Techniques for Bonding Leadwires to Surfaces Experiencing High Centrifugal Forces

Introduction

Strain gages are often used in the stress analysis of rotating components such as compressor and turbine rotors, drive shafts, wheels, gears, etc. On large or high-speed items, centrifugal forces may reach several hundred thousand times the force of gravity. As an example, the *g*-force at a 3-in (*75-mm*) radius on a component rotating at 50 000 RPM is over 200 000g. The graph below is provided to estimate *g*-force.

In strain gage applications subjected to such high centrifugal forces, it is important not only to properly bond the strain gage, but also to adequately secure the leadwires to avoid damage to the gage. The operating temperature range and other environmental factors also influence leadwire, solder, anchoring and protective coating selections.

For long-term applications with operating temperatures between –100° and +400°F (–75° and +205°C), and in short-term applications with operating temperatures up to +500°F (+260°C), M-Bond GA-61 is the recommended adhesive and coating material. M-Bond AE-10 or AE-15 may be substituted for GA-61 when operating temperatures will not exceed –100° to +200°F (–75° to +95°C).

The various installation accessories referred to throughout this Application Note are Vishay Micro-Measurements Accessories, listed in our Strain Gage Accessories Data Book and available directly from Vishay Micro-Measurements.

Leadwire Bonding Procedure

Step 1

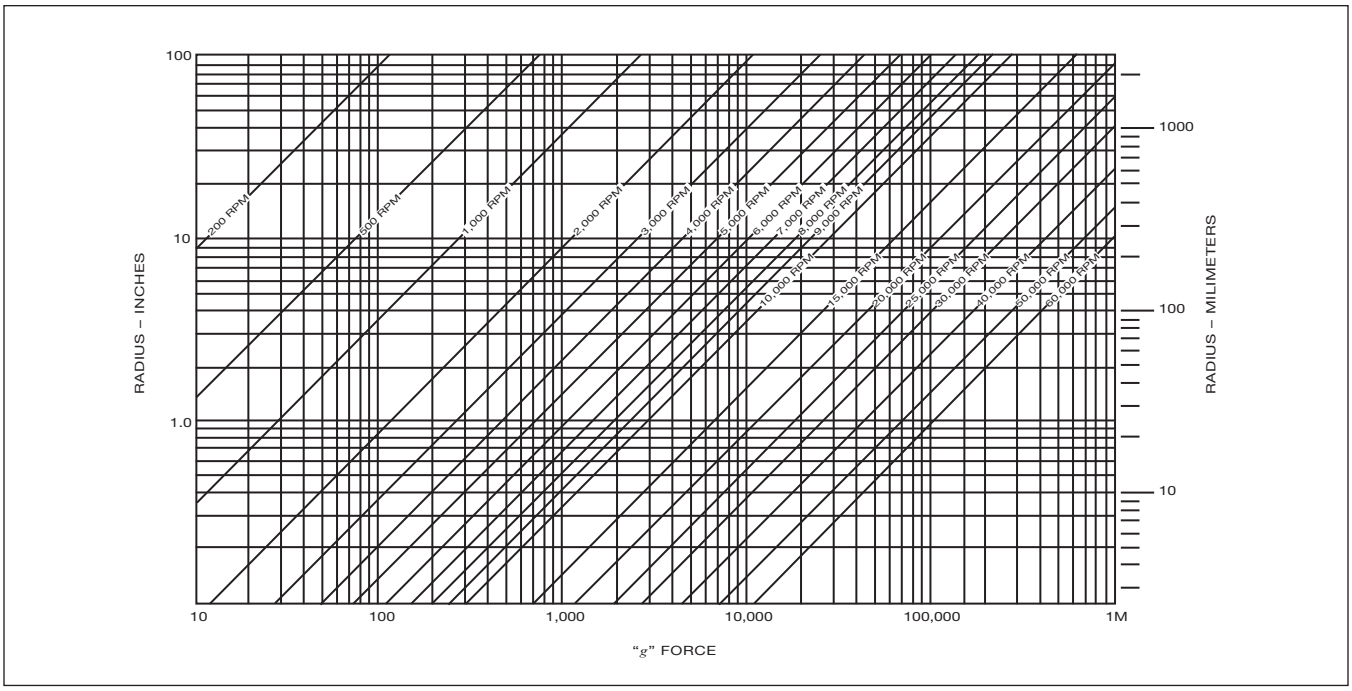
Chemically clean the specimen surface along which the leadwires will be routed, following the recommended techniques used to prepare the surface for bonding strain gages.

Step 2

Mask the surface with MJG-2 Mylar® Tape to restrict the adhesive to the desired area.

Step 3

Use a spatula to apply a thin, uniform layer of GA-61 Adhesive. (The AE-10/15 systems allow brush application and lower cure temperature.) Remove the Mylar Tape, and cure the installation for one hour at +350°F (+175°C).



APPLICATION NOTE

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Caution: Always handle uncured resin systems with care. To avoid skin contact, use polyethylene gloves. If skin comes in contact with the resin, wash immediately with soap and warm water.

Step 4

Lightly sand the surface of the cured coating with SCP-3 400-grit Silicon-Carbide Paper or GC-5 Pumice Powder to produce a dull matte finish suitable for bonding additional layers of adhesive.

Step 5

Select an appropriate leadwire. Leadwires with vinyl or Teflon® insulation are not recommended for high g-fields because high forces can cause the conductor to extrude from its insulation. Film-insulated leadwire such as 130-AWN, 130-AWQ, 134-AWN, 134-AWP, 134-AWQ or 136-AWP are recommended. Bare-copper or tinned-copper leadwires can also be used when the installation procedures outlined in this Application Note are followed.

Vinyl- or Teflon-insulated wires are sometimes used near the center of a rotating component, with the insulation removed along the length of wire routed to the high-*g* radius location. This procedure eliminates a splice connection from the heavily insulated instrument cable to the smaller diameter wire used in the high g-field.

Step 6

Solder the leadwires to the strain gage using +430°F (*+221°C*) or higher melting-point solder. Keep the solder joints very small and uniform. Remove all fluxes according to recommended procedures.

Note: Operating temperatures must be limited to 35°F (*20°C*) below solder melting temperature.

Step 7

Clean the leads thoroughly with *M-Prep* Neutralizer 5A, and dry completely with a hot-air gun or other appropriate method.

Step 8

Route leads along the surface of the specimen, securing the leads at 1-in (*25-mm*) intervals with hold-down strips of wire or Mylar tape.

Step 9

Use a spatula to apply a small amount of GA-61 to the areas between the hold-down points. Work adhesive in and around the leadwires to prevent air entrapment. Cure sufficiently to solidify resin, typically ½ hour at +300°F (*+150°C*).

Step 10

Remove the anchoring wire or tape and finish-coat the surface. Cure for two hours at +350°F (*+175°C*), or for one hour at +375°F (*+190°C*).

Step 11

When an airfoil surface is required, apply and cure additional layers of coating, sanding lightly between coats to produce an optimum bond. When sufficient thickness is obtained, contour with a portable grinder or by sanding. A thin final coat will produce a smooth, glossy finish.

Fiberglass Cloth Method

The following procedure will significantly shorten the leadwire bonding process. However, the stiffness and resonant frequency of thin or low-modulus structures may be affected.

Step 1

Chemically clean the specimen surface as in ***Leadwire Bonding Procedure***, Step 1.

Step 2

Select, attach and clean the leadwires according to the procedures described in ***Leadwire Bonding Procedure***, Steps 5, 6 and 7.

Step 3

Cut FGC-1 Fiberglass Cloth to the desired length. A second, insulating layer of cloth will be required if bare leadwires are used, or if film-coated leads are used above their recommended operating temperature.

Step 4

Place the cloth on a clean glass or metal plate. Use a spatula to work a liberal amount of GA-61 (or AE-10/15) into the cloth. Turn the cloth over and repeat the application to completely fill the weave with resin. If desired, trim the cloth width with scissors (after coating to avoid excessive fraying of the cloth). Clean scissors immediately with a suitable solvent, such as GC-6 Isopropyl Alcohol or CSM-2 Degreaser.

Caution: Always handle uncured resin systems with care. To avoid skin contact, use polyethylene gloves. If skin comes in contact with the resin, wash immediately with soap and warm water.

Step 5

Mask the specimen surface as in ***Leadwire Bonding Procedure***, Step 2, and wet the specimen surface with a film of adhesive.

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Step 6

Press the coated cloth to the surface. (Omit this step if adequately insulated leads are used.)

Step 7

Position the leadwires on the cloth or surface by pressing in place with a dental probe or similar tool. Keep leads slightly separated and wet with adhesive. Careful attention in this area will avoid air bubble entrapment later.

Step 8

Overlay the leads with a layer of fiberglass cloth treated as in Step 4. Press in place.

Step 9

Cover the assembly with a strip of TFE-1 Teflon Film, a layer of SGP-2 Silicone Rubber, and a thin, contoured pressure plate. Press the assembly firmly against the surface and tape in position with Mylar tape, applying sufficient pressure to maintain the shape while curing.

Step 10

Cure GA-61 for two hours at +350°F (*+175°C*), or for one hour at +375°F (*+190°C*). Cure AE-10 at +150°F (*+65°C*) for one hour, or for six hours at room temperature.

Step 11

Remove clamping materials. If additional resin is required, lightly sand the surface, coat and cure. Surface can be ground to produce the desired contour. A thin final coat will produce a smooth glossy finish.