



## Strain Gage Installations for Concrete Structures

### Introduction

The installation of strain gages for concrete structures presents several unique challenges to the installer, whether measurements are made on the concrete surface or within the concrete, or on reinforcement bars within the structure. For example, special preparation is required to ensure that strains on the irregular surface of the concrete are fully transmitted to the strain gage; and when gages are bonded to reinforcement bars, provisions are necessary to protect the installation from mechanical damage during fabrication and from the hostile environment of the concrete itself. This Application Note outlines recommendations for gage, leadwire and protective coating selections and installations under these conditions. The surface preparation materials and installation accessories referenced throughout are described in detail in the Vishay Micro-Measurements Strain Gage Accessories Data Book.

### Installing Strain Gages on Concrete and Other Irregular Surfaces

Strain gages can be satisfactorily bonded to almost any solid material — including concrete — if the surface is properly prepared. For smooth surfaces on nonporous materials, only the basic operations of solvent degreasing, abrading, application of layout lines, conditioning and neutralizing are required. For concrete and other materials with an uneven, rough and porous surface, an extra operation must be added to fill the voids and seal the surface with a suitable precoating before the gage is bonded.

#### Degreasing

Use a stiff-bristled brush and a mild detergent (Figure 1) to remove any loose soil or plant growth. Rinse with clean water. A degreaser such as CSM-2 may be needed if oils and greases are present. Remove surface irregularities with a wire brush, disc sander, or grit blaster. Blow or brush all loose dust from the surface.

#### Conditioning

Generously apply *M-Prep* Conditioner A, a mildly acidic solution, to the surface in and around the gaging area. Scrub with a stiff-bristled brush. Blot contaminated Conditioner A with gauze sponges. Rinse the area thoroughly with clean water. Reduce the surface acidity by scrubbing with *M-Prep* Neutralizer 5A. Blot with gauze sponges and

rinse with water. Dry the surface thoroughly. Warming the surface gently with a propane torch or heat gun will hasten evaporation.

#### Filling

Application of a 100%-solids adhesive to the gaging area (Figure 2) will provide a suitable gage-bonding surface. For test temperatures up to +200°F (+95°C), M-Bond AE-10 is normally used. At higher temperatures, M-Bond GA-61 is recommended. In applying the adhesive as a sealer to the surface, work the adhesive into any voids, and level to form a smooth surface. After the adhesive is cured, it should be abraded with 320-grit abrasive paper until the base material is exposed. (If a thin adhesive, like M-Bond 200, will be used to bond the gage, the base material should not be exposed.)

#### Layout Lines

Using a ballpoint pen or round-pointed metal rod, burnish layout lines. Scrub them with Conditioner A, apply Neutralizer 5A, and dry as before. Supplemental layout lines may be drawn with ink on the concrete outside the gaging area.

#### Gage Bonding

Normal procedures should be followed for bonding the gage to the prepared gaging surface. Special notice should be paid to several points, however. First, the gage length of strain gages used on concrete should be at least 5 times



Figure 1 – Conditioning the surface for gage installation.



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the diameter of the largest aggregate in the concrete. This often results in the use of patterns with gage lengths of 1 in (25 mm) or more. N2A-Series or encapsulated EA-Series gages, which tend to lie flatter during handling, are highly recommended for their ease of installation under these circumstances. Further, bonding with a quick-curing adhesive, like M-Bond 200, is not recommended, even when test conditions may warrant its use. Accurate gage alignment and an even application of pressure as the adhesive is cured are more difficult when bonding longer gages. A slower curing adhesive, like M-Bond AE-10 shown in Figures 3 and 4, will allow time for realigning the gage, if necessary. It will also enable the use of a suitable pressure pad and clamping fixture as outlined in Vishay Micro-Measurements Application Note TT-610.

### Soldering

Concrete and adhesive fillers are relatively poor heat conductors. Accordingly, care should be taken when soldering leads directly to the strain gage. Excessive heating of the tabs can be eliminated by using gages with Option W (integral printed circuit terminal), or Option P (preattached leadwires), which is shown in Figure 5.

Attention to these procedures will help ensure successful installations of strain gages on the surface of concrete and other similar solids. If you have any questions about your particular applications, contact our Applications Engineering Department for recommendations.

### Strain Measurement Within Concrete Structures

Vishay Micro-Measurements EGP-Series Embedment Strain Gages (Figure 6) are specially designed for measurement of mechanical strains within concrete structures. The sensing grid has an active gage length of 4 in (100 mm) to average strains in aggregate materials, and is fully encapsulated in a polymer concrete material to closely match the mechanical properties of typical structural concrete, guard against mechanical damage, and to protect against moisture and corrosive attack. EGP-Series Gages incorporate a 10-ft (3-m), jacketed, three-conductor cable for ease of use in field installations, and are compatible with conventional strain measurement instrumentation.

### Gage Installation

No preparation of the gage itself is required; however, as with bonded or welded strain gages, EGP-Series Gages must be accurately aligned along the intended strain measurement direction during the installation process. Care should be taken to secure the gage in the desired location and orientation, and to tie the leadwire cable to any available support, before the concrete is poured. While the Embedment Gage must be completely encapsulated



Figure 2 – Filling of the surface.



Figure 3 – Adhesive application.



Figure 4 – Application.

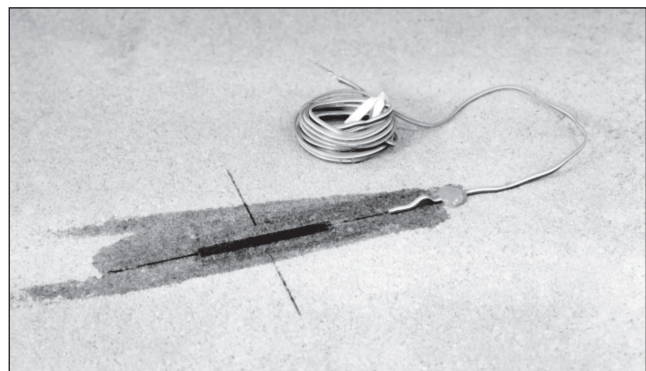


Figure 5 – Finished installation with N2A-06-40CBY-120 gage with Option P (preattached leadwires).

APPLICATION NOTE

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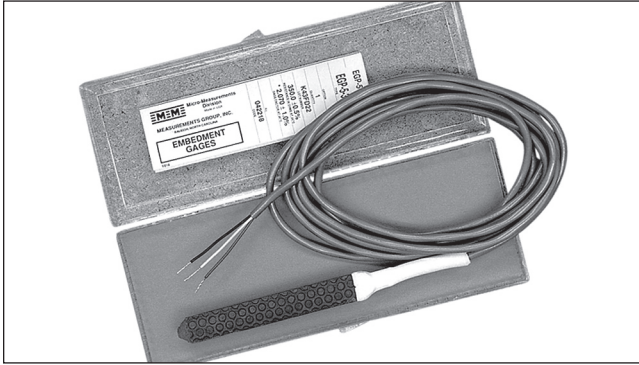


Figure 6 – EGP-Series Embedment Gage.

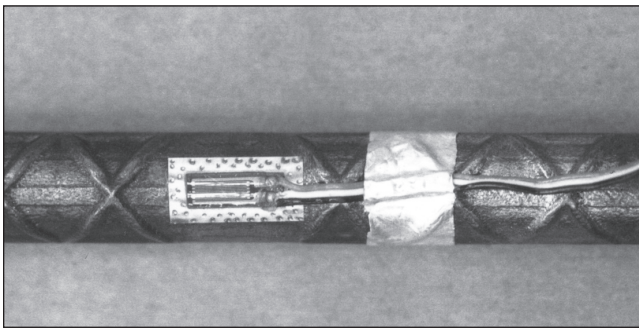


Figure 7 – CEA-Series Weldable Gage.

in concrete to ensure complete strain transfer from the structure, normal pouring techniques are usually all that are required.

#### Cable Splices

EGP-Series Gages are provided with a 10-ft (3-m) cable to allow for making cable splices outside the concrete structure. When splices are required, all connections should be soldered and then protected from moisture and other contamination with a suitable cable splice sealant.

#### Strain Gage Installation On Concrete Reinforcement

Strain gage installation on reinforcing rods follows the same general procedure recommended for most steel specimens. These rods are, however, subjected to mechanical abrasion and a moist, corrosive environment. Accordingly, the following special attention is required:

##### Surface Preparation

1. Degrease with a degreaser (CSM-2) over at least a 6-in (150-mm) length of the bar at the proposed gage location.
2. Descale and smooth the rebar around its circumference with a grinder wheel. (Aluminum oxide or silicon carbide abrasive of approximately 50 mesh is preferred.) A 3-in

(75-mm) length generally provides a sufficiently large descaled area for gage and protective coating installations. Surface finish after this operation should be about 180 microinches (5  $\mu\text{m}$ ) rms.

3. Wet abrade with Conditioner A and 220-grit silicon carbide wet-or-dry paper (SCP-1). Use sufficient Conditioner A to prevent material from drying on the rebar surface while abrading.
4. Wipe dry with a clean gauze sponge (GSP-1), then repeat Step 3 (with 320-grit paper) and dry again.
5. Surface finish should be 63 to 125 microinch (1.6 to 3.2  $\mu\text{m}$ ) rms at the completion of the second wet-abrading operation.
6. Lay out the gage locations.
7. Scrub the installation area with Conditioner A and a cotton applicator (CSP-1). Wipe dry with gauze sponges.
8. Scrub the area thoroughly with Neutralizer 5A and a cotton applicator and wipe dry with a gauze sponge as previously noted. This step must be accomplished thoroughly to neutralize all traces of Conditioner A used in Steps 3 through 7.
9. Mask an area with PCT-2M gage installation tape (or MJG-2 Mylar<sup>®</sup>) tape at the gage location to minimize flow-out of adhesive for subsequent protective coating application.

##### Adhesive Selection

M-Bond AE-10 adhesive is a good selection when a room-temperature cure of a field application is required. This adhesive will cure in 6 hours at +75°F (+24°C). Other adhesives that may be used, depending upon the test environment, are M-Bond AE-15, M-Bond 600/610, or GA-61 adhesive. Application of the adhesive should follow the specific instructions accompanying it.

##### Gage Selection

CEA-Series gages are the most popular choice when the cross section of the bar is 1/8 in (3mm) or larger in diameter. Where very stable installations are required (e.g., for tests in excess of one year) on 1/4 in (6 mm) or larger diameter rebar rod, WK-Series gages are recommended. When conditions are not favorable for bonding gages, CEA- and LWK-Series Weldable Gages (Figure 7) may be used.

##### Leadwire Considerations

When utilizing one active strain gage (quarter-bridge configuration), it is good practice to use a three-leadwire system. Vishay Micro-Measurements EA- and CEA-



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Series strain gages can be supplied with a preattached three-leadwire cable (Options P and P2, respectively) to eliminate the need for attaching leadwires at the job site, and to reduce installation time.

Alternately, leadwires may be soldered to the strain gage tabs after gage bonding. If a parallel or twisted cable is used, separate the individual (leadwire) conductors for a distance of about 1 in (25 mm) from the cable end and, if Teflon<sup>®</sup>-insulated cable is used, etch the insulation with Tetra-Etch compound; if vinyl-insulated cable is used, prime the insulation with thinned M-Coat B. These materials should not be allowed to flow onto the bare strands of the conductors.

After allowing the M-Coat B to air dry for at least two hours at room temperature [about +75° (+24°)], thermally strip the leadwire ends and tin and solder the wires to the strain gage tabs. For most rebar installations, 361A-20R solder will give excellent results. Carefully remove all rosin flux from the soldered connections using rosin solvent (RSK-1) before applying the protective coating.

### Environmental Protection

Apply M-Coat J to the gage installation carefully following the procedures outlined in Vishay Micro-Measurements Instruction Bulletin B-147. The coating should be built up to provide approximately 1/4 in (6 mm) thickness completely surrounding the rebar (Figure 8) at the gage location, and should be carried back far enough to cover the leadwire area previously primed with M-Coat B. Allow this coating to cure 24 hours at +75°F (+24°C), or 4 hours at +125°F (+50°C).

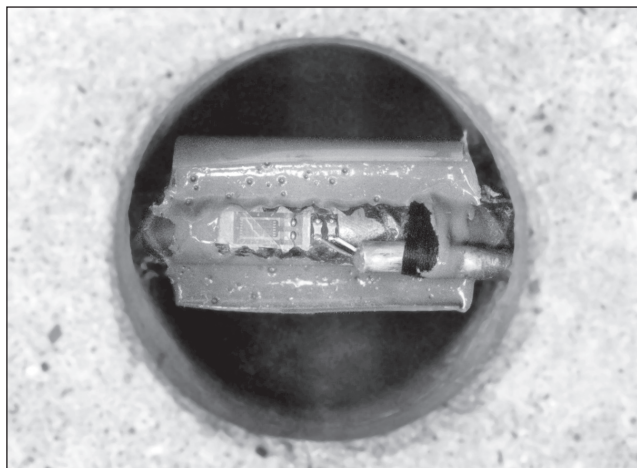


Figure 8 – Cut-away view of installation.

As a final step, the instrumentation leads extending from the gage, out through the concrete, should be placed in conduit to prevent mechanical damage to the leadwire system. Of course, the complete installations should be thoroughly checked with a Model 1300 Gage Installation Tester before and after the concrete is poured. A properly installed and protected strain gage is capable of many years of service on embedded reinforcing bars, providing data about load effects throughout the life of a concrete structure — from initial construction forces to unexpected severe loading conditions.