Application Note B-223

Instructions for Bonding Flat and Contoured PhotoStress® Sheets

Successful PhotoStress® analysis requires that PhotoStress plastic coatings be properly installed on the surface of the test part. Coating application is best accomplished in a reasonably clean area with ambient temperatures between 65° to 85°F [18° to 29°C]. Precautions should be taken to avoid or minimize:

- direct sunlight or direct radiant heat
- extreme drafts of hot or cold air
- dust or particle contamination
- moisture (rain or direct spray)
- contaminants in general

The following procedures and techniques present an organized approach that will lead to a successful coating installation. Less thorough approaches can sometimes yield satisfactory results; however, for consistent success the instructions offered here are recommended and satisfy conventional application requirements. Successful installation can be divided into four operations:

- Coating Preparation
- Surface Preparation
- Adhesive Preparation
- Bonding Procedures

2.0 Coating Preparation

Flat sheets would normally be selected for use when coating flat surfaces. Curved surfaces normally require that soft, partially polymerized sheets first be "contoured" to the curved surface and then be allowed to fully polymerize while on the surface of the part. The coating preparation comments included in this section address these fully polymerized contoured sheets, as well as flat sheets. Detailed instructions for "contouring" are presented in Application Note IB-221.

The basic objective in preparing coatings is to fit them to the test part by:

- matching the edges of the coating to the boundaries of the test part.

- providing holes to accommodate bolts, rivets, etc. in the test part

- planning the location of seams (or junctures) between adjacent plastic sheets

2.1 Matching the Edges of the Coating to the Boundaries of the Test Part

As illustrated in Figures 1 and 2, coatings should be applied with an edge that matches, and is perpendicular to, the boundary of the test part. This is particularly important around holes, or any discontinuity where stress concentrations normally occur. Accurate test information cannot be obtained unless these edge conditions are achieved.

Figures 3 and 4 illustrate two beveled-edge options for use when the plastic coating does not reach the edge of the test part.

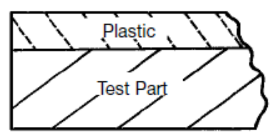


Figure 1. Edge of coating matches edge of test part.

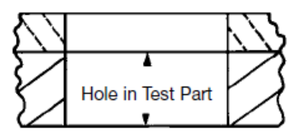


Figure 2. Coating over hole; size and shape matched, plastic perpendicular to boundary.

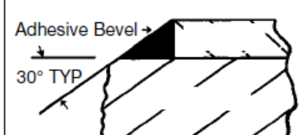


Figure 3. Coating perpendicular to adhesive bevel.

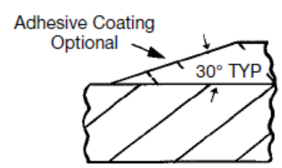


Figure 4. Coating beveled (particularly recommended for Type PS-1 Coating).

2.2 Providing Holes to Accommodate Bolts, Washers, Rivets, etc. in the Test Part

Coatings should not come into contact with bolts or rivets. Clearance holes in the coating should be approximately 1/8 in [3 mm] or greater in *diameter* than the rivet or bolt head. Figure 5 illustrates the installation around a preinstalled rivet. Also, clearance holes are needed if the coating is applied before bolts or rivets are assembled. In these cases, the clearance should be sufficient to insure that tools used to assemble the bolts or rivets do not contact the coatings.

Instructions for Bonding Flat and Contoured PhotoStress® Sheets

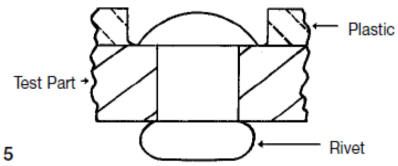


Figure 5

Important Note: If the plastic coating comes into contact with any moving part, such as a bolt or rivet, high-order color fringes will appear at these locations. These fringes indicate stresses in the plastic ***coating***, not in the structure.

2.3 Locating Seams (Junctures) between Adjacent PhotoStress Plastic Sheets

Most coating applications require more than one sheet, and it is important to plan seam locations between adjacent sheets. Properly prepared seams cause little disturbance in the photoelastic pattern; however, it is prudent to locate seams in regions removed from suspected high-stress areas. For example, when coatings are installed over holes, as illustrated in Figure 2, it is desirable to locate seams one diameter or more away from the hole boundary.

Fillets, welds, and inside corners should generally be considered as high-stress locations and, when practical, seams should be avoided in these areas. When it is necessary to run seams through fillets, welds, or intercept a hole boundary, the seam should traverse the area as near to perpendicular as practical. Figure 6 illustrates a seam arranged to cross perpendicular to a fillet and intercept a hole normal to its boundary.


Figure 6

2.4 Tools and Methods Used to Machine PhotoStress Plastic Coatings*

Saber saws, coping saws, hand drills, abrasive paper, and hand routers are common hand tools normally used to machine and trim plastic coatings to the geometries discussed in ***Sections 2.1***, ***2.2*** and ***2.3***.

*Cutting, abrading, routing, etc. of plastics can generate dust. Proper ventilation and dust-filter masks are recommended to provide protection from inhaling fine airborne particles.

There are two general approaches:

- cut and trim the edges of the coating to extend slightly beyond (1/32 in [1 mm]) the boundary of the part and then bring them to size after the coating is bonded to the part.
- accurately scribe the part boundaries on the coating and trim to size before bonding

Both approaches are valid and the decision is normally based upon practical and cost (time) considerations. In either case, the objectives are to accomplish the desired geometry without chipping or cracking the coating, and to do so without introducing residual fringes.

2.4.1 Sawing

A saber saw is commonly used for cutting plastic coatings (see Figure 7). The desired shape can be traced on the protective coating supplied on all flat sheets. The paper also protects the sheets from scratches.


Figure 7

Flat sheets and contoured sheets are readily trimmed with a saber saw. Thinner sheets are cut more effectively with a fine blade (24 teeth per inch), and a coarse blade (14 teeth per inch) is recommended on thicker sheets. Acceptable cutting requires a sharp blade and a slow, steady, and uninterrupted feed. Interrupting the feed can cause rubbing (localized over-heating), which frequently leads to unwanted residual fringes. Rubbing can also occur when saber saws are used to cut extremely sharp radii and the trailing edge of the blade contacts the coating. Sharp radii may require material removal using other tools. A model maker coping saw with a deep throat is useful in such cases.

Thicker sheets may require that a cooling air jet be directed at the saw blade. Even the low-modulus sheets plastic, Type PS-4, can be cut on a saber saw, providing that the protective paper coating has not been removed.

For contoured sheets made from Type PL-3 liquid plastic, several layers of masking tape should be applied to both sides of the sheets to aid cutting with a saw. Tape is also a desirable addition to other contoured sheets, as it reduces unwanted chipping when cutting with a coping saw or a saber saw. As with saber saws,

Instructions for Bonding Flat and Contoured PhotoStress® Sheets

the coping-saw blade should have 14 to 24 teeth per inch. Coping saw cuts are most effective with slow steady strokes in one direction. Back-and-forth sawing can cause heat to build up and produce undesirable edge birefringence.

When sawing plastic coatings to fit different edges and boundaries, it is generally preferred to saw the coating slightly oversize (1/32 in [1 mm]) and then trim to the final shape using files, abrasive paper, or a hand router. Type PS-4 sheets, and contoured sheets of Type PL-3 liquid plastic, can also be cut with a sharp pair of scissors.

2.4.2 Filing and Sanding

A set of coarse, medium and fine files including flat, round, half-round, and rat-tail geometries are extremely useful for finish trimming. While Standard American patterns are effective, the set should also include Swiss needle files for use when matching intricate fillets and radii. Abrasive paper (50, 80, and 120 grit) is equally useful for finishing work.

Filing and abrasive paper yield best results using slow steady strokes, in one direction, with moderate to light pressure. Filing or abrading coatings that are already bonded to the part must be done very carefully in order to avoid damage or delamination of the adhesive interface. Cuts or strokes can be parallel to the coating edge; however, ***never*** stroke in a direction moving from the part towards the bonded coating.

Filing and abrading Type PS-4 and PL-3 sheets is generally less than satisfactory, and final edge preparation is better accomplished using routers.

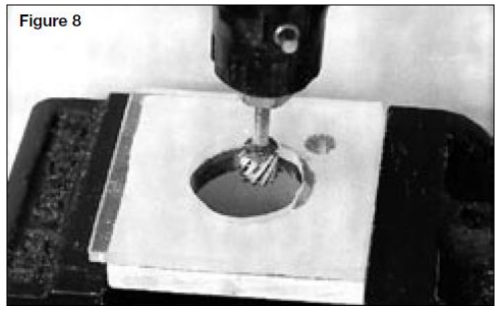
2.4.3 Routing

When flat plastic coatings are to be trimmed and bonded to flat test parts, it is reasonable to consider high-speed routers. This approach is particularly effective when trimming Type PS-1 sheets. Hand-held routers can also be used to trim. Figure 8 shows a metal burr in a small hand-held router. Double-sided tape is sufficient to hold the coating to the test part during routing. Routing can also be accomplished after the coating has been bonded to the part. In either case, it is advisable to precut an undersized hole before routing to the finished size. The router axis should be normal to the surface and best results are obtained using short strokes and very light pressure. Do not take deep heavy cuts. Stone grinder burrs are not recommended — use medium to coarse metal burrs.

2.4.4 Drilling

Drilling is best accomplished on a mechanical drill press using sharp bits, and a coolant when possible. Relatively

Figure 8



high speed and slow feed is a good general rule. The bit should be backed out of the hole frequently to clear the chips and avoid unnecessary friction. A drill press may be convenient for flat sheets; however, irregularly shaped contour sheets can make the drill press impractical.

Since the epoxy sheets are brittle, the drill bit will have a tendency to cause chipping or cracking when it breaks through the underside of the sheet. Chipping at break-through can be minimized by supporting the sheet on scrap plastic (or wood) and letting the drill bit pass through the sheet directly into the support material. The spinning bit should not be allowed to sit in the hole, as this normally produces heat and unwanted edge fringes.

It is generally preferable to drill a small undersized hole and then finish the hole size by filing, sanding, or routing. For larger holes, it is convenient to thread a saber saw blade through a small drilled hole. The larger hole can then be sawed, slightly undersized, and then finished using files or abrasive cloth.

2.5 Cleaning

After the plastic has been machined to its final shape, it must be thoroughly cleaned to be compatible with the cleaned surface of the test part. The cleaning procedure requires saturating a gauze sponge with the *recommended* solvent (see below).

Wipe the coating surface clean, and then dry with clean gauze. This procedure should be repeated several times to ensure that all traces of grease and dirt have been removed.

Both sides of the various coating materials should be cleaned with the solvents recommended as follows:

- **PS-1, PS-4 and PL-3**— Degrease and clean these sheets with *isopropyl alcohol only*. Do *not* use any other solvent on these materials.

- **PS-3, PS-10, PL-1, PL-2 and PL-10** — Degrease and clean these sheets with isopropyl alcohol, acetone, or other suitable solvents.

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3.0 Surface Preparation

The intent of surface preparation is to develop a chemically clean surface with a roughness sufficient to promote good adhesion. This process normally requires:

1. solvents for degreasing
2. abrading
3. conditioning
4. Neutralizing

Surface preparation is most effective when performed 30 minutes or less before bonding.

As in any cleaning activity, safety must always be a prime consideration. Surface preparation should be conducted in accordance with rules and regulations established by either the operator's organization or by the Occupational Safety and Health Administration (OSHA). Clearly, surface preparation of toxic materials such as beryllium, lead, etc. should be approved by the safety officer of the establishment before commencing with cleaning and preparation. Further, it is important to provide adequate ventilation, particularly when preparing and cleaning surfaces in confined quarters.

The following instructions should be carefully followed using degreasers supplied by the user, and Metal Cleaner and Neutralizer 5A supplied by Micro-Measurements.

3.1 Steels, Iron, Aluminum, Titanium, and Metals in General

A. Degreasing and Preliminary Cleaning

The surface to be coated should be cleaned by washing it down with acetone, isopropyl alcohol, or other suitable solvents. Vapor degreasing or hot-solvent dipping may be convenient for larger parts. The processes or solvents should be compatible with the material being cleaned and not leave detrimental residue.

In order to obtain a close fit between the contoured plastic coating and the test part, it is necessary to treat the surface to be coated prior to contouring the soft plastic. If the structure is cast, forged, welded, or painted, remove all foreign matter such as paint, scale, rust, oxide or weld spatter. This should be done by hand or disc sanding, grit blasting, wire brushing or any other convenient method. Rough initial degreasing is recommended. Final cleaning will be done prior to bonding the fully cured plastic coating.

B. Abrading and Conditioning

Surfaces already sand blasted or disc sanded (Step A) should not normally require extensive additional abrading. In fact, sand or grit blasting is a very cost-effective procedure for producing the desired surface texture. This is particularly true when preparing large surface areas. In these instances, it is sufficient to condition the surface by lapping lightly with abrasive paper* (120 to 220 grit) wetted with Conditioner A. After the surface has been lapped, it should be washed with Conditioner A and wiped dry. Paper towels or gauze sponges are convenient for washing and drying. Washing and drying should continue until the towels or sponges are no longer discolored when the Conditioner A is wiped dry. Conditioner A should not be allowed to dry on the surface. Take care not to drag contaminants in from the boundary of uncleaned areas.

C. Neutralizing

Wet paper towels or gauze sponges with Neutralizer 5A and scrub the cleaned area. Keep the area wet and do not allow the Neutralizer 5A to dry. Dry the wetted area with clean towels or gauze sponges, taking care not to drag contaminants into the cleaned area.

3.2 Magnesium

A. Degreasing and Preliminary Cleaning

Thoroughly wash the surface with isopropyl alcohol or other suitable solvents. Vapor degreasing or hot solvent dipping can be used, as long as the processes and solvents are compatible with magnesium and leave no detrimental residue.

B. Abrading

Do not use Metal Cleaner on magnesium. Lap the surface with abrasive paper or Scotch Brite wetted with Neutralizer 5A. Do not allow the Neutralizer 5A to dry during lapping. Air abrasion is not recommended for magnesium.

C. Neutralizing

The entire abraded surface should be washed clean and wiped dry using Neutralizer 5A. Washing and drying should continue until the towels or sponges are no longer discolored by drying. Dry by wiping from the cleaned area toward the uncleaned areas.

3.3 Brass, Bronze, Copper and Copper-Based Alloys, Manganin, and Phosphor Bronze

A. Degreasing and Preliminary Cleaning

Thoroughly wash the surface with isopropyl alcohol or other suitable solvents. Vapor degreasing or hot-solvent dipping can be used, as long as the processes and solvents are compatible with the material being cleaned and leave no detrimental residue.

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*Scotch Bright® (product of 3M) is an effective substitute for abrasive paper.

Instructions for Bonding Flat and Contoured PhotoStress® Sheets

B. Abrading and Conditioning

Abrade the surfaces with abrasive paper (120 to 220 grit) or Scotch Brite wetted with Conditioner A. It should not be allowed to dry on the surface and the entire surface should be washed and dried after abrading. Continue washing and drying until the paper towels or gauze sponges are no longer discolored by drying.

C. Neutralizing

Do not use Neutralizer 5A on these materials. Wash the surface with paper towels or gauze pads wetted with isopropyl alcohol and then rinse with distilled water and wipe dry. Take care not to drag contaminants into the cleaned area.

3.4 Plastics

Plastics vary widely in their reactivity to the solvents normally used for surface preparation. If compatibility cannot be established by testing on a disposable sample of the plastic, then the manufacturer of the plastic should be consulted. Further, some plastics (Teflon®, polycarbonates, etc.) are difficult to bond to and, again, the plastic manufacturer may recommend a presurface treatment which will promote adhesion to the adhesives common to PhotoStress coatings. For most plastics, prepare and clean the surface as follows:

A. Degreasing and Preliminary Cleaning

Wash and wipe dry using isopropyl alcohol.

B. Abrading and Conditioning

Abrade the surface with abrasive cloth (120 to 220 grit) wetted with Conditioner A. It should not be allowed to dry on the surface and the entire surface should be washed and dried after abrading. Continue washing and drying with it until the paper towels or gauze sponges are no longer discolored by drying.

C. Neutralizing

Wash the surface with paper towels or gauze sponges wetted with Neutralizer 5A and then wipe dry. Take care not to drag contaminants into the cleaned area.

3.5 Concrete, Bone, and Other Porous Materials

The following procedure should also be used to prepare a porous surface for the contouring operation, if required.

A. Remove dust and residue with gauze saturated with acetone, isopropyl alcohol, etc.

B. Repeat Step B several times until all traces of dirt are removed.

C. Allow surface to dry thoroughly.

D. Apply PhotoStress adhesive, making sure to fill in open pores and to provide a smooth surface. (Type PC-10 adhesive works well.)

E. Let adhesive thicken (20 minutes), then scrape away excess. Allow the filler adhesive to cure.

F. Abrade filler adhesive layer smooth, then wash and dry with isopropyl alcohol.

G. The surface is now ready for bonding.

3.6 Rubber and Other Elastomeric Materials

See ***Section 7.0***, "Bonding PS-4 PhotoStress Plastic Sheets to Rubber" on page 9.

4.0 Adhesive Preparation

Preparation of the adhesive for bonding the plastic sheets to the test part requires very careful attention. First, be sure that you choose the appropriate adhesive for the type of plastic being applied (see PhotoStress® Coating Materials, Document 11222).

These adhesives are two-component types consisting of resin and hardener, which must be mixed together in the proper proportions. (Resin-hardener ratios and other useful data are shown on the Adhesive Preparation Chart on page 6).

The amount of adhesive required for a given area must be calculated in advance. For bonding flat sheets, 1 gram of mixed adhesive will sufficiently cover a 1-1/2 in2 [10 cm2] area. (For example, bonding a flat 10-x-10-in [254-x-254-mm] sheet requires about 66 grams of adhesive.)

When evenly spread on the surface, a quantity using this 1 gram per 1-1/2 in2 ratio, will produce a layer approximately 0.034 in [1 mm] thick. Then, when the sheet is applied, excess adhesive will be squeezed out, leaving a final layer about 0.003 to 0.010 in [0.1 to 0.25 mm] thick, depending on the uniformity of the part surface. When bonding contoured sheets, more adhesive per in2 area should be applied.

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Some adhesives require pre-heating prior to mixing, while others are mixed at room temperature (see chart below). After adding the correct amount of adhesive hardener to its resin, the components must be mixed thoroughly with a glass rod or wooden mixer until a non-streaking, homogenous mixture is attained. The required mixing time is usually three to five minutes, after which the adhesive is ready to use. The pot life of any batch depends on its volume. Pot life can be extended by pouring and spreading the mixed adhesive onto a clean flat surface.

5.0 Bonding Procedures

5.1 Flat Sheets

A. Masking tape, applied approximately 3/16 in [5 mm] from the sheet boundaries, will afford a clean and neat adhesive boundary. Pour the mixed adhesive onto the cleaned test part surface and spread it over the entire surface with a brush (Figures 9 and 10). Brushing is best accomplished with a mildly stiff brush, which serves to wet (or paint) the surface as well. The adhesive layer should be at least 1/32 in [1 mm] thick.

B. Carefully position the flat sheet and allow one edge to contact the spread adhesive (Figure 11 on next page). Press down on the contacting edge with moderate finger pressure and slowly work additional contact toward the opposite edge. This technique will allow air to flow out along with the excess adhesive. After full contact is made, additional finger pressure should be applied. Start near one edge and slowly progress across the sheet to bleed additional adhesive from beneath. Repeat this several times, taking care to brush excess adhesive in contact along all edges of the sheet (Figure 12 on next page). This boundary of excess adhesive will prevent air entrapment after finger pressure is released. Do not attempt to squeeze all adhesive from beneath the sheet. Adhesive thickness of 0.003 to 0.010 in [0.1 to 0.25 mm] is typical.

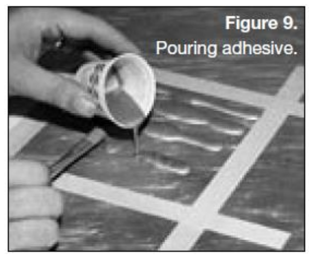
Figure 9. Pouring adhesive.

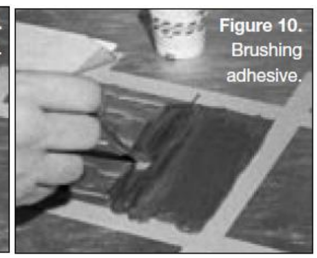
Figure 10. Brushing adhesive.

Adhesive Preparation Chart				
Adhesive Resin Type	PC-6	PC-10	PC-11	PC-12
Hardener Type	PCH-6	PCH-10	PCH-11	PCH-12
Component Handling Data				
Amount of Hardener Required (pph)*	100	15	150	100
Preheat Resin to °F [°C]	110 [45]	Room	110 [45]	90 [32]
Preheat Hardener to °F [°C]	110 [45]	Room	120 [50]	90 [32]
Mixed Adhesive Data				
Pot Life after Mixing** (In minutes, based on 30 grams)	30	10	30	30
Cure Time (Hours)**	24	4	24	30
Cure Temperature °F [C°]	Room	Room	Room	Room
Elongation After Cure (%)	50	3	>50	>50
E After Cure 1000 psi [GPa]†	30 [0.2]	450 [3.1]	1 [0.007]	1 [0.007]
Use With Plastic Types	PS-3 PL-2	PS-1 PS-10 PL-1 PL-10	PS-4 PL-3	PS-4

* Parts per hundred by weight.
** Cure time and pot life are longer at lower temperatures and shorter at higher temperatures.
† Typical.
Note: Supplemental instructions for each type adhesive are provided with the adhesive package.

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If the sheet tends to float or move from the intended position, it can be lightly tacked in place with masking tape.

C. After all of the excess adhesive is squeezed out, apply a thin coating around all edges of the plastic (including holes that may have been drilled) to provide a seal against moisture absorption. It is at this point that the adhesive bevel — if used — can be initiated (see Figures 3 and 12).

D. If plastic has been bonded to overhead or vertical surfaces, it can be held in place with masking tape or other pressure-sensitive tape.

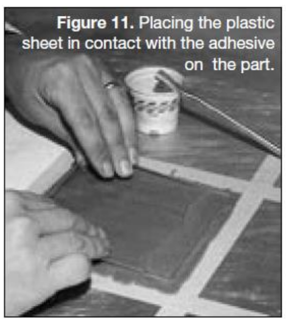

Figure 11. Placing the plastic sheet in contact with the adhesive on the part.

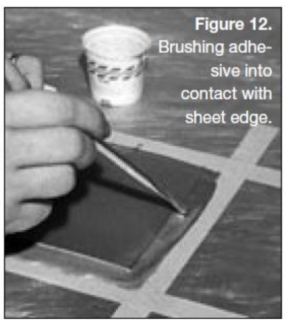

Figure 12. Brushing adhesive into contact with sheet edge.

E. Allow the adhesive to polymerize until it thickens and tends to hold its shape, then reconstruct the adhesive bevel (Figure 12). Remove the "glueline" masking tape around the edges of the plastic coating (laid down during the bonding preparation phase). This will leave a neat adhesive line around all the edges of the coating. All traces of adhesive on the outer surface of the coating *must* be removed at this time. Gauze sponges wetted with the appropriate solvent (***Section 2.5***) are recommended.

F. Allow the adhesive to cure in accordance with the time given in the Adhesive Preparation Chart on page 6.

5.2 Contoured Sheets

The procedures used to bond flat sheets are, in general, applicable when bonding contoured sheets. However, the geometric complexity of many contoured sheets requires additional considerations and slightly modified procedures.

A. When bonding contoured sheets, the initial adhesive layer should be approximately 1/16 in [1.5 mm] thick. On vertical surfaces, the adhesive has a tendency to run, and bonding the contoured sheet should take place immediately after the adhesive has been spread.

B. Flat sheets are more easily deformed during bonding (Figure 11) than contoured sheets. However, the concept of making adhesive contact first at one edge and then slowly working towards full adhesive contact remains the same. Figure 13 shows a complex part with adhesive in place for bonding two adjacent contoured sheets. Edge contact has been made for the first contoured sheet. Figure 14 shows the first sheet in place, with finger pressure being applied to bleed out excess adhesive. The second contoured sheet is applied in a like manner.

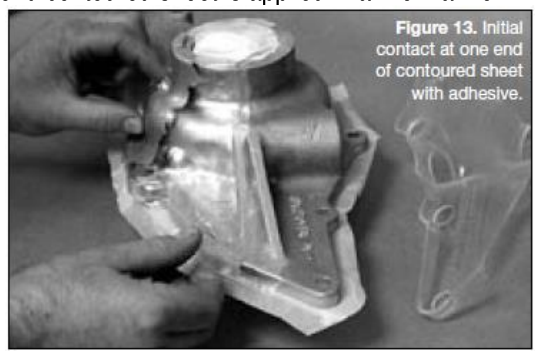

Figure 13. Initial contact at one end of contoured sheet with adhesive.

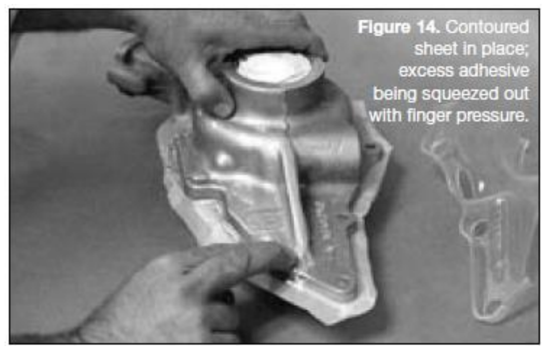

Figure 14. Contoured sheet in place; excess adhesive being squeezed out with finger pressure.

5.3 Seams Between Adjacent Sheets

Disturbances of the PhotoStress pattern can occur at seams or junctions of adjacent sheets (see ***Section 2.3***). This effect is greatly reduced by filling the seams with adhesive. Filling the seams is easily accomplished on flat horizontal surfaces and is well worth the minor effort required during bonding.

On vertical surfaces, fresh adhesive applied to seams will run, and filling the seams this way is not practical. However, fresh adhesive can be poured onto a clean, flat surface where partial curing will occur. When the adhesive becomes slightly pasty it can be worked into the seams.

Instructions for Bonding Flat and Contoured PhotoStress® Sheets

6.0 How To Remove PhotoStress Plastic Coatings

After strain measurements are made, the test part may need to be restored to its original state for other uses. Three basic methods of removing the coating — listed in order of the physical effort required to accomplish the task — are: chemical, thermal, and mechanical. Other factors which affect selection of the coating-removal method include the size and mass of the test part, and the material from which it is made. If, for example, the material will be harmed by heat or by strong solvents, mechanical methods may be dictated. The same may be true if the test part is a stationary object, or is too large and heavy for heating or solvent immersion.

6.1 Chemical Methods — Solvents, Epoxy Strippers

When feasible, leaving the coated part submerged overnight in a solvent such as methylene chloride will remove both the coating and adhesive. For this method to work most effectively, bond failure between the coating and part should be initiated at several points along the edge of the coating to let the solvent attack the adhesive.

Chemical coating removal is ideal for restoring calibration beams because it cleans the beams in a single, effortless operation without damaging the surface or changing the thickness. Other small, highly finished parts can easily be cleaned in the same way. The following should be remembered, however, when using solvents: 1) they are volatile; 2) they can irritate the skin, and rubber gloves should be worn; and 3) they can be very harmful if splashed into the eyes. The user should always read caution labels for flammability and toxicity information.

6.2 Thermal Methods

Short of burning it off, heat alone will not remove the plastic coating. But, the coating can be scraped, pried and pulled off more easily when heated to proper temperature. At temperatures in the range of approximately 200° to 300°F [100° to 150°C], the coating can be peeled off in strips, with the help of a scraper (Figure 15), and the adhesive will generally come away with the coating. If the temperature is too low, excessive effort will be required to lift the coating. If too high, the coating will deteriorate and crumble instead of peeling off cleanly. The suitable temperature for coating removal can be detected by probing the adhesive at the edge of the coating while it is being heated. When the adhesive softens, it is time to begin lifting the coating.

Small coated parts, particularly of metal, can be heated very effectively in an oven or on a hotplate. In the case of large, immobile test objects or parts made of materials that cannot be heated to the required temperatures (some plastics, for example), heat can be applied locally, and primarily to the coating, with a heat lamp or heat gun. With this procedure, it is best to begin heating at a corner or free edge. Then, when the coating and adhesive can be lifted easily from the part, the heat can be applied just ahead of the work area while continuing to lift and pry with the scraper. Because this part itself has not been heated, this technique will frequently require finish cleaning of the surface by mechanical or chemical means. Reheating the adhesive will facilitate surface cleaning if mechanical methods such as wire-brushing are used.

Figure 15. When heated, coating lifts cleanly and easily with a scraper.

6.3 Mechanical Methods

When all else fails, the coating can always be removed by chipping, sand blasting, or grinding. The coating is quite brittle, and cracks readily when struck with a hammer (at room temperature or below). Once a crack or hole has been introduced, chipping with a chisel (or other pointed tool) and hammer will remove it. It is necessary to use a face shield when chipping, because pieces of the coating fly off in small, sharp fragments. Since the chipping method usually mars the surface and leaves residual adhesive on the part after the coating is removed, subsequent sanding or chemical cleaning may be necessary to restore the original surface condition.

7.0 Bonding PS-4 PhotoStress Plastic Sheets to Rubber

PhotoStress analysis of a test part made from a soft, compliant material such as rubber requires a special coating material and adhesive with low elastic moduli that is capable of high-elongation strain measurement. In addition, preparation and bonding procedures for coating installation on these types of materials require special attention.

Precast sheets of Type PS-4 coating material bonded with PC-12 adhesive are generally recommended for these types of test applications.

Instructions for Bonding Flat and Contoured PhotoStress® Sheets

PS-4 has an elastic modulus of about 500 psi [0.004 GPa], and is available in thicknesses ranging from 0.020 to 0.120 in [0.5 to 3 mm]. It has an elongation capability >40%, and is flexible enough to be shaped and bonded to most simple curved surfaces. PC-12 is a two component, high-elongation adhesive specially formulated for use with Type PS-4 coating material.

These instructions outline recommended procedures for bonding. Type PS-4 precast sheets to rubber test parts.

7.1 Surface Preparation

Proper cleaning of both the test part and the PS-4 sheet material are particularly important to achieve a strong bond.

7.1.1 Preparation of PS-4 Sheet

The Type PS-4 PhotoStress coating material must be thoroughly cleaned on its bonding side by wiping with a clean gauze sponge saturated with Neutralizer 5A. Alternately, isopropyl alcohol may be substituted for Neutralizer 5A, but the surface should be dried quickly to avoid prolonged exposure to the alcohol.

7.1.2 Preparation of the Rubber (Test Part) Surface

1. Wipe the bonding area and the surrounding region with a clean gauze sponge saturated with acetone. Repeat this procedure several times, using a clean gauze sponge each time, until all dirt, grease, and other surface contaminants have been removed.

2. Wipe the surface with a clean gauze sponge saturated with Neutralizer 5A. Dry the surface with additional gauze sponges, wiping only once through the cleaned area, and in a single direction, to avoid recontaminating the cleaned surface.

3. Place an infrared lamp 2 to 3 ft [600 to 900 mm] from the cleaned surface of the rubber and heat the surface to approximately +150°F [+66°C].

4. Prepare an initial mix of adhesive as follows:

a. Weigh out the required amount of PC-12 resin. As a guide, 1 gram of resin will provide enough adhesive to cover an area of about 2 in2 [2500 mm2].

b. Preheat the resin to approximately +90°F [+32°C], and then add an equal weight of PCH-12 hardener. Stir the resin and hardener thoroughly until completely mixed.

Note: During storage the hardener supplied with PC-12 adhesive may become paste-like or solid, and it must be re-liquefied before use by heating to +150°F [+66°C]. After it again becomes liquid, allow it to cool to +90°F [+32°C] before mixing with the PC-12 resin.

c. Brush a thin layer of the adhesive onto the heated rubber surface and cure at +150°F [+66°C] for approximately two hours until no longer tacky.

7.2 Bonding the PS-4 Sheet to the Rubber Test Part

1. After the precoat of adhesive has cured, maintain the surface temperature of the rubber at about +130°F [+55°C], and prepare another batch of adhesive as described in Step 4 of ***Section 7.1.2***. Mix enough adhesive to permit a liberal application.

2. Brush the second layer of adhesive over the initial (cured) layer, making certain that there is a generous coating of adhesive everywhere in the bonding area.

3. Carefully place the previously prepared sheet of PS-4 coating over the adhesive-coated rubber surface. Beginning at one end of the sheet, press in place with moderate finger pressure, and slowly work toward the other end. This technique will allow any air bubbles that form to flow out from under the sheet with the excess adhesive.

4. After the sheet is in place and the excess adhesive has been squeezed out, apply a thin coat of adhesive over all edges of the sheet to seal out moisture.

5. Remove the infrared lamp, and allow the sheet installation to cure at room temperature for a minimum of 30 hours. If necessary, pressure-sensitive tape can be used to hold the coating in position during the initial part of the cure. The tape should be removed after the first five hours of the curing time.

Note: PC-12 adhesive has an unopened shelf life of three months. ***The containers should not be opened until ready to bond the PS-4 sheet material to the test part.*** Once opened, the residual moisture from the air may cause the resin to become solid within eight hours, even if the containers are resealed. Once solid, the resin cannot be re-liquefied.

Instructions for Bonding Flat and Contoured PhotoStress® Sheets

Epoxy resins and hardeners may cause dermatitis or other allergic reactions, particularly in sensitive persons. The user is cautioned to: (1) *avoid contact with either the resin or hardener;* (2) *avoid prolonged or repeated breathing of the vapors;* and (3) *use these materials only in well-ventilated areas.* If skin contamination occurs, thoroughly wash the contaminated area with soap and water immediately. In case of eye contact, flush immediately and secure medical attention. Rubber gloves and aprons are recommended, and care should be taken not to contaminate working surfaces, tools, container handles, etc. Spills should be cleaned up immediately. For additional health and safety information, consult the Safety Data Sheet.

Refer to the literature below for detailed information on:

Tech Note TN-704, “How to Select PhotoStress Coatings.”

“PhotoStress® Coating Materials” (Document 11222).

Application Note IB-221, “Instructions for Casting and Contouring PhotoStress Sheets” (Document 11221).