



Standard Guide for Testing Sheathed Thermocouples, Thermocouple Assemblies, and Connecting Wires Prior to, and After Installation or Service¹

This standard is issued under the fixed designation E1350; 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.

INTRODUCTION

Thermocouples are widely used in industry and provide reliable service when used within their specified temperature range. However, if thermocouples fail in service the consequences can range from insignificant to life-threatening. Often, a costly loss of equipment, product, or operating time will result. The user should weigh the potential consequences of thermocouple failure when considering which tests should be performed either prior to, during, or after installation.

This standard is a guide for the field testing of thermocouples, thermocouple assemblies, and their connecting wires to ensure that they were not damaged during storage, installation, or use rather than being a guide for acceptance testing of thermocouples as delivered from the vendor. The test methods range from basic tests to verify that the thermocouple was properly installed to tests necessary for failure analysis. Thermocouple tests such as homogeneity, capacitance, and loop-current step-response require elaborate equipment and sophisticated analysis and are not included in this guide.

Faulty installation practices and in-service operation beyond prescribed limits are frequently the cause of failure in properly made sheathed thermocouples. Many of the most common types of these application errors may be identified through use of the test methods described in this document. For further information, the reader is directed to MNL 12, Manual on the Use of Thermocouples in Temperature Measurement,² which is an excellent reference document on metal sheathed thermocouples.

1. Scope

1.1 This guide covers methods for users to test metal sheathed thermocouple assemblies, including the extension wires just prior to and after installation or some period of service.

1.2 The tests are intended to ensure that the thermocouple assemblies have not been damaged during storage or installation, to ensure that the extension wires have been attached to connectors and terminals with the correct polarity, and to provide benchmark data for later reference when testing to assess possible damage of the thermocouple assembly after operation. Some of these tests may not be appropriate for

thermocouples that have been exposed to temperatures higher than the recommended limits for the particular type.

1.3 The tests described herein include methods to measure the following characteristics of installed sheathed thermocouple assemblies and to provide benchmark data for determining if the thermocouple assembly has been subsequently damaged in operation:

1.3.1 *Loop Resistance:*

1.3.1.1 Thermoelements,

1.3.1.2 Combined extension wires and thermoelements.

1.3.2 *Insulation Resistance:*

1.3.2.1 Insulation, thermocouple assembly,

1.3.2.2 Insulation, thermocouple assembly and extension wires.

1.3.3 *Seebeck Voltage:*

1.3.3.1 Thermoelements,

1.3.3.2 Combined extension wires and thermocouple assembly.

1.4 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the*

¹ This guide is under the jurisdiction of ASTM Committee E20 on Temperature Measurement and is the direct responsibility of Subcommittee E20.14 on Thermocouples - Testing.

Current edition approved July 1, 2023. Published July 2023. Originally approved in 1991. Last previous edition approved in 2018 as E1350 – 18. DOI: 10.1520/E1350-18R23.

² *Manual on the Use of Thermocouples in Temperature Measurement*, MNL 12, ASTM. Available from ASTM International, www.astm.org.

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.

1.5 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:³

E230 Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples

E344 Terminology Relating to Thermometry and Hydrometry

E780 Test Method for Measuring the Insulation Resistance of Mineral-Insulated, Metal-Sheathed Thermocouples and Mineral-Insulated, Metal-Sheathed Cable at Room Temperature

E839 Test Methods for Sheathed Thermocouples and Sheathed Thermocouple Cable

E1129/E1129M Specification for Thermocouple Connectors
E608/E608M Specification for Mineral-Insulated, Metal-Sheathed Base Metal Thermocouples

E1684 Specification for Miniature Thermocouple Connectors

E2181/E2181M Specification for Compacted Mineral-Insulated, Metal-Sheathed, Noble Metal Thermocouples and Thermocouple Cable

MNL 12 Manual on the Use of Thermocouples in Temperature Measurement

3. Terminology

3.1 *Definitions*—The definitions given in Terminology **E344** shall apply to this guide.

3.2 Definitions of Terms Specific to This Standard:

3.2.1 *extension wires, n*—pair of wires having temperature-emf characteristics that match the thermocouple temperature-emf characteristics over a specified temperature range.

3.2.2 *junction class, n*—Style U junctions are electrically isolated from conductive sheaths and from reference ground and Style G junctions are electrically connected to conductive sheaths.⁴

3.2.3 *sensing circuit, n*—the combination of the thermoelements and extension wires, but excluding active signal conditioning components such as reference junction compensators, amplifiers, and transmitters.

3.2.4 *sheathed-thermocouple assembly, n*—an assembly consisting of one or more pairs of thermoelements within ceramic insulation contained within a metal protective sheath (also referred to as MIMS), having a junction, or junctions,

electrically joined to form a thermocouple, or thermocouples, with its associated parts.

3.2.4.1 *Discussion*—An assembly may include associated parts such as a terminal block and a connection head. The metal protecting tube, or sheath, has a moisture seal at the reference junction end. Usually the metal sheath is welded closed at the measuring end. However, if the thermocouple has an exposed junction, it must have an effective moisture seal at the measuring end as well as at the reference junction end.

3.2.5 *terminal block, n*—a terminal device for mechanical connection of thermoelements and extension wires or for the connection of extension wires to each other or to instruments.

3.2.6 *thermocouple connector, n*—a quick-connect plug and jack in which the electrically connecting components have temperature-emf characteristics matching the extension wires or thermoelements they are intended to connect.

3.2.6.1 *Discussion*—The temperature-emf characteristics of the connector parts will match the extension wires or the thermoelements only over a specified temperature range. Thermocouple connectors are described in Specifications **E1129/E1129M** and **E1684**.

4. Summary of Tests

4.1 Loop Resistance Measurements:

4.1.1 *Thermocouple*—The electrical loop resistance is compared to the resistance measured before installation to ensure that the thermoelements have not been broken or been short circuited (for example, at the thermocouple connector) during the installation process.

4.1.2 *Sensing Circuit*—The measurements may be used to establish the loop resistance of the combined thermocouple assembly and extension wires and to ensure that the extension wires are not shorted and that all connections are secure. The resistance of the extension wires should be measured separately before they are connected to the thermocouple assembly.

4.2 Insulation Resistance Measurements:

4.2.1 *Thermocouple Assembly*—The room temperature insulation resistance of the installed Style U thermocouple assembly is compared to the resistance measured before installation to ensure that the sheath and moisture seal have not been damaged and that the thermoelements were not shorted to the sheath during installation.

NOTE 1—This test applies only to thermocouple assemblies with Style U thermocouple junctions or exposed junction thermocouples with an effective moisture seal at the junction. Thermocouples having Style G junctions cannot be tested in this manner.

4.2.2 *Sensing Circuit*—The measurement is to establish that the electrical isolation of the Style U thermocouples has not been degraded by the extension circuit.

4.2.3 *Extension Wires*—The measurement is to establish that the extension wires are continuous and not shorted to each other, or to any other component, including earth ground. This is a necessary measurement when Style G thermocouples are tested.

4.3 Seebeck Voltage Measurements:

4.3.1 *Thermocouple Assembly*—The measurement, dependent on a temperature difference between the measuring

³ 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.

⁴ Historically referred to as class 1 and class 2 junctions.