Strain Gages and Instruments | Tech Tip TT-610

Strain Gage Clamping Techniques

Introduction

All organic strain gage adhesives require that some form of clamping pressure be applied and maintained throughout the curing stage. In the case of the fast-curing M-Bond 200 adhesive, clamping pressure is applied with the thumb or finger, and maintained for a minimum of one minute. However, M-Bond 200 is not recommended for elevated-temperature or long-term strain measurements. For these applications, or when gages must be installed in confined areas such as inside tubing or bored holes, epoxy or epoxy-phenolic adhesives are commonly selected.

With epoxy-based adhesives it is always necessary to maintain a specified uniform clamping pressure while the adhesive is curing. The instruction bulletins accompanying all Micro-Measurements strain gage adhesives include, in each case, the recommended clamping pressure and curing cycle. Since the curing process usually takes several hours and may involve elevated temperatures, it is important that the clamping device be physically stable and capable of holding the specified force for the required time.

This Tech Tip describes several popular, and some unusual, gage clamping methods and hardware.

Clamping Hardware

The mechanical arrangement used to obtain a steady, non-shifting clamping force obviously depends on the nature of the test object and the gage installation. Sometimes a simple spring clamp will suffice. In other cases, it may be necessary to devise a more elaborate clamping fixture. For any type of clamp, the assembly generally consists of four components:

1. A release film is used between the gage/adhesive and the pressure pad. It prevents the pressure pad from adhering to the adhesive layer. For low-temperature-curing epoxies [<+150°F (*+66°C*)] such as AE-10/15 and GA-2, this film is usually gage installation tape (PCT-2M). For higher-temperature-curing epoxies, such as 600, 610, 43-B and GA-61, it is usually a sheet of Teflon® film (TFE-1) or Mylar tape (MJG-2).
2. A resilient rubber pressure pad is used to provide a uniform clamping pressure over the gage area. It should be soft enough to conform to slightly irregular surfaces but not so soft as to extrude from under the clamping plate. Recommended hardness is durometer A40-60. Silicone gum or silicone rubber are preferred because of their high-temperature capability.
3. A metal clamping plate serves to distribute the clamping force over the entire area of the pressure pad. It should be formed to match the contour of the pressure pad or test part and should have sufficient thickness to prevent deformation under normal clamping force.
4. A force application device is used to apply steady force on the metal clamping plate. It could range from simple dead weights to sophisticated vacuum pads with integral heaters.

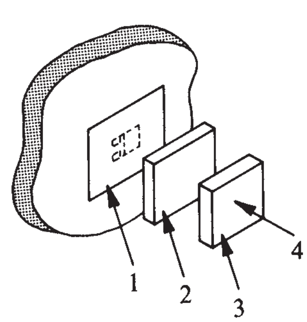

Figure 1

Calculating Clamping Pressure

All Micro-Measurements instruction bulletins for epoxy adhesives specify a recommended clamping pressure. Specified in pounds per square inch (psi) or kilonewtons per square meter (kN/m^2), clamping pressure is calculated by dividing the applied force by the surface area of the rubber pad in contact with the strain gage and specimen surface. Normally the desired clamping pressure is known from the instruction bulletin, and the proposed pressure pad area can be measured. Therefore, the necessary quantity to be determined is clamping force.

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As an example, the gage shown in Figure 1 is to be bonded with M-Bond 610 adhesive at a recommended clamping pressure of 45 psi (312 *kN/m²*). The gage pattern selected can be conveniently covered with one of the clamping pads from the GT-14 pad kit. These pads measure 0.5 x 1.25 in (*13 x 32 mm*). The necessary clamping force can be computed by multiplying the required clamping pressure by the pad area:

clamping force = clamping pressure x pad area
= 45 psi x 0.625 in^2 (*312 kN/m^2 x 0.0004 m^2*)
= 28 lbs (*125 N*)

Thus a 28-lb (*125-N*) clamping force for the example in Figure 1 would yield the recommended 45 psi (*312 kN/m^2*) clamping pressure.

Clamping Techniques

A selection of gage clamping techniques is shown in the sketches that follow. Whether one of these or another clamping scheme is used, there are two precautions that need to be observed in every case. The first is to always apply the clamping force through some form of spring (preferably low-rate). Rigid clamps (C-clamps, hose clamps, etc.), such as those shown in Figures 4 and 5, should not be used without a spring in series with the clamping force. The spring is necessary to ensure that the force does not vary significantly with small dimensional changes which may occur as the adhesive flows and cures, or as the temperature changes. The second is to always provide a means for determining the actual clamping force, thus making certain that it is within the range specified by the supplier. This can be done by precalibrating the spring for force versus deflection, or by direct measurement on the clamping assembly with an inexpensive spring scale (e.g., a “fish scale”). The latter technique is particularly appropriate for arrangements such as those shown in Figures 2 and 7.

The selection of additional clamping methods is limited only by the imagination of the gage installer. Following the guidelines provided in this Tech Tip, there should be very few applications where adequate gage clamping pressure cannot be achieved.

For further assistance in applying the clamping techniques illustrated, contact our Applications Engineering Department.

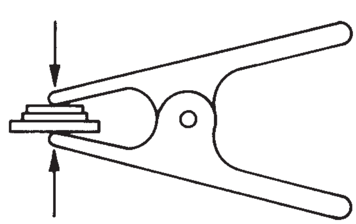

Figure 2 – Common spring clamp available in various sizes. Clamping force exerted should be checked at different jaw openings, as force may vary.

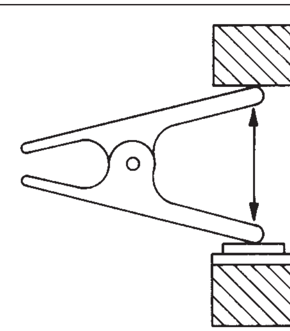

Figure 3 – Spring clamp used in a reverse (pushing) mode. Force can be checked by pressing handles down on platform or bathroom scale.

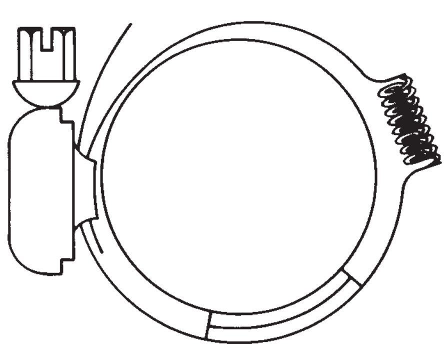

Figure 4 – Hose clamp with spring in series to provide constant and measurable force.

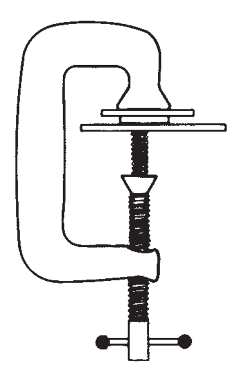

Figure 5 – C-clamp with compression spring that can be removed and checked for force versus deflection.

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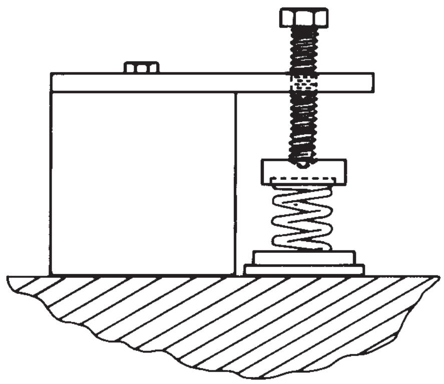

Figure 6 – Magnetic or metal block that can be attached to structure with dental cement or M-Bond 200. Spring can be calibrated separately.

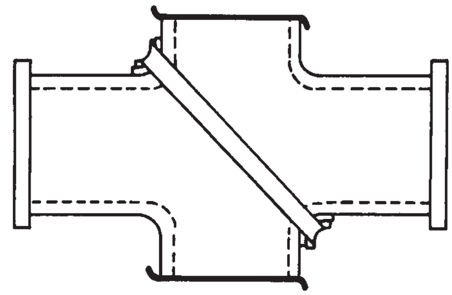

Figure 7 – Rubber-band clamp (usually surgical tubing) wrapped tightly around structure can be force-calibrated with spring scale.

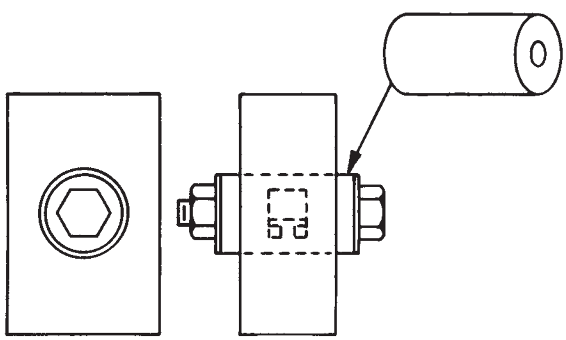

Figure 8 – Silicone rubber plug expands to provide clamping force to gage inside hole. Difficult to calibrate.

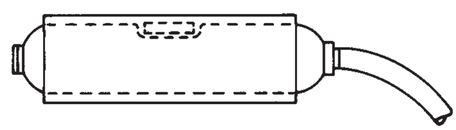

Figure 9 – Silicone rubber tubing has both ends plugged and fitted with air hose. Under pressure, tube expands to provide clamping force for gage inside pipe. Gage can also be prewired and temporarily installed upside down on tubing before insertion in pipe. Adhesive is then applied to gage bonding surface and assembly slid into pipe to the proper position and inflated.

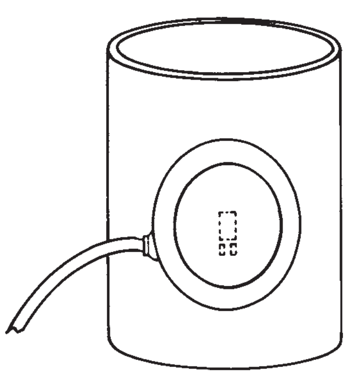

Figure 10 – Commercially available vacuum pads adhere to surface through suction. Internally heated models are available.

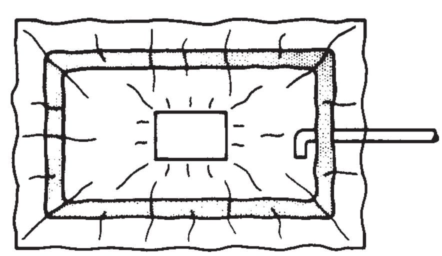

Figure 11 – Homemade vacuum clamping fixture. Putty is formed into a shallow box shape with vacuum hose molded into side. After gage placement, a plastic film (usually mylar) is placed over putty frames, and the vacuum is applied. Normally heat lamps are used to cure elevated-temperature-curing epoxies.