Instructions for Using PS-6 Precast Plastic Sheets, PL-6 Liquid Plastic, and PC-9 Adhesive

1.0 Introduction

Type PS-6/PL-6 coating broadens the capability of PhotoStress® testing to elastomeric materials where strains up to 100% or more may occur. This coating is available in the form of precast sheets (designated PS-6) for use on flat or simply curved surfaces, and as a liquid (PL-6) for casting and contouring to surfaces with compound curvatures. Since the coating is extremely soft and pliable, there is minimal reinforcement of the object being tested. The compatible adhesive for the PS-6/PL-6 coating materials is Type PC-9. This coating system is generally preferred when strains are expected to exceed 30%. The PS-6/PL-6 coating material exhibits a strain optical coefficient "K" of approximately 0.0006 and has a nominal modulus of elasticity of 100 psi [0.0007 GPa] after one minute at constant strain.

Section 2 of these instructions deals with making contourable sheets from PL-6 Liquid Plastic, while Section 3 addresses bonding of both the PS-6 Precast Flat Sheets and PL-6 Contoured Sheets to test-part surfaces with PC-9 Reflective Adhesive.

2.0 Using PL-6 Liquid Plastic

PL-6 is a room-temperature-curing, two-component resin/hardener system for making contourable PhotoStress sheets. It is primarily used to coat polymers and other very high-elongation, low-modulus materials.

Because of its elastomeric properties, PL-6 is more difficult to work with than the other available PhotoStress coating materials. It is important, therefore, that the instructions given here be followed without exception in order to ensure success in casting contourable sheets. Should you have difficulty in handling the material, please call Micro-Measurements Applications Engineering Department for guidance.

1. ***Preparation of the Test Part for Contouring*** Before mixing and casting PL-6, the surface of the test part should be thoroughly cleaned, and then lubricated with mineral oil. This step will aid in the contouring operation after the semi-polymerized PL-6 sheet is removed from the casting plate. Specific procedures for cleaning the test-part surface will depend on the material composition of the part. For most elastomers, a simple washing with a mild solvent, such as isopropyl alcohol, may suffice. For general guidelines on test-part surface preparation, see Application Note B-221.

2. ***Preparation of the Casting Plate*** - For general familiarization on preparation of the casting plate, reference Section 2.0 in Application Note B-221.

Since PL-6 is a very low-modulus material, it presents some handling constraints when ready to be removed from the casting plate for contouring. To facilitate handling, the surface of the casting plate is covered with a thin sheet of Teflon® which serves as a carrier for the cast PL-6 material. Specific instructions follow:

a. Clean and level the Casting Plate per Application Note B-221.

b. Set the casting plate temperature controller to 130°F [54°C] at least 30 minutes before pouring the plastic.

c. When the set temperature is reached, apply the Teflon carrier sheet . The Teflon sheet is applied by positioning it at one end of the casting plate, and carefully smoothing it out using a gauze sponge.

Note: Do not attempt to apply the Teflon carrier sheet to an unheated casting plate, since large voids will appear upon subsequent heating of the plate.

d. Following application of the Teflon carrier sheet to the heated casting plate, assemble the Adjustable Snap-Together Frame on top of the carrier sheet. The inside frame dimensions should be at least 0.25 in [6 mm] larger on all sides than the dimensions of the required sheet.

e. Cover the casting plate assembly with the acrylic lid to protect the prepared surface from dust and other contaminants.

3. ***Preparation of the Plastic*** - If the PL-6 Resin and/or PLH-6 Hardener were kept refrigerated*, bring them to room temperature prior to opening the container. If the hardener was not refrigerated and/or has been stored for extended periods, it is important to check its appearance. If the hardener is cloudy or contains foreign particles, discard in favor of a new container free of such impurities. After extended storage periods (three months or longer), both the resin and hardener should be thoroughly stirred prior to mixing together.

The total amount of plastic required must be calculated in advance according to the size and thickness of the sheet to be cast. The total amount of plastic (resin plus hardener) is determined by:

W = 17.2 x A x t (English Units in inches)

[W = 105 x 10^{-3} x A x t (Metric Units in mm)]

where: W = the total amount needed in grams,

A = the area of the sheet to be cast (width x length),

t = the desired thickness.

Note: Plastic density = 17.2 gm/in^3 [1.05 x 10^{-3} gm/mm^3]

Example: To cast a sheet 7 in x 8 in x 0.10 in thick, the total amount of plastic required is:

W = 17.2 x [8 x 7] x 0.10 = 96 grams

Resin/Hardener Proportion - The amount of hardener required is calculated in parts per hundred, or "pph". In other words, 10 pph of hardener means 10 grams of hardener for 100 grams of resin. The hardener amount for Type PL-6 Plastic is 70 pph.

Continuing with the above example, if 96 grams of mixed plastic is required, the resin/hardener amounts are calculated as follows:

PL-6 Resin: 96 x 100 / 170 = 56.5 grams

PLH-6 Hardener: 96 x 70 / 170 = 39.5 grams

Note: PL-6 has a higher viscosity than the other liquid plastics, and will tend to cling to the inside wall of the cup; therefore, adding 10% of the weight to the resin and the hardener is recommended.

Weigh out the proper amounts of resin and hardener, in separate mixing cups, using an accurate scale (±0.01 gram). Six-ounce plastic-coated cups are recommended for mixing. Do not use wax-coated containers. Remember to account for the weight of the mixing cup when weighing. Prior to mixing, both the resin and hardener should be warmed to at least 125°F [52°C], but never higher than 135°F [57°C]. Warming will lower the viscosity of the resin and facilitate a more uniform mix with the hardener. As noted in Application Note B-221, the mold (casting plate) must be warmed to 130°F [54°C] for at least 30 minutes before pouring the plastic. This will allow the mixed plastic to flow properly after pouring.

Note: It is not necessary to weigh the material when using the PL-6 80-gram kit, since the exact proportions of both resin and hardener have been pre-weighed. To use the pre-weighed kit, the contents of the hardener are simply emptied into the resin container after warming.

Add the hardener to the resin and stir with a stem thermometer. It is very important to achieve a uniform mixture prior to pouring the resin on the casting plate. Stir slowly using small circular motions around the inside periphery of the mixing cup. The mixture will remain viscous and bubbles will most likely occur during the mixing process. (The bubbles can be eliminated later in the process.) As stirring continues, the temperature will drop slightly, and the viscosity may increase slightly. Continue stirring for five minutes, or until a clear non-streaking mixture is obtained, then pour the liquid plastic onto the casting plate.

When pouring into the mold, keep the cup as close as possible to the surface of the casting plate. Move the cup over the casting plate area to improve flow to all edges of the mold.

After completing the pour, the resin will begin to flow out and fill the mold. The stem thermometer may be used to help spread the resin evenly. Next, lower the casting plate temperature by readjusting the temperature control dial on the heat controller to 80°F [27°C]. Any small bubbles introduced during the mixing process will be evident on the top surface of the plastic. These bubbles are easily removed with the use of a hot-air gun or hair dryer. Direct the hot air onto the bubble formations until the bubbles disappear, then cover the mold with the acrylic cover to keep out dust and prevent humidity absorption. The approximate time for the cast PL-6 sheet to reach the contourable stage is one hour, depending on the cure environment, and the thickness of the sheet. A 0.12-in [3-mm] thick sheet will require about 45 minutes; thinner sheets will require more time.

4. ***Removing the Semi-Polymerized Sheet from the Casting Plate for Contouring*** - Remove the silicone rubber frame from around the cast plastic sheet with quick pulling motions. The sheet will be very soft and have a tendency to adhere to the silicone rubber if one attempts to remove the frame slowly. Do not use a slow, steady pull. One of the first indications that the plastic sheet is ready to be removed is the ease of separating the rubber frame from the sheet. Open one corner of the rubber frame and try to separate one frame member with a quick snapping movement. If the sheet clings to the frame, wait five more minutes and try again.

Lubricate hands, scissor blades, and the surface of the test part with mineral oil. Mineral oil must also be applied to the top surface of the plastic sheet. The sheet, on its Teflon carrier, can now be removed from the casting plate. If the part to be coated is a very complex, irregular shape, it may be necessary to cut the sheet into smaller pieces for contouring. Cutting is done with scissors while the plastic sheet rests on the palm of the hand with a Teflon carrier separating the hand from the plastic. In preparation for contouring, the "mineral-oil lubricated sheet" should be inverted and placed in contact over the surface area to be coated. The Teflon carrier sheet is then pulled away, and the contouring process can begin (See Application Note B-221, Section 6.0, for general instructions on contouring.) The time required for the contoured PL-6 sheet to fully cure prior to bonding is 12 hours.

Important Note: These instructions for using PL-6 apply for environmental temperature conditions between 70° to 75°F [21° to 24°C] only. Because PL-6 is exothermic, its polymerization time is shortened by higher temperatures and/or the casting thicker sheets. Thin sheets cast at lower environmental temperatures require longer polymerization times.

3.0 Bonding PS-6 Precast Sheets, and Contouring Sheets made from PL-6 Liquid Plastic, with PC-9 Reflective Adhesive

PC-6 is a two-component, room-temperature-curing low-modulus, high-elongation adhesive that has mechanical properties identical to the PS-6/PL-6 materials. Unlike other PhotoStress coating adhesives, PC-9 has the reflective additive incorporated into the hardener (PCH-9) rather than in the resin.

Note: During long-term storage, the hardener may become a pasty solid. To re-liquefy the hardener, simply heat to 150°F [66°C]. After it has reached the liquid state, it should be allowed to cool to 90°F [32°C] before mixing with the resin.

1. ***Surface Preparation of the Test Part for Bonding*** - Wipe the bonding area and surrounding region with a gauze sponge saturated with a solvent that is compatible with the test material. For most materials, isopropyl alcohol will suffice. Using a clean gauze sponge each time, repeat the procedure several times until all traces of dirt, grease, and other surface contaminants have disappeared.

Soak a clean gauze sponge with M-Prep Neutralizer 5A and swab the surface, then wipe the surface dry with a fresh gauze sponge. The cleaned test-part surface is now ready to accept the PC-9 Adhesive.

2. ***Surface Preparation of the PS-6/PL-6 Coating Material*** - PS-6 Precast Sheets are shipped with a protective paper coating applied to their surfaces. To prepare the sheet for bonding, the shape of the test-part surface can first be drawn on the protective coating, and then cut out with sharp scissors. Next, the adhesive paper can be removed, and the bonding surface cleaned by simply wiping with a gauze sponge saturated with isopropyl alcohol. Contoured sheets made from PL-6 Liquid Plastic are similarly degreased and cleaned with the alcohol. Do not use any other solvents to clean the bonding surface of the PS-6/PL-6 material.

3. ***Masking the Bonding Area*** - Place the cleaned plastic over the cleaned surface of the test part. Then, using masking tape, mask off an open space around the plastic, leaving about 1/4 in [6 mm] between the edge of the plastic and the tape. When the tape is removed after bonding, the procedure will leave a clean, neat glue line.

4. ***Adhesive Preparation*** - The amount of adhesive required must be calculated in advance. One gram of mixed adhesive will cover approximately a 1 to 1.5 in^2 [10 cm^2] area. No more than 100 grams of adhesive should be prepared per mix.

The resin-hardener proportion for PC-9 Adhesive is 90 pph hardener for 100 pph of resin. If, for example, a total amount of 100 grams of adhesive is required, the resin/hardener amounts are calculated as follows:

PC-9 Resin: 100 x 100 / 190 = 52.6 grams

PCH-9 Hardener: 100 x 90 / 190 = 47.4 grams

Note: PCH-9 Hardener, with its reflective powder additive, is prone to settlement during storage and should be thoroughly mixed in its original bulk container before dispensing.

The mixing container should be made of a disposable nonabsorbent material.

To facilitate mixing, preheat the PC-9 Resin and PCH-9 Hardener to approximately 90°F [32°C], then add the hardener to the resin and stir thoroughly using a wooden mixer until a homogeneous mixture is achieved. A minimum mixing time of 5 minutes is recommended. The pot life of mixed adhesive depends on the amount prepared; for a 50-gram mix, the pot life is approximately 30 minutes.

5. ***Bonding Procedure*** - Immediately after mixing, pour and brush the adhesive over the cleaned bonding area of the test part. Brush the adhesive in a uniform layer, approximately .031 to .063 in [0.8 to 1.6 mm] thick depending on the irregularity of the surface. Any adhesive left in the mixing container should be poured onto a clean paper towel and the mixing container discarded. This procedure will extend the pot life of the excess adhesive, since the mass is spread out over a larger area.

Carefully place the PS-6/PL-6 Plastic over the adhesive. Beginning at one end, press down on the plastic with moderate finger pressure and slowly work towards the opposite end. This technique will allow any air bubbles that form to flow out with excess adhesive. If air pockets return when finger pressure is relaxed, reapply pressure and brush additional adhesive along the edge of the plastic. After releasing the pressure, adhesive will flow in instead of air. A layer of adhesive approximately 0.003 to 0.005 in [0.076 to 0.13 mm] is optimum, although the actual thickness will vary according to the surface condition of the test part and complexity of the contour.

Important: After all of the excess is squeezed out, apply a thin coating of adhesive around all edges of the plastic (including holes that may have been introduced) to provide a seal against moisture absorption. Depending on the application, the coating may have a tendency to slide from its bonded position before the adhesive begins to set. This is particularly true when bonding coatings to vertical and overhead surfaces. In these situations, masking tape can be used to securely hold the coating in place.

The adhesive will become stiffer as it cures. After several hours, it will be about the consistency of putty. At this time, final adhesive bevels should be built around all edges of the plastic coating, and any remaining adhesive on the coating surface should be cleaned off using the isopropyl alcohol. The masking tape should also be removed and a final clean up made. After 24 hours of cure at room temperature, the part will be ready for testing.

Important Note: These instructions for using PC-9 apply for environmental temperature conditions between 70° to 75°F [21° to 24°C] only. Because PC-9 is exothermic, its pot life, working time, and curing time will be longer for lower temperatures, and shorter for higher temperatures.

PS-6/PL-6 Optical and Mechanical Properties

Strain Optic Constant (K-Factor): 0.0006 nominal; calibration required for precise value (see B-238)

Strain Optic Sensitivity Constant To: 90°F [32°F]

Elongation: >100%

Modulus of Elasticity (E): 100 psi [0.0007 GPa] after 1 min at constant strain

Transparency: Good. Will not appreciably darken with time.

CAUTION

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 these publications for detailed information on:

Tech Note TN-704, "*How to Select PhotoStress Coatings*."

Document 11222, "*PhotoStress Coating Materials and Adhesives*."

Application Note B-221, "*Instructions for Casting and Contouring PhotoStress Sheets*."

Application Note B-223, "*Instructions for Bonding Flat and Contoured PhotoStress Sheets*."

Application Note B-238, "*Calibration of Low-Modulus PhotoStress Coatings by Imposed Curvature*."

For applications involving special materials or unusual testing conditions, consult Micro-Measurements Applications Engineering Department.

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*Hardener should be stored at 40° [5°C].