Designation: E 1237 – 93 (Reapproved 1998)

Standard Guide for Installing Bonded Resistance Strain Gages[1]

This standard is issued under the fixed designation E 1237; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ϵ) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This document provides guidelines for installing bonded resistance strain gages. It is *not* intended to be used for bulk or diffused semiconductor gages. This document pertains only to adhesively bonded strain gages.

1.2 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*

E 251 Test Methods for Performance Characteristics of Metallic Bonded Resistance Strain Gages[2]

2.2 *Other Standards:*

ANSI/SEM 1-1984; Standard for Portable Strain-Indicating Instruments—Designation of Strain Gage Bridge and Color Code of Terminal Connections; August 16, 1984.[3]

3. Terminology

3.1 *Definitions:*

3.1.1 *lead wire*—an electrical conductor used to connect a sensor to its instrumentation.

3.1.2 *resistance strain gage bridge*—a common Wheatsone bridge made up of strain gages used for the measurement of small changes of resistance produced by a strain gage, where the gages may be wired in the following configuration (see also Fig. 1 and Fig. 2):

Arm 1 between + excitation and − signal
Arm 2 between − excitation and − signal
Arm 3 between + signal and − excitation
Arm 4 between + signal and + excitation

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *bonded resistance strain gage*—a resistive element with a carrier that is attached by bonding to the base material so that the resistance of the element will vary as the surface of the base material to which it is attached is deformed. (For a complete definition of this term see Test Methods E 251.)

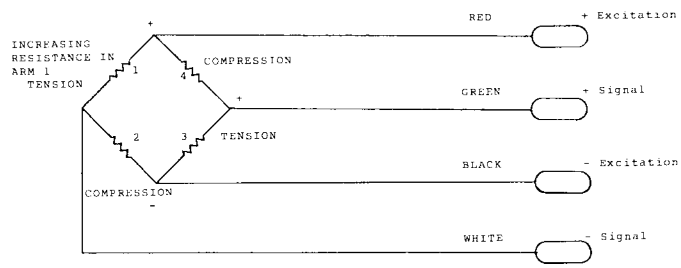

FIG. 1 Designation of Strain Gage Bridge and Color Code of Lead Wires (Full Bridge)

4. Significance and Use

4.1 Methods and procedures used in installing bonded resistance strain gages can have significant effects upon the performance of those sensors. Optimum and reproducible detection of surface deformation requires appropriate and consistent surface preparation, mounting procedures, and verification techniques.

5. Gage Selection

5.1 Careful consideration must be given to the intended use when selecting an appropriate gage. Installation and operating characteristics of a gage are affected by many factors such as resistive element alloy, carrier material, gage length, gage and resistive element pattern, solder tab type and configuration, temperature compensation characteristics, resistance of active elements, gage factor, and options desired.

5.2 Factors that should also be considered include type of test or application, operating temperature range, environmental

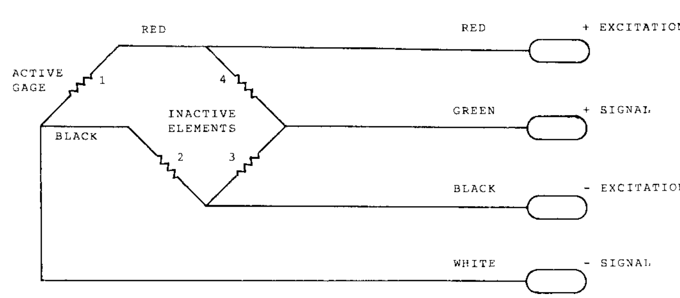

FIG. 2 Designations of Strain Gage Bridge and Color Code of Lead Wires (¼ Bridge)

[1] This guide is under the jurisdiction of ASTM Committee E-28 on Mechanical Testing and is the direct responsibility of Subcommittee E28.14 on Strain Gages.

Current edition approved Feb. 15, 1993. Published April 1993.

[2] *Annual Book of ASTM Standards*, Vol 03.01.

[3] Available from American National Standards Institute, 11 W. 42nd St., 13th floor, New York, NY 10036.

conditions, accuracy requirements, stability, maximum elongation, test conditions (static or dynamic) and duration, and simplicity and ease of installation. Dissipation of self-generated heat to the carrier should be considered in selecting gage resistance and size of grid.

5.3 To minimize errors due to strain gradients over the gage area, gage size should normally be small with respect to the dimensions of an immediately adjacent geometric irregularity (hole, fillet, etc.). However, the gage size should generally be large relative to the underlying material structure (grain size, fabric-reinforced composite weave pattern, etc.).

5.4 A two- or three-element rosette gage should be used unless the strain state is unquestionably uniaxial. A single element gage may be selected to measure the strain due to a uniaxial strain state if the principal directions are known.

5.5 Temperature compensation of the gage should be selected to match the thermal coefficient of expansion of the base material, where possible. As a note of caution, for extreme temperature changes, nominal or handbook data on the thermal expansion characteristics of the base material may not be sufficiently accurate, and actual calibration may be required.

5.6 Strain gage manufacturers provide detailed critiques of the various factors which affect gage selection **(1)**.[4]

5.7 For nonroutine applications, the advice of experienced users and of strain gage manufacturers should be sought. Specific verification tests may be required to ensure accurate results.

6. Bonding Technique Selection

6.1 Selection of the proper bonding technique and agent is important. Because the bonding agent becomes part of the strain gage system, many of the gage selection factors should be considered in bonding technique or agent selection.

6.2 Additional selection factors include compatibility of the bonding materials used in the selected gage construction with the material under test, environmental conditions, and available installation time.

6.3 Strain gages from different manufacturers may differ. Generally, each manufacturer will supply instructions and recommendations for bonding. These instructions should be considered when making a selection.

7. Surface Preparation

7.1 The surface must be properly prepared to ensure good bonding. Surface preparation includes solvent degreasing, cleaning, mechanical preparation, and chemical preparation. The surface should be smooth, but not highly polished. Preparation of this surface must be compatible with the gage, bonding method, and base material.

7.2 Erroneous gage readings may be caused by poor bonding of strain gages, which could be due to unremoved coatings such as paint, scale, rust, and oils. Poor bonding may also result from applying gages to improperly prepared surfaces, such as mirror smooth finishes or surfaces containing deep pits and gouges.

7.3 Strain gage manufacturers supply surface preparation suggestions and recommendations. This information should be reviewed and considered when preparing base material surfaces for the particular gages selected.

8. Gage Installation—General

8.1 All work must be performed with clean hands and tools. All materials needed should be assembled and readily available at the gage installation location.

8.2 The specific surface preparation procedures should be in accordance with the instructions supplied for the bonding agent selected. Bonding agent handling and safety precautions should be reviewed and carefully followed.

8.3 The detailed gage installation procedures available from the strain gage manufacturer for the particular gage/bonding technique system selected should be carefully reviewed and rigorously followed. Deviations from these procedures, if any, should be documented and verified to ensure that the installation will yield suitably accurate results.

8.4 Gage handling and alignment procedures should be rigorously followed. Deviations, if any, should be documented.

9. Gage Installation—Adhesive

9.1 Ensure that the proper adhesive is selected for a given gage type. Follow gage manufacturer's recommendations for selecting an adhesive.

9.2 The environment to which a gage is to be subjected and test duration should be considered when selecting an adhesive.

9.3 Ensure that the adhesive to be used is not out-of-date with regard to storage and shelf life requirements.

9.4 Ensure that test material temperature range and gage/bonding system temperature range are compatible.

9.5 Temperatures and times should be monitored to ensure that the adhesive temperature and pot life requirements, if applicable, are not exceeded.

9.6 Adhesive curing methods and schedules should be rigorously followed. Deviations, if any, should be documented.

9.7 If curing with pressure is required, take special care to make sure the pressure is proper and is distributed uniformly over the entire gage. Nonuniform pressure may result in an irregular bond line. Care should be taken to ensure that the gage position does not shift as a result of applying this pressure.

10. Lead Wire Connection

10.1 Care must be exercised in attaching the lead wires. In order to prevent lead wire forces from damaging the strain gage or degrading its performance, the use of gages with integral copper terminals or bonded terminals is recommended. Bondable terminals are recommended where extended use of the test piece is expected. References **(2)**, **(3)**, and **(4)** provide supplemental information on these subjects.

10.2 Wire splices should be avoided, but if a splice is required, ensure a good electrical and mechanical connection. The preferred method includes crimping, soldering, and insulating.

10.3 It is important to select the proper wire type, size, and length to maintain strain gage stability, sensitivity, and integrity. Moisture can cause signal instability and drift, hence the

[4] The boldface numbers in parentheses refer to the list of references at the end of this standard.