Doc. No.: MTD 03 (24951) WC
February, 2024

भारतीय मानक ब्यूरो

DRAFT FOR WIDE CIRCULATION

Draft *Indian Standard*

Method for Accelerated Life Test of Electrical Resistance Alloys for Heating Elements

(*Second Revision of IS 3394*)

ICS 77.120.40

Mechanical Testing of Metals Sectional Committee, MTD 03

Last date for receipt of comments is 27/03/2024

FOREWORD

(*Formal clause of the foreword will be added later*)

This standard was first published in 1965 and subsequently revised in 1985. In this revision the life of the heating element of alloys of Nickel-chromium, nickel-iron-chromium, iron-chromium-aluminium alloys, etc, under the prescribed conditions of the test shall be determined at specified temperatures, namely, 1120 °C, 1205 °C and 1230 °C. The selection of the particular alloy material would be made by the user on the basis of indigenous availability, cost and reliability for continued service as per IS 12045. 7 grades of alloys as per IS 12045 have been added along with their test temperatures. Test specimen dimensions have been incorporated for different type of alloys. This standard also covers the testing of specimens having shape other than wires.

Nickel-chromium, nickel-iron-chromium, iron-chromium-aluminium alloys, etc, have - high resistance to oxidation at elevated temperatures and are widely used for heating elements. The heating elements made of these alloys are suitable for heating devices, such as toasters, percolators, iron machines, heater pads and for electrical applications, namely, high-resistance rheostats and radio and moving-picture equipment, potentiometers, thermocouples and resistors. Method for carrying out the accelerated life test for these heating elements is covered in this standard.

For accuracy in test results some precautions are required to be observed while carrying out the test. Such precautions are described in Appendix A of this standard.

In reporting the result of a test or analysis made in accordance with this standard, is to be rounded off, it shall be done in accordance with IS 2 : 2022 ‘Rules for rounding off numerical-values (*second revision*)’.

Doc. No.: MTD 03 (24951) WC
February, 2024

Draft *Indian Standard*

Method for Accelerated Life Test of Electrical Resistance Alloys for Heating Elements

(*Second Revision of IS 3394*)

1 SCOPE

1.1 This standard prescribes the method for carrying out accelerated life test of electrical heating alloys for determining the resistance to oxidation of Nickel chromium iron, iron-chromium-aluminium, nickel-chromium and other nickel chromium ferrous alloys at elevated temperatures under intermittent heating.

2 PRINCIPLE OF TEST

2.1 The test consists of heating a wire or strip of suitable length and cross-section, at specified temperatures, by passing ac until the wire burn out or for a period of 100 hours, whichever is less. The current is alternately put on for two min and put off for two min. The wire shall be made in the form of U shape, connected between two terminals spaced at a given distance.

3 TEST PANEL

3.1 Size and Location

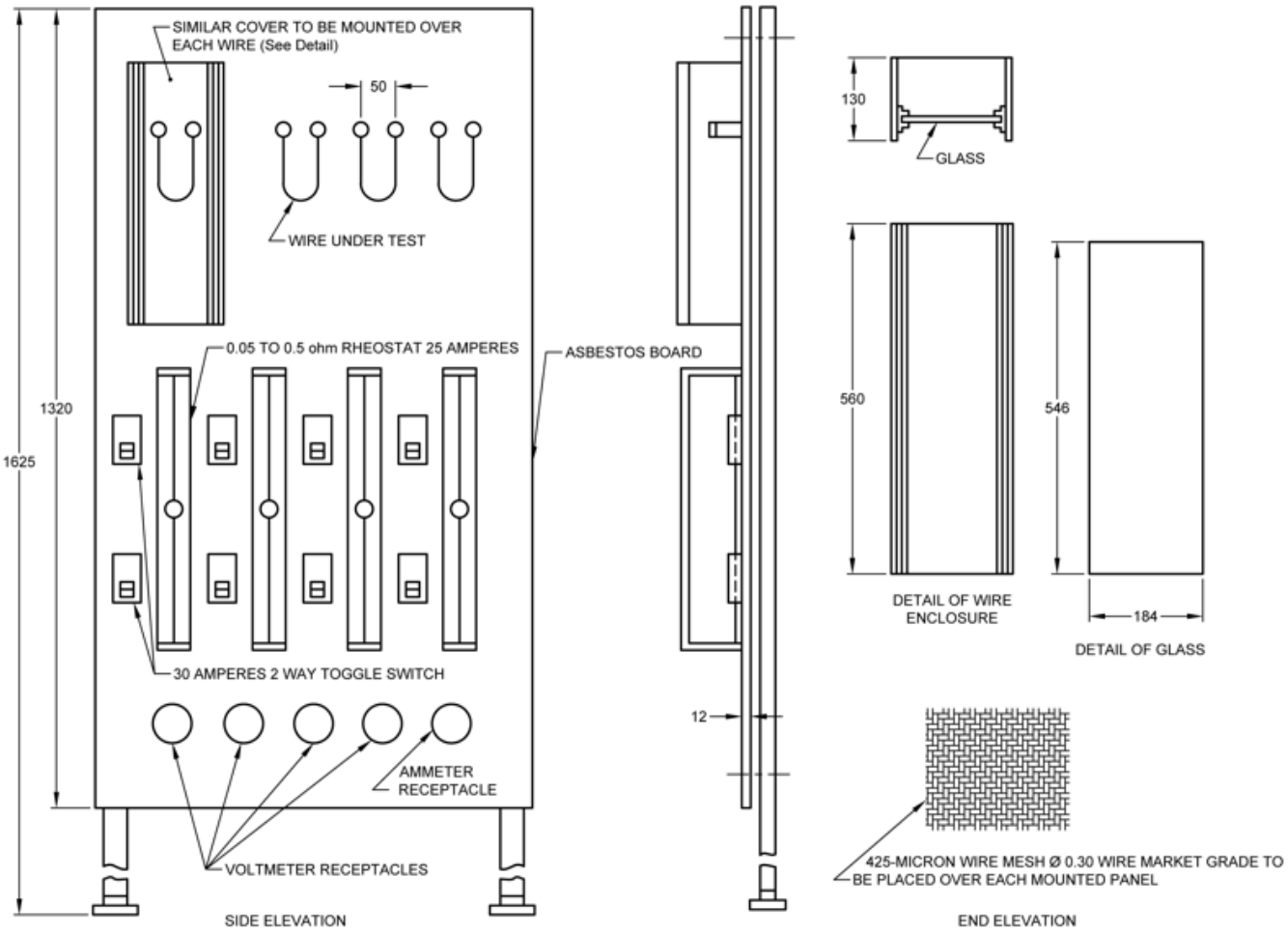
The dimensions of the test panel shall conform to those shown in Fig. 1. The test panel shall be located in a position free from draughts of air.

3.2 Terminals

The two terminals shall be spaced 50 mm apart from centre-to-centre and shall be in a U-shaped pattern as described in **6**. The specimen terminal junctions shall be 75 mm lower than the plane of the top of the enclosure.

3.3 Screen

A screen of mesh size 425 μm with 0.30 mm wire diameter, shall be used as a cover over each mounted panel.



All dimensions in millimetres.

FIG. 1 TEST PANEL

4 TESTING APPARATUS

4.1 The apparatus shall consist of the following and shall be connected as shown in Fig. 2.

4.1.1 *Power Supply*

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

4.1.2 *Voltage Control*

The automatic voltage control shall be capable of maintaining across the bus bars a constant voltage within ± 0.5 percent.

4.1.3 *Rheostat*

The rheostat shall be capable of adjusting the current through the specimen to within approximately 0.25 percent of any desired value within the working range and shall have a continuous current rating of approximately 25A.

4.1.4 *Ammeter and Voltmeter*

The ammeter and voltmeter shall have an accuracy of one percent 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. A compensating resistance shall be cut into the circuit to replace the resistance of the ammeter so that the overall resistance of the circuit is not changed. This resistance shall be inserted in series with the contact of the upper switch as shown in Fig. 2.

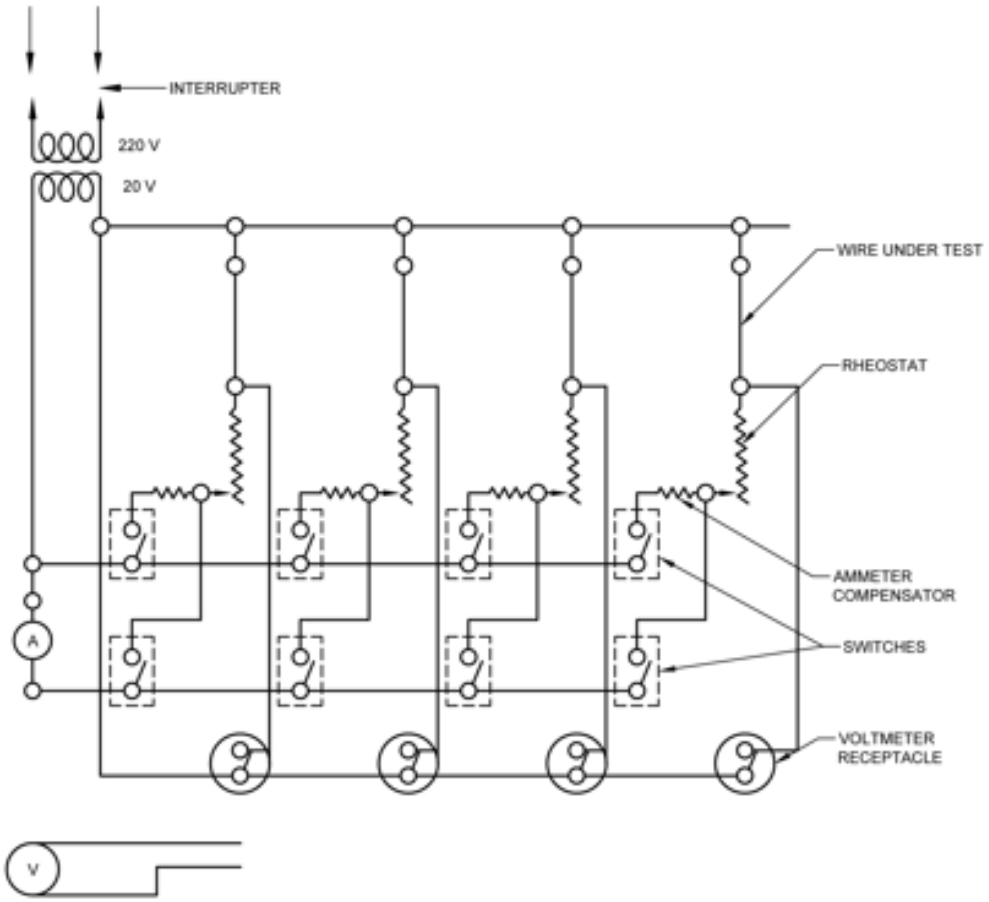


FIG. 2 ELECTRICAL CIRCUIT DIAGRAM FOR ACCELERATED LIFE TEST

4.1.5 *Optical Pyrometer or Infrared Thermometer*

The optical pyrometer shall be of the disappearing filament type. 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 with accuracy of ± 5 °C.

4.1.6 *Interrupter*

A suitable apparatus shall be used as interrupter to open and close the circuit.

4.1.7 *Apparatus for Recording Life Time*

If no apparatus is available for recording the life time, arrangements shall be made for hourly observations of the specimen. Small thermocouples made from fine wire may be attached to the test panel and the hot junction placed near the specimen under test. A multiple-point recording pyrometer may be attached to the thermocouples, which will give a complete record of the number of cycles or some sort of electric clock mechanism which can be connected into the circuit may be used.

5 TEST SPECIMEN

5.1 The test specimen shall be in the **form of wire. If the product is in any other shape, take sample from the same melt, hot roll in the wire form and test in wire form**. It shall have an electrical resistivity within the specified limits for the alloy being tested. Dimensions of the test specimen for the alloys shall be as mentioned below:

Table 1 Dimensions of the test specimen

	Diameter of wire	Length of the specimen between the two terminals
Nickel Chromium Iron Alloys	0.64 mm	305 mm
Iron Chromium Aluminium Alloys	0.64 mm	254 mm

5.1.1 The test specimen shall be representative as regards the surface of the average of the coil or spool of wire/strip which has been selected for test. Particular care shall be taken to see that the specimen selected is free from kinks. The precaution is necessary, since a kink, even though later removed, may cause burn out at that point.

6 MOUNTING SPECIMEN

6.1 A straight length of the specimen shall be formed into a U pattern, 250 mm of which shall be mounted between the terminals as described in **3.2**. The U pattern shall consist of two parallel legs and a semi- circle of 25 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 percent of the specimen resistance at the beginning of the test, but shall not be greater than the specimen resistance.

8 TEMPERATURE OF TEST

8.1 The test temperature shall be as mentioned in Table 2. For the alloys apart from mentioned in Table 2 shall be tested as per the temperatures specified in the corresponding product specification:

Composition of alloy	Temperature of Test
80Ni 20 Cr (Type 1)	1205 °C
60Ni 15Cr 25Fe (Type 2)	1205 °C
45Ni 23Cr 37Fe (Type 3)	1120 °C
35Ni 20Cr 45Fe (Type 4)	1120 °C
32Ni 20Cr 48Fe (Type 5)	1120 °C
Fe 25Cr 5Al (Type 6)	1230 °C
Fe19 Cr 3Al (Type 7)	1230 °C

NOTE – The types of alloys mentioned are as per IS 12045

9 TEST PROCEDURE

9.1 The filament current of the optical pyrometer shall be adjusted to the value corresponding to the required test temperature specified in **8**.

9.2 The switches should be so adjusted that the voltmeter and ammeter are in circuit while the temperature is being adjusted. The pyrometer telescope shall be supported in such a way that it can be quickly adjusted and read. The interrupter shall not be in operation while the temperature is being adjusted.

9.3 The series rheostat shall then be set at a maximum resistance and the switch in series with the specimen shall be closed and the time shall be recorded. The resistance in the rheostat shall be cut out rapidly until the specimen is at a low red heat. The rheostat slider shall be adjusted until the specimen exactly matches the lamp filament of the pyrometer corresponding to the test temperature in brightness. This adjustment should be done until one and a half min have elapsed from the starting of the test.

9.4 The test shall be allowed to continue until 14 min have elapsed from the time of starting the test. Then, after carefully resetting the current in the optical pyrometer, the temperature of the specimen shall be readjusted to the test temperature. Final adjustment shall be completed within 15 min from the time of starting the test. It is extremely important that the time schedule specified rigidly adhered to. If a greater amount of time than that specified is taken to make the adjustments, the specimen shall be discarded, another one put in its place and the test started again.

9.5 The voltage and the current, together with the starting temperature and the starting time shall be recorded at the end of the 13 min period.

9.6 The interrupter shall then be started. The timing device of the interrupter shall be previously regulated so that the 'on' period and the `off' period shall be equal and each shall have a duration of 2 min.

9.7 The temperature shall be adjusted to the test temperature after 5 h and 24 h total elapsed time and the voltage and current shall be recorded after each resetting. Before each resetting the interrupter shall be stopped and after making the observation, it shall be started again.

9.8 After the first 24 h period and each 24 h thereafter, the temperature of the specimen shall be adjusted and after each temperature adjustment, the voltage and current shall be recorded. In determining the temperature, if the wire/strip has developed a 'hot spot', the pyrometer shall be focussed on a section of the wire or strip showing even emission. The time of appearance of the 'hot spot' shall be recorded.

9.9 The resistance at 72 h and 96 h shall be determined, if 'burn out' has not taken place. This will indicate the rate of growth of 'hot spot' in case it has appeared.

10 TEST REPORT

10.1 The test report shall include the following:

a) Nominal composition of the heating elements,
b) Identification of specimen,
c) Cross-sectional dimensions of the specimen,
d) Temperature of test,
e) Life of the specimen in h (total elapsed time from the end of the first 15 min aging period to burn out if the burn out takes place before in 100 h. In case of specimens where burn out does not take place during in 100 h testing, the life of the specimen may be indicated as 100 h),
f) The time of the first formation of a 'hot spot',
g) The increase in resistance in 72 h and 96 h,
h) The increase in resistance as noted for the last resistance reading before burn out,
j) A curve showing the relation between resistance and time, and
k) A description of the physical condition of the specimen after completion of the test.

Note- For more detailed record of the test data, it should be recorded as shown in Annexure B

11 REPRODUCIBILITY

11.1 In this test method, the major source of irregularity is in respect to temperature measurement. Therefore, no attempt shall be made to run standard accelerated life tests until consistent results are obtained 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 shall also 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 percent from the average. It is desirable to select and keep as a reference standard for comparison a spool of wire/strip that is uniform in cross-section from one end to the other. Tests may then be made at any time on reference standard and any change in life of standard at different times due to changed conditions may be correlated with the results on other wires/ strips.

ANNEXURE A

(*Clause* **0.4)**

PRECAUTIONS TO BE OBSERVED IN SETTING UP AND OPERATION OF THE LIFE TEST EQUIPMENT

A-l. TEMPERATURE

A-l.1 Temperature is one of the most important variables in a life test. The probable life of a wire/strip varies inversely with an exponential function of the temperature.

A-l.2 To determine the temperature accurately, the disappearing filament type optical pyrometer may be used and 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/strip under test is very greatly affected by draughts. The enclosure, therefore, should be left in place at all times during 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 the error. This effect is nearly independent of the kind and thickness of the glass. Reflection from external light sources shall be avoided. 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.

A-2. VOLTAGE CONTROL

A-2.1 It is not possible to get uniform results using the regular line voltage with no regulation. It is, therefore, essential that voltage control be used.

ANNEXURE B

(Clause **10.1**)

TEST RESULT FORMAT

Laboratory Name : ……

Dimensions of the specimen	Test Temperature, °C	

Date	Time	Elapsed Time	Voltage across specimen, V	Current through specimen after adjustment, A	Resistance of specimen after adjustment, Ω	Temperature after adjustment, °C

Total life of specimen	Final resistance, percentage of resistance at the end of 15 min	Elapsed time to 10% increase in resistance starting from end of first 15 min, h

Remarks : ……..