CEMENTING OF OPTICAL ELEMENTS

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SUMMARY

1. This instruction details the method of cementing optical elements. The cementing will be done by instrument artificers and instrument technicians in RCEME workshops.

TD 9034 (6710)
HQ 6980-1

DESCRIPTION

2. The optical cement is a thermosetting synthetic resin made by mixing styrene-polyester adhesive with tertiary butyl perbenzoate catalyst. Polymerization action is accelerated immediately upon mixing the adhesive and catalyst. This results in a gradual thickening of the solution until it has solidified into a hard, transparent, and tenacious substance.

3. Each package of cement contains a 4-oz bottle of adhesive and a glass vial of catalyst. The bottle and the vial each have metal foil-lined screw caps to permit unused portions of the adhesive and catalyst to be stored without danger of being contaminated by dust or lint.

4. Uncatalyzed cement may be stored for approximately 18 months at an average room temperature of 70 to 75 deg F without signs of deterioration. Polymerizing action may be greatly retarded by storage at average temperatures of 40 to 50 deg F.

5. Mixed cement should not be kept longer than 30 days at any temperature.

EQUIPMENT AND MATERIALS

6. The following is a list of equipment and materials needed to cement optical elements:

Equipment

Stock Number	Designation
8020-21-106-6068	BRUSH ARTISTS, sable hair, 3/8-in by 1/16-in
8020-21-106-6071	BRUSH ARTISTS, sable hair, 9/16-in by 3/32-in

Equipment (Cont'd)

Stock Number	Designation
6640-102-3125	BURNER, alcohol, 1/2 pt
4K 306732	DISH, baking pyrex, round 1 1/2 qt
8415-21-103-8355	GLOVES, cloth, work type, asbestos
8415-21-103-8435	GLOVES, rubber, work type, men's
6H 300003	HOT PLATE, electric, 3 stage
3W 35250	OVEN, thermal, drying, electric
6H 306717	THERMOMETER, self-indicating, 30 to 730 deg F
6H 307347	TONGS, flask, 9-in

Materials

1H 50	ACETONE, industrial
8040-00-266-0828	ADHESIVE, synthetic resin, optical, thermosetting
2H 309209	CLOTH, cotton, cheese cloth
8305-21-102-9082	CLOTH, glass, 38-in
6810-21-103-7647	ETHYL ALCOHOL-METHYL ALCOHOL mixture
21 GM 1-900	OLEUM RICINI (castor oil)
2H 311318	PAPER, asbestos, 18-in x 1/32-in thick
6760-101-9015	PAPER, mounting, photographic album, black, 18 x 24-in
6H 310506	ROD, glass, 4 ft length, 5mm dia

METHOD

7. A definite sequence of operations must be followed when cementing optical elements to ensure successful bonding of the glass surfaces.

Matching of Optical Surfaces

8. To eliminate edge separations and air bubbles in the cement only those optical elements which have well matched surfaces should be cemented. The optical surfaces are matched if they create a regular colour pattern when brought into contact with each other and a slight pressure exerted. This is indicated by the contour of the rings and/or bands produced by the interference colours in the thin air film between the surfaces. Perfectly matched surfaces will show one solid colour of even intensity over the entire area. Flat surfaces are matched if the colour bands are straight, parallel, and extend to the extreme edges; spherical surfaces are matched when the pattern is circular and concentric.

9. The formation of the pattern from the edge toward the centre indicates a low surface. Formation of the pattern in the centre and diminishing in sharp contrast toward the edge indicates a high surface. Matched spherical surfaces which show not more than 3 rings high nor more than 15 rings low and matched flat surfaces which show a regular pattern and parallel bands are acceptable for cementing. Deviations from these patterns indicate irregularity of one or both surfaces.

10. The irregular element can be detected by noting which surface the irregular pattern follows when one element is repositioned over the other. If the pattern remains fixed it belongs to the stationary element and vice versa.

11. The use of monochromatic light from a sodium arc or helium tube intensifies the contrast of the interference colour bands and enables easier observations.

Cleaning of Optical Surfaces

12. The surfaces of optical elements must be thoroughly cleaned with authorized cleaning solvents prior to cementing as the presence of a microscopic film of oil or grease will reduce adhesion.

13. Place the elements in a tray containing the cleaning solvent. A piece of cheese cloth should be placed in the tray to prevent scratching the polished glass surfaces. Leave the elements in the cleaning solvent for a few minutes, then remove with suitable tweezers and dry thoroughly with lint-free material. Use optical linen and tissue to obtain final cleaning. Place the cleaned element on a piece of clean paper in a desiccating jar until ready to apply the cement. Avoid touching the polished surfaces of the elements with the fingers during the cleaning process.

Preparation of Cement

14. Optical cement will set at normal room temperature and for this reason it should be prepared only when required.

15. To prepare the cement add the catalyst to the adhesive and mix thoroughly by stirring with a glass rod. The glass vial contains the proper amount of tertiary butyl perbenzoate to catalyze the entire 4-oz of styrene-polyester adhesive.

16. When the amount of cement to be prepared is less than the 4-oz unit the ratio will be fourteen drops of catalyst to one ounce of adhesive. It is imperative to mix small quantities in glass bottles fitted with glass stoppers or metal, foil-lined, screw caps. The cement will dissolve many types of plastic caps and become contaminated.

17. Cement which becomes contaminated through solvent action, ingress of dust, lint or other non-soluble materials should be disposed of immediately.

Application of Cement

18. The lens phase will be used to describe the application procedures and with slight modification this procedure will also be used for prisms.

19. Place the clean, dry, concave element on a sheet of photographic black paper or equivalent, with the concave surface upward. Remove any dust specks which may have settled on the polished surface, by means of a clean water-colour brush.

20. Apply a few drops of cement to the centre of the concave surface with a clean glass rod. Ensure that the convex surface of the matching element is clean and then place it on the cement-laden concave surface. By means of a cork stopper or rubber-tipped pencil, apply a light downward pressure to spread the film evenly between the elements. A slight rotary movement of the top element may be required to obtain an even bubble-free film. Care will be taken not to use a lateral movement where the top element moves beyond the rim of the lower concave surface as this will scrape off some of the cement film and start a run over the edge of the lens.

21. Wipe excess cement from the edge of the elements using a piece of soft lint-free cloth dampened slightly with alcohol. The wiping cloth should be sufficiently moist to remove the excess cement but not wet enough to permit seepage. Lateral movement of the elements must be avoided while cleaning the edges. If the surface being cemented is exposed to the alcohol enough cement film may be removed to make it uneven, thereby causing edge separation during the polymerizing cycle. Extreme care is necessary to prevent the alcohol penetrating the cement film.

22. The elements will be mounted in suitable holding fixtures or jigs to correct and maintain their alignment before being polymerized.

Polymerization by Baking

23. Place the mounted elements upon a suitable plate or pyrex glass sheet covered with soft paper. Place the plate in a levelled electric oven at room temperature, set the oven control to approximately 150 deg F, and switch on the oven. Ensure that the oven temperature never exceeds 175 deg F during this stage. When the cement has set firm enough to prevent slippage of the top element, switch off the oven, remove the components and make any necessary final alignment of the elements.

24. Place the cemented elements in the oven once again and slowly raise the temperature to 212 deg F. Maintain this temperature for 16 hours then permit the oven to cool slowly to room temperature before removing the components from the oven.

25. Jigs or holders may be removed from the components after 6 hours of baking without danger of shifting the elements or breaking the cement bond. Care must be taken however to ensure that the full polymerization cycle time of 16 hours at a temperature not lower than 212 deg F is adhered to.

26. It is essential to prevent any sudden change of temperature which may cause thermal shock to the optical elements through all stages of polymerization by baking.

SEPARATION OF CEMENTED ELEMENTS

27. Separation is accomplished by producing thermal shocks and results in a very low percentage of breakage when the techniques are adhered to strictly. Two methods of separation are described in this manual. The castor oil method which is suitable for all components and the flame method which is restricted to certain sizes and types of components.

Castor Oil Method

28. Place a quantity of spun glass cloth or equal in the bottom of a pyrex baking dish into which a quantity of castor oil has been poured.

29. Place the cemented components in the dish ensuring that the crown lens is down and that all components are completely covered with castor oil.

30. Heat the castor oil uniformly to a temperature of 450 deg F and hold at that temperature until the cement fractures enough to allow separation. An indication of this is a fern-like pattern or diffraction rings. In some cases the top element will slide partially off the lower element.

31. Using preheated tongs remove the components from the castor oil, place the lens in a wooden holder and apply pressure with a wooden stick to separate the lenses. Obstinate cases will require longer heating periods and several attempts at separating.

32. Slowly cool the elements between several layers of dry cheese cloth to prevent contact with drafts.

33. Remove the castor oil from the elements with soft absorbent cloth. Remove the cement film with acetone by submerging the elements in the solvent and scrubbing them with a swab of cheese cloth.

Flame Method

34. The flame method is restricted to cemented areas not exceeding 2-in in diameter with normally long radii or flat surfaces. Cemented short radii present too great a glass thickness differential over the lens diameter thereby increasing the possibility of breakage.

35. Place the cemented component on a hot plate covered with a 1/32-in thickness of asbestos paper. Raise the hot plate temperature to 400 deg F and maintain this temperature until a fern-like pattern or diffraction ring is clearly visible.

36. Grasp the lens firmly with preheated laboratory tongs. Pass the hot lens slowly through an alcohol burner flame. Make ten passes through the flame with the convex element down, then ten with the convex element up. Continue this operation until the cement starts to separate, then grasp each element with gloved hands and force the elements apart.

37. The elements may also be separated by inserting a heated, sharp, knife edge in the groove between the cemented elements and applying a light pressure. Do not use the knife point as it invariably produces chips in the perimeter of the concave surface.

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