Designation: E1237 – 20

Standard Guide for Installing Bonded Resistance Strain Gages[1]

This standard is issued under the fixed designation E1237; 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 U.S. Department of Defense.

1. Scope*

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

1.2 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.3 *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, health, and environmental practices and determine the applicability of regulatory limitations prior to use.*

1.4 *This international standard was developed in accordance with internationally recognized principles on standardization established in the Decision on Principles for the Development of International Standards, Guides and Recommendations issued by the World Trade Organization Technical Barriers to Trade (TBT) Committee.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

E6 Terminology Relating to Methods of Mechanical Testing

E251 Test Methods for Performance Characteristics of Metallic Bonded Resistance Strain Gages

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 The terms accuracy, gage factor, lot, and type are used as defined in Terminology E6. In addition, the following terms common to strain gages from Terminology E6 are defined.

3.2 *Definitions:* Definitions of terms common to mechanical testing:

3.2.1 *lead wire, n—for strain gages*, an electrical conductor used to connect a strain gage to its instrumentation.

3.3 *Definitions of Terms Specific to This Standard:*

3.3.1 *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.

3.3.1.1 *Discussion*—For a complete explanation of this term see Test Methods E251.

3.3.2 *resistance strain gage bridge*—a common Wheatstone bridge made up of strain gages used for the measurement of small changes of resistance produced by a strain gage, where the strain gages are 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

3.3.2.1 *Discussion*—In this standard, the term "strain gage bridge" is equivalent to resistance strain gage bridge.

3.3.3 *strain gage, n*—The term "strain gage" is equivalent to the longer, but more accurate, "bonded resistance strain gage."

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

[1] This guide is under the jurisdiction of ASTM Committee E28 on Mechanical Testing and is the direct responsibility of Subcommittee E28.01 on Calibration of Mechanical Testing Machines and Apparatus.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

[3] Available from American National Standards Institute (ANSI), 25 W. 43rd St., 4th Floor, New York, NY 10036, http://www.ansi.org.

*A Summary of Changes section appears at the end of this standard

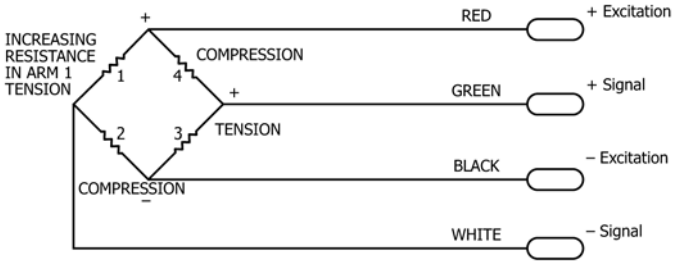

FIG. 1 Designation of Resistance Strain Gage Bridge and Color Code of Lead Wires (Full Bridge)

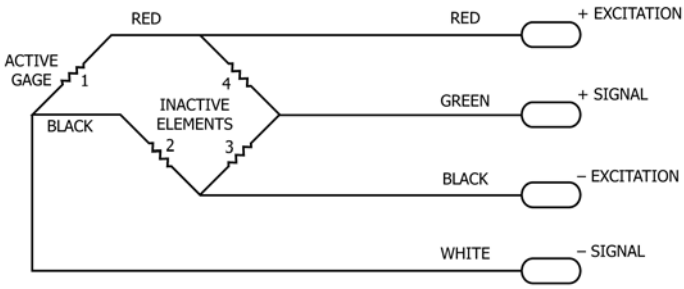

FIG. 2 Designations of Resistance Strain Gage Bridge and Color Code of Lead Wires (Quarter Bridge)

detection of surface deformation requires appropriate and consistent strain gage and bonding technique selection, surface preparation, procedures for gage installation and adhesive use, lead wire connection, validation of operation, and protective coating application.

5. Strain gage Selection

5.1 Carefully consider the intended use when selecting an appropriate strain 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 terminal type and configuration, temperature compensation characteristics, resistance of active elements, gage factor, and options desired.

NOTE 1—Strain gage manufacturers provide detailed critiques of the various factors that affect strain gage selection (1)[4]

5.2 Factors that should also be considered include type of test or application, operating temperature range, environmental 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 strain gage resistance and size of grid.

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

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

5.4 A two- or three-element rosette strain gage should be used unless the strain state is unquestionably uniaxial. A single-element strain 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 strain gage should be selected to match the thermal coefficient of expansion of the base material, where possible.

NOTE 2—For extreme temperature changes, the accuracy of nominal or handbook data on the thermal expansion characteristics of the base material can be insufficient, and actual calibration can improve the accuracy.

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

6. Bonding Technique Selection

6.1 Select the proper bonding technique and adhesive. Because the adhesive becomes part of the strain gage system, many of the strain gage selection factors should be considered in bonding technique or adhesive selection.

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

6.3 Strain gage manufacturers' bonding instructions should be considered when making a selection.

NOTE 3—Strain gages from different manufacturers can differ. Generally, each manufacturer will supply instructions and recommendations for bonding.

7. Surface Preparation

7.1 Properly prepare the surface 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 shall be compatible with the strain gage, bonding method, and base material.

NOTE 4—Erroneous strain gage readings can be caused by poor bonding of strain gages, which could be due to unremoved coatings such as paint, scale, rust, and oils. Poor bonding can also result from applying strain gages to improperly prepared surfaces, such as mirror smooth finishes or surfaces containing deep pits and gouges.

7.2 Strain gage manufacturers' surface preparation suggestions and recommendations should be reviewed and considered when preparing base material surfaces for the particular strain gages selected.

8. Strain Gage Installation—General

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

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