Designation: B78 – 90 (Reapproved 2013)

Standard Test Method of Accelerated Life of Iron-Chromium-Aluminum Alloys for Electrical Heating[1]

This standard is issued under the fixed designation B78; 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 the determination of the resistance to oxidation of iron-chromium-aluminum electrical heating alloys at elevated temperatures under intermittent heating using a constant-temperature cycle test. This test is used for internal comparative purposes only.

1.2 The values stated in inch-pound units are to be regarded as standard. The values given in parentheses are mathematical conversions to SI units that are provided for information only and are not considered 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 This test method is used by producers of electrical heating alloys to measure the cyclic oxidation resistance of these alloys.

2.2 Because of the effect of environment, design and use, the life values obtained from this test method may not correlate with that of an appliance or industrial heating unit.

3. Test Panel

3.1 *Size and Location*—The dimensions of the test panel shall be similar to those shown in Fig. 1. The test panel shall be located in a position free from drafts of air.

3.1.1 The enclosure shall fit tightly on the panel and the glass slide shall fit snugly to prevent leakage of air at this point during the operation of the test, as even a slight draft of air in contact with the specimen will cause excessive variation in length of life. A screen of 40 wire mesh, 0.010-in. (0.025 mm) wire diameter, market grade, may be used as a cover over the individual stations.

3.2 *Terminals*—The two terminals shall be spaced 2 in. (50.8 mm) apart, center to center and shall be so positioned that the wire specimen when secured therein shall be in a U-shaped pattern as described in Section 5. The specimen terminal junctions shall be 3 in. (76.2 mm) lower than the plane of the top of the enclosure.

4. Apparatus

4.1 The apparatus shall be similar to the requirements specified in 4.2 to 4.8, inclusive, and shall be connected as shown in Fig. 2.

4.2 *Power Supply*—The transformer or motor generator set shall be capable of delivering a controlled voltage of from 10 to 35 V to the circuit. It shall have a continuous current capacity of at least 20 A/specimen.

4.3 *Voltage Control*—The automatic voltage control shall be capable of maintaining across the bus bars a constant voltage within ±0.5 %.

NOTE 1—It has been found impossible to make accurate tests without voltage control, as changes in line voltage are sufficient to cause considerable variation in the results obtained (see Annex A1).

4.4 *Variable Transformer*—The variable transformer shall be capable of adjusting the voltage across the specimen to within approximately 0.25 % of any desired value within the working range and shall have a continuous current rating of approximately 25 A.

NOTE 2—A variable transformer having a working range of adjustability from approximately 0 to 20 V, provides for testing wires within a considerable range of size and resistivity.

4.5 *Ammeter and Voltmeter*—The ammeter and voltmeter shall have an accuracy of 1 % of normal test deflection (approximately 15 A and 15 V respectively). For alternating current the range shall be such as to give a reading above the lower fifth of the scale range. The ammeter has appreciable resistance. A compensating resistance shall be cut into the circuit to replace the resistance of the ammeter so that the over-all resistance of the circuit is not changed. This resistance shall be inserted in series with the contact of the upper switch shown in Fig. 2.

[1] This test method is under the jurisdiction of ASTM Committee B02 on Nonferrous Metals and Alloys and is the direct responsibility of Subcommittee B02.10 on Thermostat Metals and Electrical Resistance Heating Materials.

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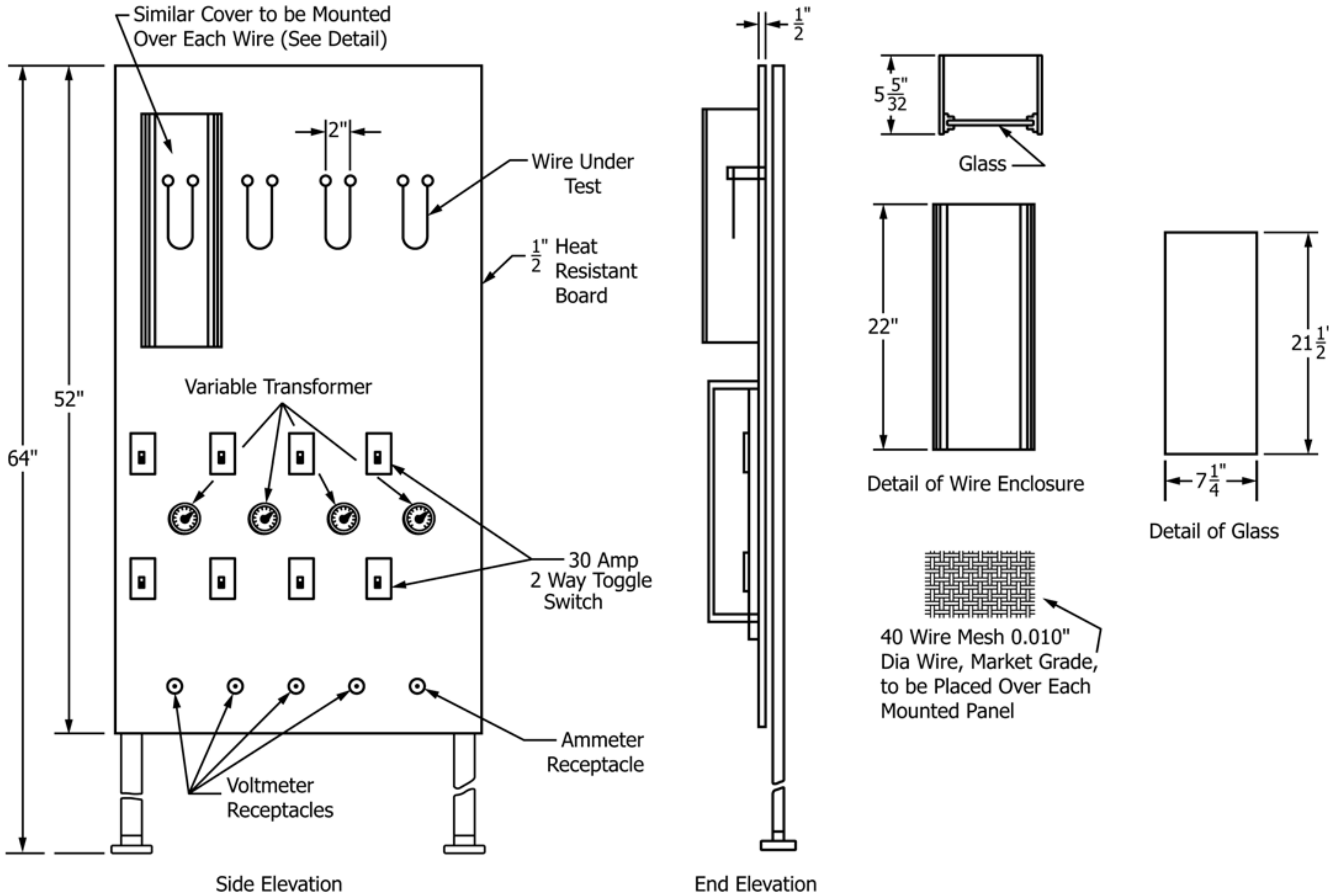

Metric Equivalents

in.	mm
½	12.7
5⁵⁄₃₂	131.0
7¼	184.2
21½	546
22	559
52	1321
64	1626

FIG. 1 Test Panel

4.6 *Optical Pyrometer or Infrared Thermometer* The optical system shall be such as to provide a magnification of at least four diameters. This may be accomplished by means of a special lens or combination of two standard lenses in the objective to provide a short focal length and the desired magnification (see Annex A1). These instruments must have an accuracy of ±10°F (5.5°C) and UBS traceability.

NOTE 3—It is highly important that the temperatures of the test specimen be adjusted as accurately as possible, as small variations in temperature result in considerable variation in length of life. Optical pyrometer or infrared pycnometer makes it possible to determine the temperature at any particular point on the wire, and with the arrangement described, the temperature of a comparatively small wire may be taken quite readily.

4.7 *Interrupter*—Some form of apparatus shall be used as an interrupter to open and close the circuit.

4.8 *Apparatus for Recording Time of Burnout*—If no apparatus is available for recording the time of burnout, arrangements shall be made for hourly observations for burnouts.

5. Test Specimen

5.1 The test specimen shall be 0.0254 in. (0.645 mm) in diameter. The length of the wire selected for test shall be such as to give a test length of approximately 10 in. (254 mm).

5.2 The test specimen shall be representative with regard to the surface of the average of the coil or spool of wire which has been selected for test. Particular care shall be taken to see that the specimen selected is free from kinks. This precaution is necessary, since a kink, even though later removed may cause burnout at that point.

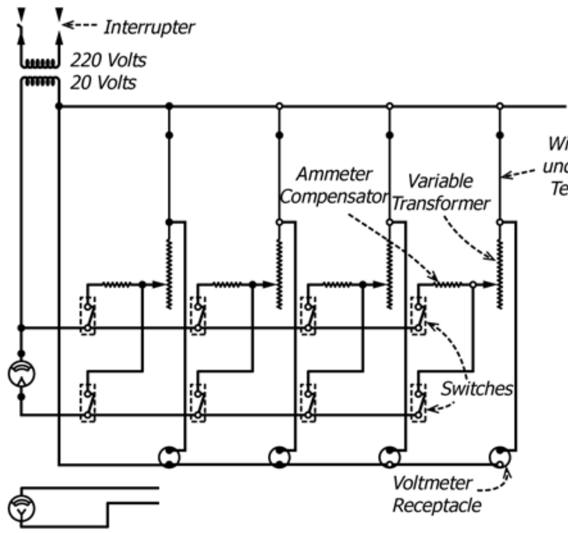

FIG. 2 Electrical Circuit Diagram for Accelerated Life Test

NOTE 4—It is also very desirable to select and keep as a reference standard for comparison, a spool or coil of wire that is uniform in cross section from one end to the other. Tests may then be made at any time on the reference standard, and if conditions have changed they will be noted by the length of life of the standard. Comparisons between tests made at different times on the standards and other wires may be correlated in this manner (see Annex A1).

6. Mounting Specimen

6.1 A straight length of the specimen shall be shaped into a "U" pattern, 10 in. (254 mm) of which shall be mounted between the terminals described in 2.2. The "U" pattern shall consist of two parallel legs and a semicircle of 1-in. (25.4-mm) radius, the plane of which is parallel to and equidistant from the front and back panels, and the legs of which are equally spaced from the side panels.

7. Ballast Resistance

7.1 The ballast resistance in series with the specimen shall be at least 60 % of the specimen resistance at the beginning of the test, but shall not be greater than the specimen resistance.

8. Test Temperature

8.1 The true temperature of the test shall be 2250°F (1232°C).

NOTE 5—The apparent temperature is approximately 50°F (27.8°C) lower than the true temperature for the type alloy composed of 23 % chromium, 5 % aluminum, and the remainder essentially iron. [2]

9. Procedure

9.1 Support the temperature measuring instrument so that it can be quickly adjusted and read.

9.2 Set the variable transformer at minimum voltage.

NOTE 6—Do not operate the interrupter while the temperature is being adjusted.

9.3 Close the switch in series with the specimen.

9.4 Adjust the variable transformer until the specimen is at a low red heat.

9.5 Adjust the temperature of the specimen to 2000°F (1093°C).

9.6 Allow the specimen to operate under this condition until 2 h have elapsed, in order to bring the emissivity nearer to a black body condition.

9.7 Set the temperature of the specimen to 2200°F (1204°C). Maintain this balance until 1 min has elapsed.

9.8 After another 13 min, readjust the temperature of the specimen to 2250°F (1232°C). Final adjustment shall be completed within the next minute or a total of 15 min. The end of this 15-min period is the start of the test. It is important to maintain this time schedule.

9.9 Measure the voltage and the current and record the values together with the starting temperature and time of starting the test.

9.10 Start the interrupter, the timing device of which shall have been previously regulated so that the "on" period and the "off" period shall be equal and shall each have a duration of 2 min.

NOTE 7—Various cycles have been tried varying from 10 min on and 5 min off to 30 s on and 30 s off, whence it was found that the 2-min-on and 2-min-off cycle gave the shortest life for a given temperature. It appears that sufficient cooling time has to be allowed to permit the specimen to reach a low enough temperature to cause any loosening or cracking of scale which will occur due to variations in coefficient of expansion of the scale and the metal. The heating and cooling operation is more damaging to wire than maintaining it at a definite temperature.

9.11 Adjust the temperature to the test temperature after 5 h and 24 h total elapsed time. Record the voltage and current after each resetting. Stop the interrupter before each resetting and start it again after making the observation.

9.12 After the first 24-h period and each 24 h thereafter until burnout, adjust the temperature of the specimen to the test temperature. After each temperature adjustment, observe and record the voltage and current.

10. Record

10.1 Measurements and observations shall be recorded on a data sheet similar to that shown in Fig. 3.

11. Report

11.1 Report the following information:

11.1.1 Nominal analysis,

11.1.2 Identification of specimen,

11.1.3 Cross-sectional dimensions of the specimen,

11.1.4 Life of the specimen in hours (total elapsed time from the end of the first 15-min aging period to burnout), and

11.1.5 The increase in resistance as noted for the last resistance reading before burnout.

12. Precision and Bias

12.1 The life test is an individual internal comparative test only. Too many variables exist to define a unit that would

[2] For reference see Roeser, W. F., "Spectral Emissivity (at 0.65μ) of Some Alloys for Electrical Heating Elements," *Proceedings*, ASTM, Vol 39, 1939, p. 780.

DATA SHEET FOR ACCELERATED LIFE TEST RECORD FOR IRON-CHROMIUM-ALUMINUM ALLOYS LABORATORY

DATE .... SHEET NO ....
SAMPLE .... NOMINAL ANALYSIS ....
DIAMETER OF SPECIMEN .... TEST TEMP DEG F .... OBSERVER ....

Date and Time	Elapsed Time, h	Voltage, V	Current, A	Resistance, Ω	Percent increase in Resistance
	¼				
	5				
	24				
	72				

Total Life of Specimen, h .... Approximate Growth at 72 h .... Approximate Total Growth at Burnout ....
Remarks—Including Physical Condition of Specimen after Test, and Nature and Color of Oxide.
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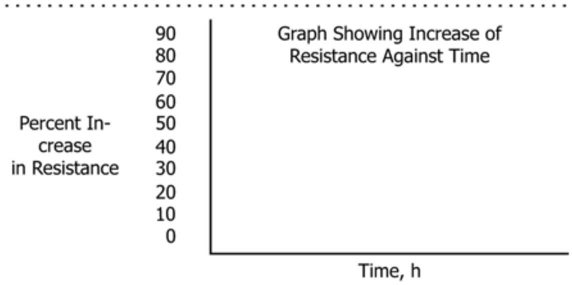

FIG. 3 Data Sheet for Accelerated Life Test Record for Iron-Chromium-Aluminum Alloys

enable precision and bias to be defined. Insufficient need exists to alter the existing test method. Therefore, precision and bias are not defined.

12.2 *Reproducibility*—In the course of the development of this test method, it has been found that the major source of irregularity is in respect to temperature measurement. Therefore, no attempt shall be made to run standard accelerated life tests until it has been definitely proved that the operator can obtain consistent results with specimens taken from the same sample coil or spool. Four or five specimens shall be tested at the same time to make sure that no variables, such as errors in temperature measurement, would affect one test and not another. Consecutive tests also shall be run. If the tests are properly made and controlled, the life of a number of specimens cut from the same spool should not vary more than ±10 % from the average.

13. Keywords

13.1 accelerated life test; heating alloys; iron-chromium-aluminum; life test; oxidation resistance

ANNEX

(Mandatory Information)

A1. PRECAUTIONS

A1.1 General

A1.1.1 Following are a few of the general considerations and precautions that should be kept in mind in the setting up and operation of the life test equipment and in the making of the accelerated life test.

A1.2 Temperature

A1.2.1 Temperature is one of the most important variables in a life test. The probable life of a wire varies inversely with an exponential function of the temperature. This is readily understandable when it is considered that the life of the wire when operated at a temperature close to the melting point will be but a few hours, while at lower temperatures, as for example, about a red heat, it will endure for several thousand hours.

A1.2.2 In general, it has been found desirable to use a temperature for any particular alloy which will result in a total life of approximately 100 h. Experience has indicated that this is a sufficient length of life to give a fair index of the quality of the material. A measure of the necessary length of time to get a good life test is shown by the consistency of the results; for example, if the test temperature is too high, the results are likely to be inconsistent since the excessive temperature causes aggravated hot spot conditions.

A1.2.3 To determine the temperature accurately, if the disappearing filament-type optical pyrometer is being used, the desired magnification can be obtained by substituting for the standard objective lens, another lens having approximately one half its focal length. The temperature of the wire under test is very greatly affected by drafts. The enclosure, therefore, should be left in place at all times during the temperature observation and the pyrometer reading made directly through the glass front of the enclosure. In taking this reading through the glass front, it is necessary to allow for the reflection and absorption of the glass. Reflection on the surface of the glass is the principal cause of error. This effect is nearly independent of the kind and thickness of the glass. Reflection from external light sources shall be avoided. A correction of approximately 10°F (5.5°C) or a correction as determined by a specific test for the conditions involved shall be added to the temperature as observed. The glass slide shall be kept clean at all times to avoid increase in the absorption of light.

A1.3 Voltage Control

A1.3.1 In a number of cases, it has been attempted to make life tests, using the regular line voltage with no regulation, but this has never succeeded in producing uniform results. It is absolutely essential that voltage control be used.