Designation: B 84 – 07

Standard Test Method for Temperature-Resistance Constants of Alloy Wires for Precision Resistors[1]

This standard is issued under the fixed designation B 84; 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 test method covers determination of the change of resistance with temperature of alloy wires used for resistance standards and precision resistors for electrical apparatus.

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 become familiar with all hazards including those identified in the appropriate Material Safety Data Sheet (MSDS) for this product/material as provided by the manufacturer, to establish appropriate safety and health practices, and determine the applicability of regulatory limitations prior to use.*

2. Significance and Use

2.1 Procedure A covers the determination of the equation of the curve relating resistance and temperature where the curve approximates a parabola. This test method may be used for wire of any metal or alloy over the temperature interval appropriate to the material.

2.2 Procedure B covers the determination of the mean temperature coefficient of resistance for wire of any metal or alloy over the temperature interval appropriate to the material.

3. Apparatus

3.1 The apparatus for making the test shall consist of one or more baths for maintaining the specimen at the desired temperatures; thermometers for measuring the temperatures of the baths; and suitable means for measuring the resistance of the specimen. Details of the apparatus are given in Sections 4 to 6.

4. Baths

4.1 Baths for use from −65 to +15°C may consist of toluol, or equivalent.

4.2 Baths for use above 15 to 250°C may consist of chemically neutral oils with a low viscosity, having a flash point at least 50°C higher than the temperature of use.

4.3 The liquid in these baths shall be of such quantity and so well stirred that the temperature in the region occupied by the specimen and the thermometer will be uniform within 0.5°C for any temperature between − 65 and +100°C, and within 1.0°C for any temperature above 100 to 250°C. If the temperature range is less than 100°C, the uniformity of temperature shall be proportionately closer.

NOTE 1—It is recommended that a solvent bath at room temperature shall be used to rinse specimens before immersion in any temperature bath.

5. Temperature Measurement Apparatus

5.1 The temperature shall be measured to an accuracy of ±0.5°C, or 1 % of temperature range, whichever is smaller.

6. Resistance Measurement Apparatus

6.1 The change of resistance of the specimen shall be measured by apparatus capable of determining such changes to 0.001 % of the resistance of the specimen if the temperature range is 50°C or more. If the temperature range is less than 50°C, the accuracy of the resistance change measurements shall be correspondingly greater.

6.2 The connections from the specimen to the measuring device shall be such that changes in the resistance of these connections due to changes in their temperature do not appreciably affect the measurement of the change in resistance of the specimen.

6.3 The temperature of the measuring apparatus shall not change during the test by an amount sufficient to introduce appreciable errors in the results. With apparatus of good quality, a change in 1°C in room temperature is allowable.

6.4 The test current shall not be of such a magnitude as to produce an appreciable change in resistance of the specimen or measuring apparatus due to the heating effect. To determine experimentally that the test current is not too large, the specimen may be immersed in a bath having a temperature at which it has been found that the wire has a relatively large change in resistance with temperature. Apply the test current and maintain until the resistance of the specimen has become

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constant. Then increase the current by 40 % and maintain at this value until the resistance has again become constant. If the change in resistance is greater than 0.01 %, the test current is too large and shall be reduced until the foregoing limitation is reached.

6.5 The measurements shall be made in such a way that the effects of thermoelectromotive forces and parasitic currents are avoided. When these effects are small, the resistance of the specimen may be obtained by either of the following methods:

6.5.1 Obtain the galvanometer zero with the galvanometer key open. Balance the bridge both with the direct and reversed connection of the battery, the average value of the two results being the resistance of the specimen.

6.5.2 Obtain the zero of the galvanometer with the galvanometer key closed and the battery key opened. A single balance of the bridge is then sufficient to obtain the resistance of the specimen.

7. Sampling

7.1 Take one test specimen from each continuous length of the material to be tested.

8. Test Specimen

8.1 The test specimen shall be of a length that will give a resistance that can be measured to the required accuracy.

8.2 If the wire is insulated, it may be wound in a circular, open coil not less than 50 mm in diameter.

8.3 If the wire is not insulated, it may be wound on an insulating form of a type that will not introduce strains in the wire when subjected to temperature changes.

8.4 The tension used in winding shall be no more than sufficient to produce a neat coil of insulated wire or to prevent the touching of adjacent turns when bare wire is wound on an insulating form.

8.5 For fine wires of sufficiently high-resistivity alloys, straight wire specimens may be used. Precautions should be taken to avoid the introduction of strains in the sample during preparation.

9. Terminals

9.1 For specimens having a resistance so large that the resistance of the leads is negligible, a copper wire may be brazed, soldered, or welded to each end of the specimen for use as a terminal. The resistance of the copper terminals shall be less than 0.02 % of the resistance of the specimen.

9.2 If the resistance of the specimen is less than 10 Ω, so that it is necessary to use both current and potential terminals in measuring the resistance, two copper wires may be brazed, soldered, or welded to each end of the specimen for use as terminals. The terminals shall be placed so that the measured potential does not include the potential drop in the current connections.

9.3 In coils made of fine wire where there is not sufficient rigidity in the coil itself to furnish a satisfactory support for the terminals, short lengths of thin glass or ceramic rods may be found across the coil to act as struts and furnish an anchorage for the terminals.

10. Preliminary Treatment of Specimen

10.1 The finished specimen shall be subjected to a baking treatment as necessary to stabilize the resistance of the specimen. For manganin the treatment shall be at 140 ± 10°C continuously for a period of 48 h.

11. Procedure A

11.1 Connect the test specimen in the measuring circuit and submerge entirely in the bath. For a check on the constancy of the specimen, make an initial resistance measurement at 25°C. Raise the temperature of the bath or transfer the specimen to a bath maintained constant at the highest temperature at which measurements are to be made. When the specimen has attained a constant resistance, record the reading of the measuring device and the temperature of the bath.

11.2 Decrease the temperature of the test specimen to the next lower temperature either by cooling the bath and maintaining it constant at the next lower temperature, or by removing the specimen to another bath maintained at the lower temperature. When the resistance of the specimen has become constant, again make observations of resistance and temperature.

11.3 In this manner, make a series of determinations of the change of resistance with temperature for the desired descending temperature range, measurements being taken at intervals of approximately 10 % of the temperature range or any temperature interval specified by agreement between producer and consumer.

11.4 Test at not less than four temperatures.

11.5 Note the temperature of the measuring apparatus at frequent intervals during the test of each specimen.

12. Procedure B

12.1 See Section 11, except 11.4. Tests shall be made at not less than three temperatures, including 25°C.

13. Resistance-Temperature Equation

13.1 Express the results in terms of the constants in an equation of the following form:

$$R_t = R_{25}[1 + \alpha(t - 25) + \beta(t - 25)^2] \quad (1)$$

where:

R_t = resistance of the specimen in ohms at temperature, °C, t,
R_{25} = resistance of the specimen in ohms at the standard temperature of 25°C,
t = temperature of specimen, °C, and
α *and* β = temperature-resistance constants of the material.

Temperature of maximum or minimum resistance

$$= 25°C - (\alpha/2\beta)$$

NOTE 2—This equation will yield either a maximum or a minimum, depending on which exists in the temperature range in question. However, this equation is normally used for those alloys such as manganin, having a temperature-resistance curve approximating a parabola with a maximum near room temperature.