FSEL

PROCEDURE FOR

INSTALLATION OF STRAIN GAGES ON STEEL

1. PROCEDURE OVERVIEW

This procedure is to be used for installation of bonded strain gages on steel members. It includes necessary materials and a recommended practice for surface preparation, installation, and protection of strain gages.

1.1. Student Responsibilities:

- Read and understand the requirements of this procedure
- Provide steel for instrumentation
- Acquire all materials for strain gage installation

1.2. Staff Responsibilities:

- Read and understand the requirements of this procedure
- Assist students with installation as needed

2. EQUIPMENT AND TOOLS

There are two primary suppliers for strain gages at FSEL: Texas Measurements (http://www.straingage.com/) and Micro Measurements (http://www.vishaypg.com/micro-measurements/). Texas Measurements is an importer of gages manufactured by Tokyo Sokki Kenkyujo (http://www.tml.jp/e/).

Lead times for purchasing gages vary wildly. Occasionally gages are in stock in the U.S. and can be shipped right away. Often gages are not in stock and occasionally gages must be sent from Japan to local suppliers. In that case, lead times can be 2 to 3 months. Historically, Micro Measurements has had a longer lead-time than Texas Measurements. It is recommended that the supplier be contacted prior to ordering to get estimated lead times.

2.1. Gages Purchased from Texas Measurements

The typical gage for steel is FLA-6-350-11-5LT. This gage is a general purpose, uniaxial gage that is temperature compensated for mild steel. It has a pre-attached 3-lead wire that is 5 m long.

2.2. Gages Purchased from Micro Measurements Strain Gages

The typical gage for steel is CEA-06-250UN-350/P2. These gages are very similar to the FLA-6-350-11-3LT gages described in the previous section.

2.3. Materials from Texas Measurements

▪ CN adhesive ▪ W-1 Wax[1]

2.4. Materials from Micro-Measurements

▪ Gage Installation Tape (PCT 2M) ▪ M-Coat W-1 Wax[1]

2.5. Materials Generally Available at FSEL

▪ Angle Grinder ▪ Die Grinder ▪ Flapper Wheel ▪ Grinding Stone

▪ Razor Blade or Utility Knife ▪ Hot Plate ▪ Small Metallic Container

2.6. Additional Materials

▪ Acetone ▪ Electrical Tape ▪ Small Paintbrush

3. PERSONAL PROTECTIVE EQUIPMENT

▪ Safety Glasses ▪ Safety Shoes ▪ Dust Mask ▪ Rubber Gloves

4. DETAILED PROCEDURE

4.1. Mark the general area of the steel to be gaged.

Typically, an area about 1 to 2 in. by 1 to 2 in. is sufficient for gage installation.

4.2. Using an angle grinder with a flapper wheel, remove the mill scale from the steel surface.

The flapper wheel will remove the mill scale faster than a die grinder (electric or pneumatic). Thus, it is the recommended tool to remove the majority of the material. Take care not to reduce the cross-sectional area of the steel by removing a significant amount of the metal below the mill scale.

4.3. Use a die grinder and die grinder stone to perform the final smoothing of the area to be gaged.

Using the die grinder, polish the ground surface. The finished surface should be smooth but not a mirror finish. Take care not to remove so much material that the cross section is affected.

This process can also be performed using a 100 grit sanding disk on a pneumatic.

[1] These wax coatings are equivalent products; only one of these two items is needed.

4.4. Clean the steel surface using acetone and non-woven sponges.

Wet the sponge thoroughly with acetone and wipe across the polished area. Repeat the process with fresh sponges and wiping in one direction until the non-woven sponge remains white after wiping. Be careful not to wipe the sponges through a dirty un-polished area into the clean, polished area.

Note that acetone is a highly flammable material and should be handled accordingly. Wear safety glasses to protect your eyes from acetone. Long-term exposure to acetone vapors is harmful and at a minimum, can cause headache and dizziness. Use acetone in a properly ventilated area and avoid breathing in acetone vapors.

4.5. Mark the gage location

Mark the final gage location with a pencil or marker. The mark should be adjacent to the freshly cleaned area to avoid contamination.

4.6. Attach the strain gage.

For satisfactory bonding of the gage to the bar, it is essential that the bar surface be completely clean prior to gage installation. If there is a delay between surface preparation steps described above and the gage installation, carefully inspect the surface and repeat the cleaning steps as needed. Re-applying acetone is highly recommended to remove the collected dust on the surface. Using the fine sanding disc might also be needed for delays that are longer than 1-2 days.

Attaching the gage consists of a number of smaller steps. These steps need to be done quickly and smoothly to ensure a reliable bond between the gage and the substrate.

4.6.1. Identify the top and bottom surfaces of the strain gage before removing it from the packaging.

The "top" of the strain gage has the visible metallic wires printed on it. The "top" of the gage will also have the lead wires attached to it. The printed wires are visible from the "bottom," but they will be dull in color. The top and bottom surfaces are shown in Figure 1.

Do not touch the bottom surface of the gage, as it would contaminate the bonding surface.

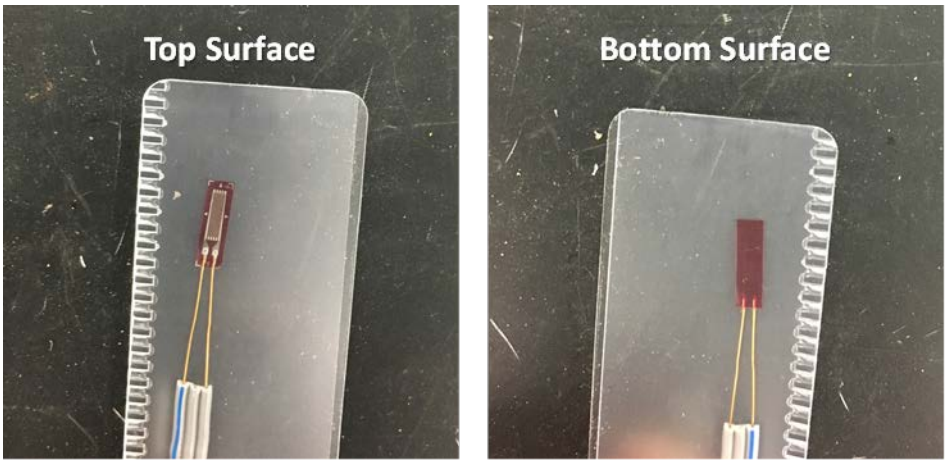

Figure 1 - Identifying the top of the gage

4.6.2. Remove the gage from the protective plastic and apply a piece of gage installation tape to the top of the gage.

The tape serves two purposes: 1) it allows handling of the gage without touching it and 2) it helps position the gage on the specimen for gluing. The piece of tape should be 2 to 3 in. long with the gage centered on the strip of tape. The gage can be temporarily placed on a clean glass surface to apply the tape.

4.6.3. Position and tape the gage on the steel.

Using the tape to handle the gage, position the gage over the ground and cleaned area of the steel. Press the tape to the steel to temporarily hold the gage in place. Inspect the position of the gage and reposition using the tape as needed.

4.6.4. Partially peal back the tape to expose the bottom surface of the gage.

Starting with the end of the tape near the lead wires, slowly peel the tape from the steel. Stop peeling the tape once the complete gage is exposed. The portion of the tape beyond the gage should be left adhered to the steel to allow the gage to be returned to its previous location.

4.6.5. Apply one drop of CN adhesive to the junction between the peeled back tape and the steel.

4.6.6. Slide a finger or thumb from the attached end of the tape to the free end of the tape in a smooth and continuous motion to press the gage into the adhesive and force out air bubbles.

4.6.7. Maintain pressure on the tape and gage for approximately 1 minute to allow the adhesive to set and harden.

Adhesive drying times are affected by ambient temperature and humidity.

4.6.8. Carefully remove the tape from the gage and wire.

Peel back the tape from the end of the gage opposite the lead wires. The tape must be peeled back slowly and carefully to avoid damaging the gage or lead wires.

4.6.9. After removing the tape, inspect the gage for unbonded areas.

Unbonded areas will appear as air bubbles or areas of a slightly different color than the bonded areas. If the unbonded areas are on the edges of the gage, more adhesive can be added. If more adhesive is added, reapply pressure to allow the adhesive to cure.

4.6.10. Secure the lead wires.

The lead wires should be secured to the steel to prevent them from touching each other and to prevent the wires from being damaged if they are pulled.

4.7. Apply waterproofing and mechanical protection to the gage.

Since the gage is exposed to atmospheric moisture, it will need waterproofing to prevent the glue from releasing.

4.7.1. Melt blocks of protective wax coating.

Plug in the hot plate so that it can begin warming. Place the wax in a metallic container on top of the hot plate for melting. Typically, a soda can that has been cut in half is used for wax melting. Melting the wax can take some time. It may be desirable to begin melting the wax early in the strain gaging process.

4.7.2. Using a small paintbrush, apply coating(s) of melted wax to the strain gage.

The wax provides a waterproof coating. Additional layers of wax can be added to ensure a watertight seal.

4.8. Check the electrical resistance of the gage and ensure the gage is not electrically connected to the steel.

It is recommended that the electrical connectivity of the gage be checked as a quality control measure. If the checks below indicate a problem, the gage will likely need to be removed and replaced with a new gage.

For typical strain gages, three lead wires are attached to each gage. One of these three wires is independent and the remaining two are connected to each other. For gages purchased from Texas Measurements, the independent wire is in a gray sheath marked with a blue stripe and the two connected, or dependent, wires are in unmarked, gray sheaths. For gages purchased from Micro Measurements, the independent wire is red and the dependent wires are black and white.

4.8.1. Check electrical resistance between the independent wire and each of the dependent wires.

Using a multimeter set to measure resistance, connect the independent wire to one of the probes of a multimeter. Connect one of the dependent wires to the other multimeter probe. These connections can be made by firmly pressing the bare wires to the multimeter probes. The measured resistance should approximately match the nominal resistance of the gage (120Ω or 350Ω). Perform this check on each of the two dependent wires.

4.8.2. Check the electrical resistance between each of the three lead wires and the steel.

One at a time, connect each lead wire to a multimeter probe while holding the other multimeter probe to the bare steel. The multimeter should read "OL" for overload, indicating a very high resistance. The overload indicates the gage is electrically isolated from the steel as it should be.

4.9. Label all strain gage wires.

4.10. Record the gage factor for the gage.

When setting up the data acquisition system, the gage factor will be needed to convert voltage measurements to strain values.

5. SUPPORTING DOCUMENTS

None.

6. REFERENCED DOCUMENTS

None.

7. RECORD OF REVISIONS

Revision	Date	Affected Pages	Description
0	2016-09-23	All	Initial Issue