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Designation: E574 – 19

Standard Specification for Duplex, Base Metal Thermocouple Wire With Glass Fiber or Silica Fiber Insulation[1]

This standard is issued under the fixed designation E574; 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.

1. Scope

1.1 This specification sets forth the requirements for duplex, types E, J, K, N and T thermocouple wire, insulated with E-glass, S-glass, amorphous silica fiber or polycrystalline fiber.

1.2 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

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]

D1125 Test Methods for Electrical Conductivity and Resistivity of Water

E207 Test Method for Thermal EMF Test of Single Thermoelement Materials by Comparison with a Reference Thermoelement of Similar EMF-Temperature Properties

E220 Test Method for Calibration of Thermocouples By Comparison Techniques

E230/E230M Specification for Temperature-Electromotive Force (emf) Tables for Standardized Thermocouples

E344 Terminology Relating to Thermometry and Hydrometry

3. Terminology

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

3.2 *Definitions of Terms Specific to This Standard:*

3.2.1 *amorphous silica fiber, n*—continuous filament of heat-insulating material whose principal constituent is amorphous silica.

3.2.2 *duplex wire, n*—matched pair of parallel, solid thermoelements, individually insulated (double wrap or braid) with insulating fibers and a fiber braid of the same material overall.

3.2.3 *E-glass, n*—family of calcia-alumina-silicate glasses that are used for general purposes and most electrical applications.

3.2.4 *impregnate, v*—to saturate the fiber insulation of wires with a high-temperature electrical insulating compound to form a moisture barrier around the wires and to inhibit fraying of the fibers.

3.2.5 *polycrystalline fiber, n*—continuous polycrystalline filament of heat-insulating material whose composition is alumina, boria, and silica in an approximate ratio of 3:1:2, respectively.

3.2.6 *S-glass, n*—family of magnesia-alumina-silicate glasses with a higher tensile strength and higher softening temperature than E-glass.

4. Significance and Use

4.1 This specification presents the requirements for impregnated and non-impregnated fiber-insulated thermocouple wire for normally accepted industrial use, but does not attempt to define such usage.

4.2 A supplement contains the requirements for insulated thermocouple wire that will be exposed to high humidity. The purchase order or inquiry shall specify if the requirements in this supplement are required.

5. Classification

5.1 *Class A–Duplex*—E-glass fiber insulated, impregnated with a high-temperature electrical insulating compound and color-coded in accordance with Specification E230/E230M.

[1] This specification is under the jurisdiction of ASTM Committee E20 on Temperature Measurement and is the direct responsibility of Subcommittee E20.12 on Thermocouples - Specifications.

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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.

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5.2 *Class B–Duplex*—E-glass fiber insulated (Note 1) not impregnated and not color-coded.

5.3 *Class C–Duplex*—Amorphous silica fiber insulated (Note 2) not impregnated and not color-coded.

5.4 *Class D–Duplex*—Polycrystalline fiber insulated (Notes 2 and 3) not impregnated and not color-coded.

5.5 *Class E–Duplex*—S-glass fiber insulated, impregnated with a high-temperature electrical insulating compound and color-coded in accordance with Specification E230/E230M.

5.6 *Class F–Duplex*—S-glass fiber insulated (Note 1) not impregnated and not color-coded.

NOTE 1—May be heat treated to retard fraying when specified in the ordering information (6.1.8).

NOTE 2—Fibers may be pre-treated with an organic compound to facilitate braiding.

NOTE 3—May be heat cleaned after braiding to remove organic compound when specified in the ordering information (6.1.8).

6. Ordering Information

6.1 The purchase order shall specify the following information:

6.1.1 Total insulated wire length,

6.1.2 Thermocouple type,

6.1.3 Tolerance on initial values of emf versus temperature (standard or special),

6.1.4 Class of insulation (see Section 5);

6.1.5 Thermoelement diameter (see 7.1.2);

6.1.6 Minimum acceptable continuous length per spool, if applicable;

6.1.7 Supplementary testing, if required (see Supplementary Requirements);

6.1.8 Special requirements (if any);

6.1.9 Deviations or special requirements not covered herein; and

6.1.10 Required documentation (see Section 9).

7. Technical Requirements

7.1 *Insulated Thermocouple Wire:*

7.1.1 *Materials*—Thermoelements shall be solid thermocouple grade materials with a smooth, bright finish (Note 4) and shall be fully annealed prior to insulating.

NOTE 4—An optional copper-flash coating on the iron thermoelement for type J thermocouple material is permitted to prevent rusting. This coating must be applied uniformly so that the final calibration tolerance requirement for the specific insulating material is still met.

7.1.2 *Sizes*—Thermoelements shall be specified in American Wire Gauge (AWG) nomenclature. Corresponding thermoelement diameters shall be as listed in Table 1.

7.1.3 *Calibration:*

7.1.3.1 *Standard Method*—When required by the purchase order, calibration of the insulated thermocouple wire shall be performed by one of the procedures described in Test Method E207 or E220.

7.1.3.2 *Thermoelement Initial Calibration Tolerances*—Standard and special tolerances on initial values of emf versus temperature are given in Table 1 of Specification E230/E230M. The purchase order shall specify whether standard or special tolerances are required.

TABLE 1 Maximum Outside Transverse Dimensions of Insulated Wire

Uninsulated Thermoelement Diameter			Maximum Outside Dimensions			
Gage (AWG)	Nominal Diameter		Classes A, B, E and F		Classes C and D	
	mm	(in.)	mm	(in.)	mm	(in.)
20	0.8	(0.032)	2.7	(0.105)	4.5	(0.180)
22	0.6	(0.025)	2.3	(0.090)	4.1	(0.160)
24	0.5	(0.020)	2.1	(0.080)	3.8	(0.150)
30	0.3	(0.010)	1.7	(0.065)	none	

7.2 *Insulation Materials:*

7.2.1 Individual thermoelements shall be covered with a braid, or double wrap (one wrap in each direction) of glass fibers (Classes A and E), a braid of glass fibers (Classes B and F), or braid of fibers (Classes C and D).

7.2.2 The outer covering shall consist of a braid of the same material applied over the bare thermoelements.

7.2.3 For Classes A and E duplex thermoelements, the insulation on the individual thermoelements and the outer braid shall be impregnated with a moisture and heat-resistant electrical insulating compound. The fibers shall be bonded sufficiently to each other to prevent fraying under normal conditions of installation and service.

7.2.4 Each individual Class A and E thermoelement wrap or braid and the outer braid shall be color-coded in accordance with Specification E230/E230M.

7.2.5 The purchase order may specify that an enamel coating be applied to each bare thermoelement designated as Class A and Class E.

7.2.6 Classes B, C, D and F insulated thermoelements are supplied without impregnation, color coding, or enamel (Notes 1-4).

7.2.7 Insulating materials shall be suitable for continuous use up to temperatures listed in Table 2.

7.2.8 The amount of insulation coverage affects the durability and abrasion resistance of the insulating material. Application conditions should be discussed with the manufacturer to address these needs.

7.3 *Dimensions and Finish:*

7.3.1 The maximum outside transverse dimension as shown in Fig. 1, including outer covering of insulated duplex thermocouple wire, shall not exceed the dimensions given in Table 1.

TABLE 2 Maximum Recommended Continuous Use Temperatures for Insulating Materials

Materials	Temperature	Comment
Enamels and impregnants	200 °C (400 °F)	May be used to 500 °C (930 °F) with decomposition and color loss in hot zone
E-Glass fibers (not impregnated)	340 °C (650 °F)	Retains 75 % of tensile strength, softens at 730 °C (1350 °F)
S-Glass fibers (not impregnated)	395 °C (750 °F)	Retains 80 % of tensile strength, softens at 850 °C (1560 °F)
Amorphous silica fibers (not impregnated)	980 °C (1800 °F)	None
Polycrystalline fibers (not impregnated)	1250 °C (2300 °F)	None

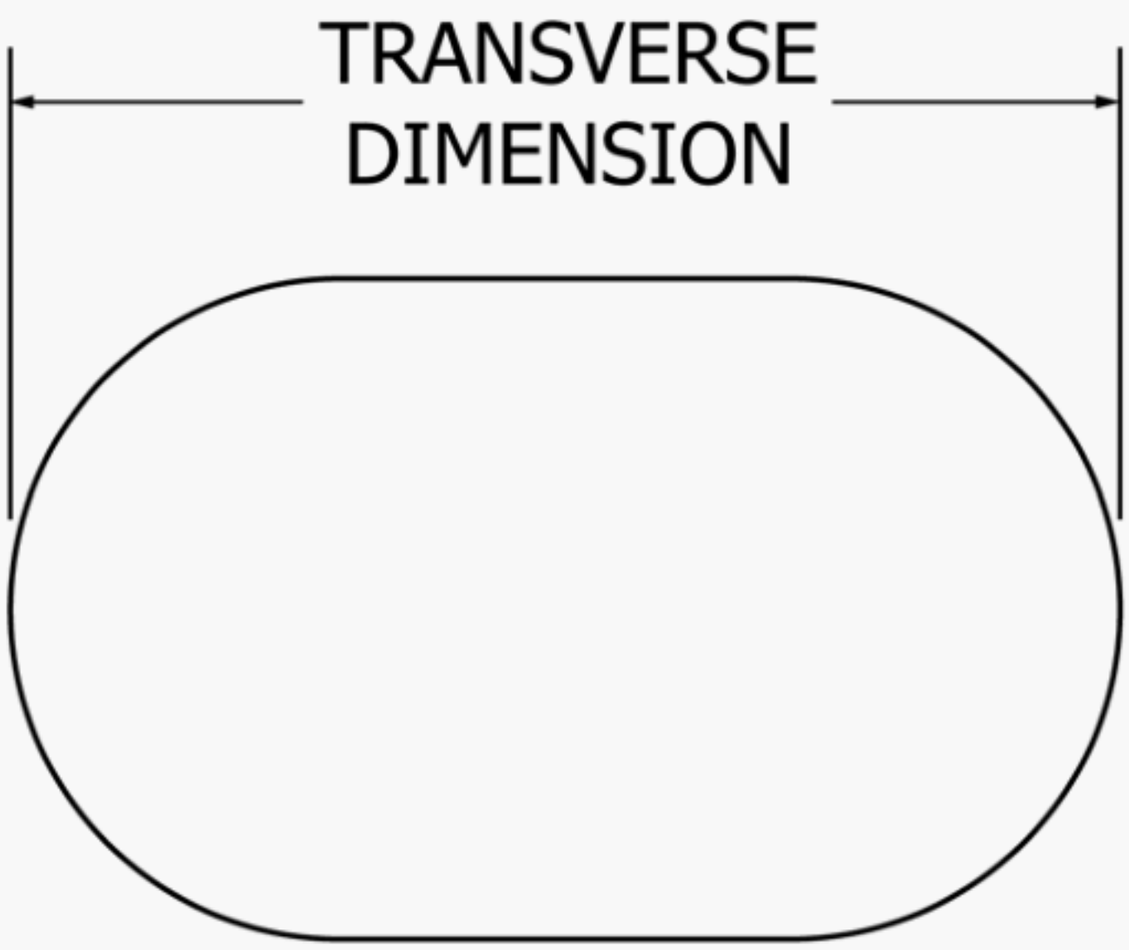

FIG. 1 Transverse Dimension

7.3.2 The duplex insulated thermocouple wire shall be capable of being wound around a mandrel having a diameter of 1.5 times the maximum outside dimension (Table 1) without cracking or fracturing of the insulation to an extent visible to the unaided eye.

8. Packaging and Package Marking

8.1 The insulated thermocouple wire shall be packaged for shipment in containers that will protect it from physical damage and moisture.

8.2 The insulated thermocouple wire shall be wound on spools, one continuous length per spool. The purchase order shall specify accessibility of the inner 3 m (10 ft) of insulated wire on the spool, when required by the user.

8.3 The minimum spool core diameter for fiber insulated duplex thermocouple wire shall be 50 mm (2 in.).

8.4 Spools or inner packaging shall be marked plainly with the following:

8.4.1 Thermocouple type,

8.4.2 Thermoelement diameter,

8.4.3 ASTM specification and insulation class,

8.4.4 Manufacturer's name,

8.4.5 Length of wire on spool, and

8.4.6 Thermoelectric tolerance (standard or special).

9. Quality Assurance Procedure

9.1 This specification recognizes the need for quality assurance and control of the product being supplied. The level of quality assurance requirements, enforcement, and documentation must be determined by the application and specified in the purchasing documents. Table 3 lists the tests which shall be performed on the specific lot of insulated wire furnished, when specified in the purchase order:

9.1.1 The absence of specified testing does not relieve the manufacturer of the responsibility to supply material meeting the technical requirements of this specification (excluding Supplementary Requirement S1). The manufacturer may perform any of the listed tests and any other test deemed necessary to ensure the quality of the material. The user may perform any of the listed tests (see above) as the basis of acceptance.

9.2 The test covered by Supplementary Requirement S1 shall be performed by the manufacturer when specified in the purchase document.

9.3 The manufacturer shall supply the following when specified in the purchase document:

9.3.1 A statement of compliance certifying that all material supplied is in accordance with this specification, and

9.3.2 The results of specified tests.

10. Keywords

10.1 amorphous silica fiber insulated wire; duplex insulated thermocouple wire; glass fiber insulated wire; glass insulated thermocouple wire; insulated thermocouple wire; polycrystalline fiber insulated wire; thermocouple wire

TABLE 3 Tests to be Performed when Specified in the Purchase Order

Test	Paragraph
Size Verification	7.1.2, 7.3.1, 8.3
Calibration	7.1.3
Insulation Quality	7.3.2

SUPPLEMENTARY REQUIREMENTS

The following supplementary requirements shall apply only when specified by the purchaser in the inquiry or purchase order.

S1. Resistance Test

S1.1 The finished Classes A and E duplex insulated wire shall be capable of passing the following wet insulation resistance test (Note S1): A sample of wire at least 300 mm (12 in.) long shall be bent at its center 180° around a 13 mm (½ in.) diameter mandrel to form a U-shaped loop with straight sides.

S1.2 The loop shall be immersed to a depth of 50 mm ± 6 mm (2 in. ± ¼ in.) in 25 °C ± 2 °C (77 °F ± 4 °F) water having a resistivity (Note S2) of not more than 1×10^3 Ω-cm for at least 10 min.

NOTE S1—The purchasing document may specify an alternate wet

insulation resistance test which has been agreed upon by the purchaser and the manufacturer.

NOTE S2—The resistivity of water shall be determined in accordance with Test Methods D1125.

S1.3 The wet insulation resistance will be acceptable if the current is less than 50 µA when 180 V dc is impressed between the thermoelements or a megohmeter meter measures more than 3.6×10^6 Ω resistance when a minimum of 200 V dc is impressed between the thermoelements.

S2. Precision and Bias

S2.1 Wet insulation resistance measurement in the supplementary requirement is primarily used to determine the moisture resistance of the insulated thermocouple wire over a specified arbitrary time period. Both parties should concur as to the sampling procedure prior to undertaking this pass or fail test. Consequently, statements of precision and bias are not relevant.

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