Geosynthetic Institute
475 Kedron Avenue
Folsom, PA 19033-1208 USA
TEL (610) 522-8440
FAX (610) 522-8441

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GRI Guide GS26*

Standard Guide for

"Attaching Foil Strain Gauges to Geosynthetics"

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1. Scope

1.1 This guide outlines procedures that have been successfully used when attaching foil strain gauges to geosynthetics.

1.2 This standard guide may involve hazardous operations, equipment and climates. This standard guide does not purport to address all of the safety problems associated with its use. It is the responsibility of the user of this standard guide to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.

2. Referenced Documents

2.1 ASTM Standards

D 4439 Terminology for Geosynthetics

2.2 GRI Documents

*This GRI standard guide is developed by the Geosynthetic Research Institute through consultation and review by the member organizations. This guide will be reviewed at least every 2 years, or on an as-required basis. In this regard it is subject to change at any time. The most recent revision date is the effective version.

GS3 Guide for selecting In-Situ Monitoring Methods and Devices for Evaluation of Geosynthetic Performance

3. Terminology

3.1 Geosynthetic, n- a planar product manufactured from polymeric material used with soil, rock, earth, or other geotechnical engineering related material as an integral part of a man-made project, structure, or system.

4. Summary of Method

4.1 Strain gauge monitoring quantifies the actual strain induced on different locations of the geosynthetic. When used in conjunction with a data acquisition system (DAQ), this type of monitoring provides reliable information by relating resistivity measurement to deflection, yielding strain via a calibration curve. The strain gauges used are electrically resistant (foil-type) strain gauges that have a resistance of 120 ohms and vary in lengths from 10 to 100 mm. Instructions are given for the proper installation of such gauges.

4.2 There are several very good YouTube video tutorials which can also guide you through the essential steps for installing foil strain gauges. Unfortunately, these videos are not specifically targeted to geosynthetics, but one would be remiss not to have a look.

4.3 Please note that the installation procedure recommended by the manufacturer of the foil strain gauge should be precisely followed and usurps the information provided below. This is only a guide, and not following the manufacturer's recommendation may void the warranty of some equipment or instrumentation. In all cases, the stain gauge assembly consists of a strain gauge, jumper wires, and connection terminals with leads to the read out or data acquisition system (DAQ).

5. Significance and Use

5.1 This guide provides a method by which samples of geosynthetics can be instrumented with foil strain gauges. The technique described has been successful in the past with survivability statistics of greater than 50% over a one-year time period in both laboratory and field environments.

6. Required supplies

6.1 Glass plate, scissors, tweezers, eraser, tape, terminals, strain gauges, degreaser, cleaner, neutralizer, compressed air supply or aerosol computer duster, adhesive, disposable mixing bowl, sponge, gauze, paper towels, Q-tips, T-square, triangle, and marking pen.

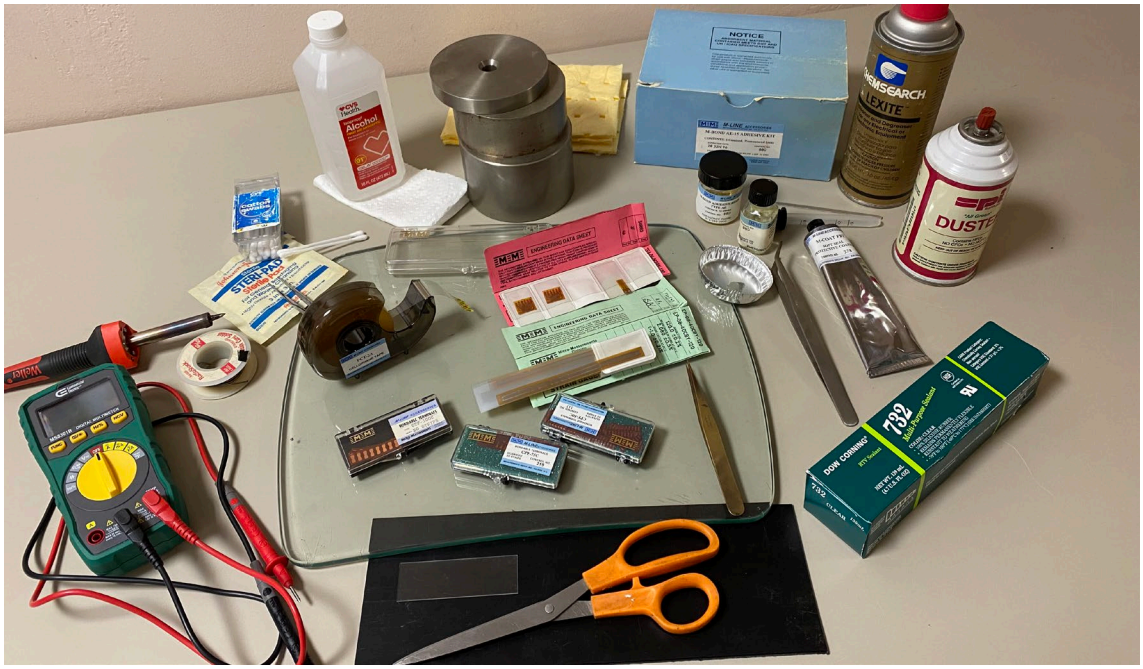

Figure 1 – Photograph of supplies and equipment needed for the installation of foil strain gauges on geosynthetics

7. Procedure

After unpacking the strain gauge, place it on a clean glass surface and follow the procedure below.

7.1 Clean and degrease: The surface preparation technique is very important. The initial step is to thoroughly clean and degrease the gauging area with solvents. A chlorinated degreaser is recommended. However, some materials will react with such solvents. In this case, isopropyl alcohol should be considered. At this stage in the process, it is very important to look out for cross contamination between the surface and the sample.

7.2 Abrade: You may need to dry-abrade the area with 200-300 grit silico-carbon paper or a Scotch Brite pad to remove scale or oxides. One might also consider wet abrasion with a drafting pencil eraser or a Mr. Clean magic sponge. One can also scrub with a cotton-tipped applicator until a clean applicator is no longer discolored by the scrubbing. Please note that after all this prep work, one must remove all residue and cleaning fluids from the gauge area. This is done by slowly wiping down the gauge area with cotton gauze, pad, or sponge.

7.3 Air Blast: Spray the gauge area with compressed air to remove small residual particles from the abrading process. This can be done with a computer aerosol duster or with air from a compressor wand.

Figure 2 – Photograph of cleaning supplies and drafting equipment for aligning target as a reference on the geosynthetic

7.4 Neutralize surface: Apply a liberal amount of neutralizer to the gauge area. Keep the surface wet and do not allow it to evaporate, since this would leave a thin unwanted film in the gauge area. Remove the neutralizer by slowly wiping through the gauge area, allowing the gauze pad or sponge to absorb the neutralizer. Do not wipe back and forth over the gauge area since this may allow contamination to be redeposited on the cleaned gauge area. The technique should be a one-way swipe.

7.5 Position gauge: Remove the gauge from the acetate envelope by grasping the edge of it with tweezers and placing it on a chemically clean glass plate with the bonded side down. Also position the solder terminal on the glass plate adjacent to the head of the gauge. Approximately 2 mm should be left between the head of the gauge and the terminal. Using 100 mm of tape, tack one end to the glass plate behind the tail of the gauge and wipe forward onto the gauge and terminal, assuring that they are evenly adhered to the tape. Then carefully lift the tape at a shallow angle off the glass, bringing with it the gauge and terminal. To avoid excessive stretching of the tape, use only enough force to evenly lift the tape in one smooth motion, (note: this is a learned skill which might take practice to master). The gauge and terminal are now ready to transfer to the geosynthetic sample.

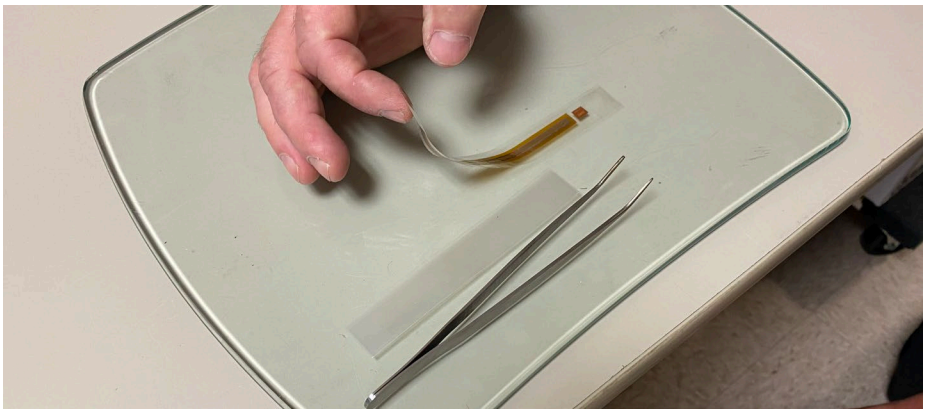

Figure 3 – Photograph of adhering foil strain gauge and terminal to tape on a glass plate

7.6 Substrate: Assure that a flat, clean, and rigid substrate is ready to receive the geosynthetic and strain gauge assembly. Note that this is critical, and you may want to put down an additional clean rigid PET or PE film on the substrate to serve as an added bond breaker or spill apron.

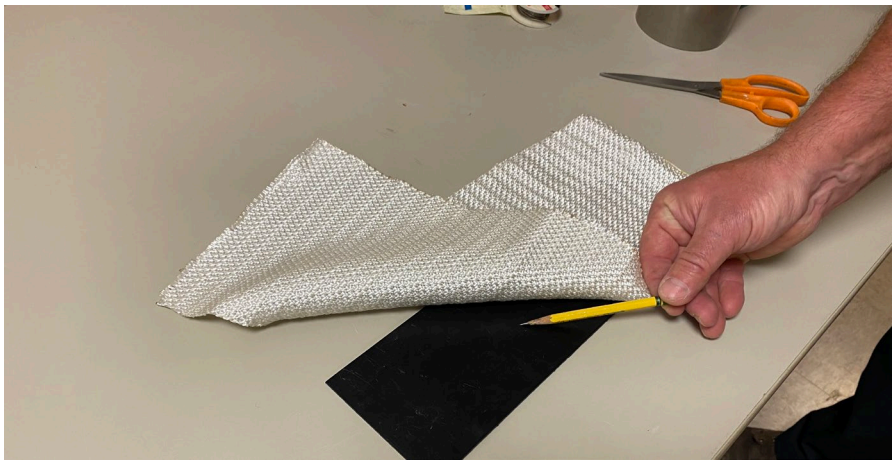

Figure 4 – Photograph of HDPE flat, clean, rigid substrate under geosynthetic

7.7 Mark Target Gauge Area on Geosynthetic: To align the strain gauge assembly properly, X-X and Y-Y target axis lines are generally drawn beyond the gauge area. These lines are usually made with permanent marker in a contrasting color from the geosynthetic. For a straight reference line square to the axis, align a T-square or drafting triangle edge, then mark the straight reference line onto the surface in question.

7.8 Fold Back: Position the gauge and tape assembly so that they are aligned properly over the specimen. Holding the tape at a shallow angle, wipe the assembly onto the specimen surface. Lift the tail end of the tape at a shallow angle to the surface until the gauge and terminal are free from the specimen surface. Tuck the loose end of the

tape under itself into a roll and lightly tack it temporarily into position. Leave enough slack in the tape to make sure you can easily undo it.

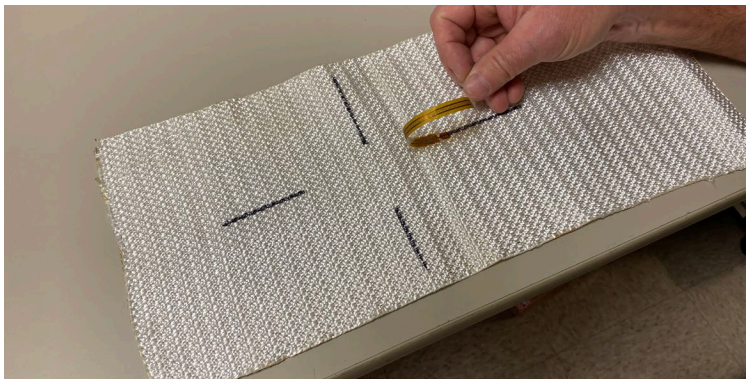

Figure 5 – Photograph of positioning the taped gauge and terminal on geosynthetic in the target area prior to gluing

7.9 Apply adhesive: Apply a thin layer of adhesive to the bonding area of the specimen. The adhesive film should be just thick enough to cover the gauge and terminal area without bubbles or voids. Approximately 0.1mm thick adhesive is typically used. Any lumps of unmixed adhesive should be removed before proceeding.

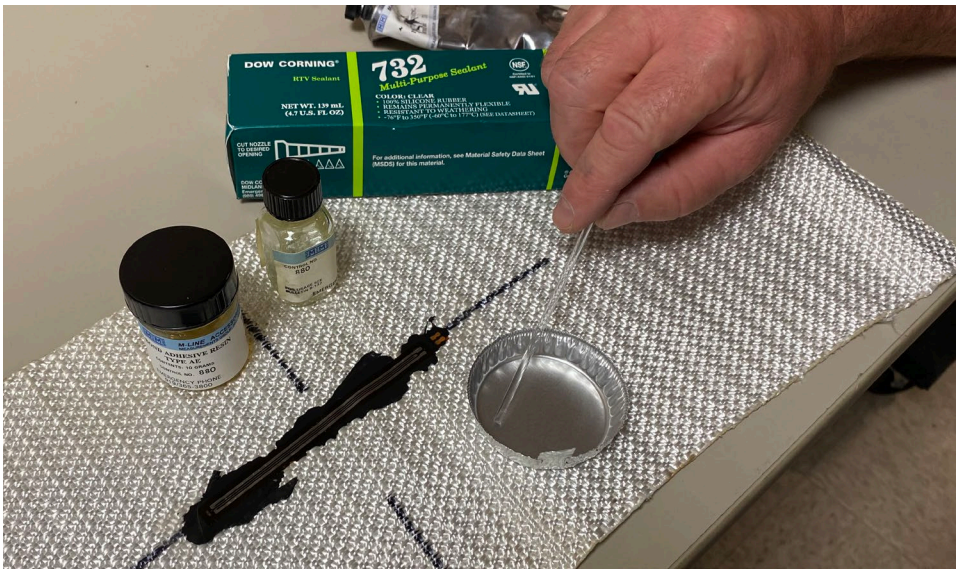

Figure 6 – Photograph of taped gauge and terminal pressed into the adhesive

7.10 Realign gauge: Replace the gauge tape assembly over the adhesive. This is done by unfastening and flipping the gauge terminal tape assembly roll in one gentle motion. Using a piece of gauze, slowly make a single wiping stroke over the assembly applying even pressure and squeezing the adhesive evenly under the gauge and the terminal.

7.11 Overlay gauge with bond breaker: Overlay the gauge terminal area with a clean piece of rigid plastic or glass. This is necessary to evenly distribute pressure over the gauge and terminal assembly.

7.12 Apply mass: Place dead weights over the bond breaker so that at least 10 psi (70kPa) is attained. Take special care that the mass is evenly distributed over the entire assembly area so that the adhesive dries in a uniform thickness.

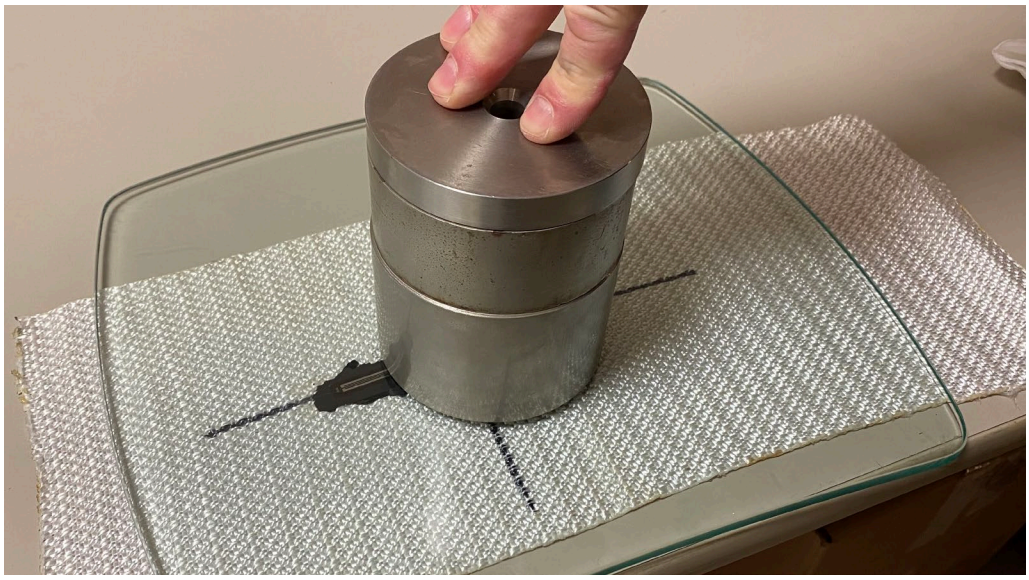

Figure 7 – Photo of glass overlay bond breaker and weights on the gauge area for curing

7.13 Wait for cure time: Unfortunately, different adhesives have different cure times. Note that most ductile adhesives have long cure times. One should also note that an adhesive's cure time in air is shorter than that its cure time under tape. A little experimenting ahead of time will save time, money, and frustration. Another key factor for curing adhesives is temperature: the hotter the faster.

7.14 Unwrapping: Upon completion of the curing cycle, remove the weights and the bond breaker, and then carefully remove the tape. All residual mastic should be removed with a solvent and a dry gauze sponge.

7.15 Soldering: After curing for at least one hour in air, the gauge can be soldered to the terminal and then to the lead wires. Select an appropriate solder and make sure to remove any flux with rosin solvent after the solder has cooled. Remember, the gauges and terminals are extremely fragile. You will only get one chance!

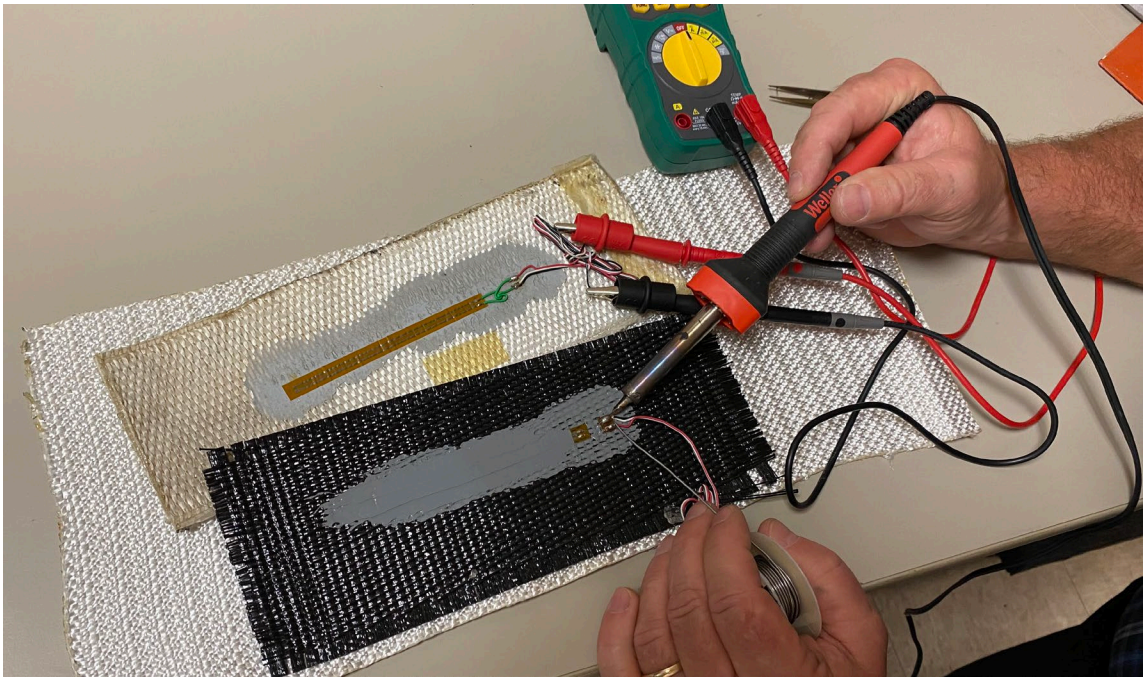

Figure 8 – Photograph of soldering the terminal and subsequently checking the resistance of the gauge with an ohmmeter prior to placing the gauge in service

7.16 Verify resistance: After everything is wired, it is a good practice to check the resistance of each gauge, terminal, and lead wire arrangement prior to commissioning. It is important to ensure that the strain gauge has been installed correctly. Visually examine whether the strain gauge appears even in the X, Y & Z directions. Then use an ohmmeter to double-check the isolation and volume resistance of the strain gauge.

7.17 Coating: Select and apply a protective coating over each gauge, terminal, and lead wire arrangement. We have had great success with Dow Corning 3145 RTV Mil-A-46146 adhesive sealant in this regard. It works well at water proofing and is extremely flexible, so it does not get in the way of strain measurements. It should be noted that mechanically protecting the gauge, terminal, and cables also protects the assembly from impact and other survivability challenges. Unfortunately, we only have a 50% survivability rate of strain gauges in the field after one year of service. We also do not trust the gauges after four years.

7.18 Connect to DAQS: There are many amplifier module systems that one can hook the strain gauges up to for lab or field use. This is typically done via easy clamp on the connector in a quarter bridge configuration. The Vishay system has proven itself over the years and is recommended. There is also a remote microwave system that shows promise and can control, monitor, and record foil strain gauges through a smart phone.

8.0 Recommendations

8.1 The connection terminal is highly recommended to prevent the gauge from being subjected to unexpected eccentric stresses. Some people choose not to use it. However, this is risky for long term monitoring. Also note that pre-wired strain gauge with connection terminals built into the design will save you a lot of time and hassle (i.e., soldering these tiny fragile things well takes patience and practice).

8.2 Several manufacturers, such as M&M, HBM, and M-line, offer a variety of strain gauges and accessories (adhesives, cleaners, swabs, etc.), and they are recommended. However, we have also used the following adhesives with some success: Armstrong two-part resin A-12, Dow Corning 3145 RTV Mil-A-46146 adhesive sealant, 3M Scotch-Weld DP-8005 and 3M Scotch double sided tape 665.

9. Keywords

9.1 geosynthetic; foil strain gauge; and instrumentation