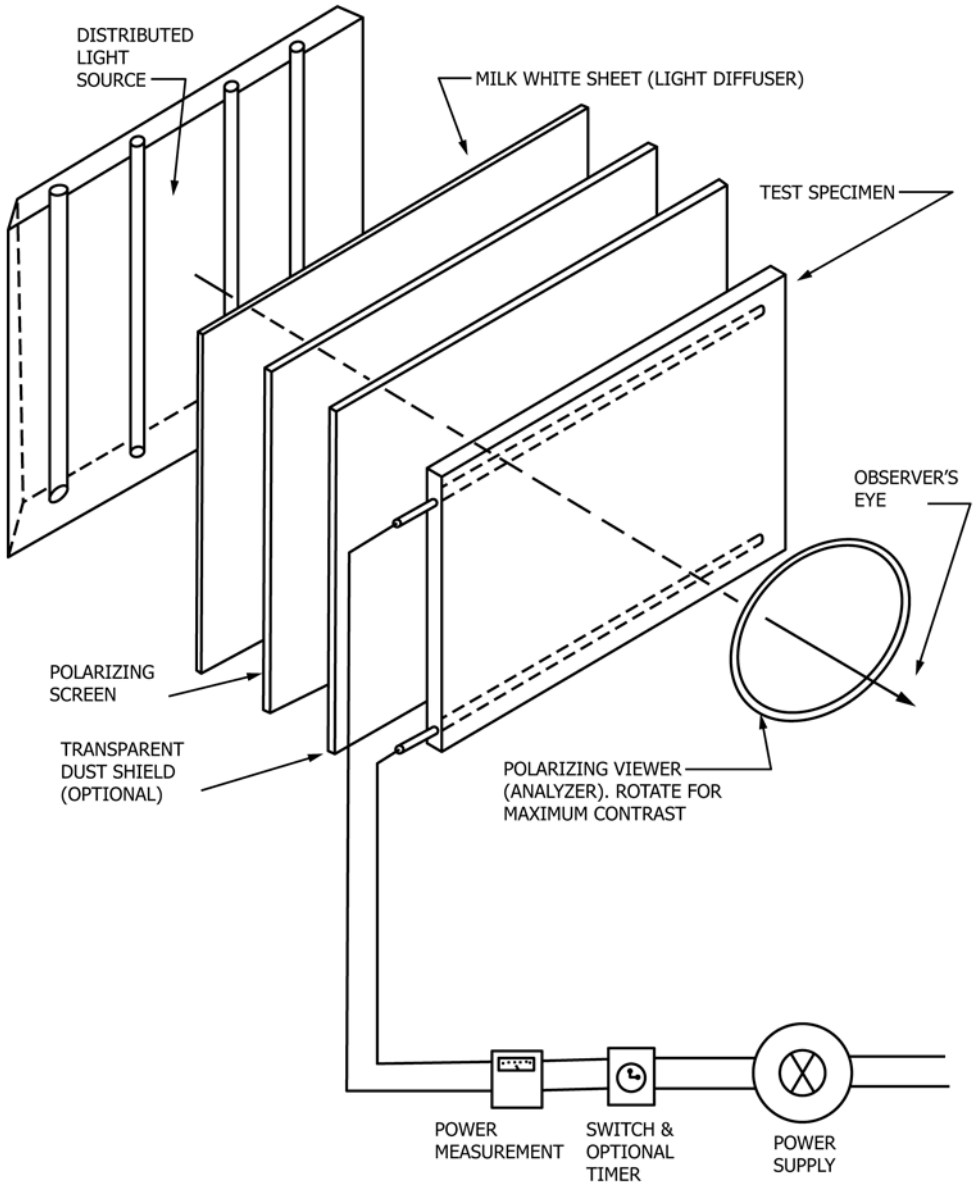

FIG. 1 Typical Arrangement for Polarized Light Method

5.2.5 *Support* for the specimen.

5.2.6 *Polarizing Viewer,* hand-held or mounted so it can be rotated to give maximum contrast as an analyzer.

5.2.7 *Electrical Power Supply,* regulated.

5.2.8 *Timer,* for controlling power application.

5.2.9 *Meters,* for measuring power input to heater element.

6. Safety Precautions

6.1 This practice may require application of high voltages. Exercise precautions to prevent direct or indirect exposure of test personnel to terminals, test leads, and so forth.

6.2 Wear protective glasses to prevent damage to eyes by flying glass particles which may be generated by shattering from thermal shock or handling when glass parts are tested.

7. Sampling

7.1 When specified for use as a final acceptance procedure, all deliverable electrically heated transparencies will be tested in the final laminated condition for heater element flaws.

7.2 Heater elements may be tested prior to lamination of the assembly to screen out defective or marginal electrical conductive coatings.

8. Test Specimen

8.1 The test specimen shall be a full-size monolithic or laminated part as specified in drawings that detail materials and dimensions. The test specimen shall be complete and full scale with respect to contour, conductive coating, deletion lines, bus-bars, temperature sensing elements, electrical connections, and any other permanent electrical functional parts or elements affecting the electrical flow direction or magnitude anywhere within the active portion of the conductive coating.

8.2 The test specimen need not have final fabrication details such as reinforcement bonding, trimming, drilling of edges, and so forth, provided that the incomplete fabrication does not affect the heating pattern and maximum temperatures of the electrically conductive coating.

8.3 The final inspection of a laminated part shall be conducted only when all elevated temperature adhesive and cure cycles have been completed and the part temperature has returned to ambient room temperature.

9. Preparation of Apparatus

9.1 Install the test specimen in relation to the test apparatus as shown in Fig. 1. Position the specimen so that it is parallel to the polarizing screen.

9.2 Connect the power leads to the specimen.

9.3 If the part is severely curved, make provisions for adjustment of the part relative to the polarizing apparatus such that the viewing angle does not deviate more than 20° from normal to the surface of the uniform light source diffuser plate.

10. Procedure

10.1 Turn on the polarized light source.

10.2 Visually survey the test specimen at a distance of 1.5 m, using the polarizing viewer to determine defect patterns that exist before power is applied. Mark all defect locations. The object of this step is to record defects that are unrelated to the energized conductive coating.

10.3 *Power Application*—With the specimen stabilized at room temperature, apply the minimum voltage levels defined below for a period required to achieve a visually identifiable pattern of flaws. Apply voltage suddenly, by closing a switch. Do not use a gradual change in voltage.

NOTE 1—Care should be taken to limit application time to prevent overheating, which could occur in a few seconds.

10.3.1 For electrically conductive coatings on plastic materials, apply a minimum of 110 % of the nominal design voltage.

10.3.2 For electrically conductive coatings on glass, apply a minimum of 125 % of the nominal design voltage.

10.3.3 Alternative voltage levels and power-on times may be as specified by contractual documents.

10.4 Watch through the viewer for flaws, which appear during the power cycle as intense and localized areas of light or shadow. Rotate the viewer for maximum contrast.

NOTE 2—The flaws are most pronounced immediately after the application of power. Flaws, depending on cause, produce star, cross, or butterfly-shaped light patterns. The highest practical electrical power level produces the strongest image.

NOTE 3—Preliminary experimentation with instrumented specimens containing typical flaws may be required to establish the power levels and durations required for maximum image strength without overheating.

11. Interpretation of Results

11.1 After application of power and when viewed from the eye position, record every flaw that appears in the primary viewing area (as defined by the part drawing).

11.2 If an eye position is not defined, view the entire heated area from a distance of approximately 1.5 m. Mark all flaw locations and describe them by size, shape, and location.

12. Report

12.1 When required by the customer, a report shall be prepared for all specimens considered satisfactory for further processing or delivery.

12.2 The report shall be a record showing the locations, sizes, and shapes of all minor heating element flaws that appeared during power application. The dimensional record may be a drawing, a photo of the marked up specimen, or a photo of the specimen under lighted conditions. The report shall include a record of the setup, test procedures, test equipment used, and any other data required to confirm the use of appropriate equipment and procedures and all data required for verification of the quality of the part.

13. Precision and Bias

13.1 No statement is made about either precision or bias, since the result merely establishes the detection of flaws without specifying an acceptable criteria.

14. Keywords

14.1 coatings; conductive coatings; heating elements; polarized light; polarized light inspection