14 October 1942

NRL Report No. R-1947
BuShips Problem M3-38

NAVY DEPARTMENT

Report of

Test of Six Wire Wound Style A Fixed Resistors

FR-1947

Submitted by Hardwick, Hindle, Inc.

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WASHINGTON, D. C.

Number of Pages: Text - 4 Tables - 1 Plates - 1

Authorization: BuShips ltr. S67/63 (480K) of 24 April 1942

Dates of Test: 13 April to 19 April 1942

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BuShips (10)

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APPENDICES

AUTHORIZATION

1. This problem was authorized by reference (a). References (b), (c) and (d) are also pertinent.

References:

(a) BuShips ltr. S67/63 (480 K) of 24 April 1942
(b) Specifications RE 13A 372J
(c) NRL Report No. R-1913 of 28 July 1942
(d) Telephone conversation NRL to BuShips on 17 April 1942 reporting results of tests.

OBJECT OF TEST

2. This test was made to determine whether or not these Navy Style "A" wire wound resistors, manufactured by Hardwick, Hindle, Inc., comply with reference (b), as Grade 1, Class I units. This was a restricted qualification test.

ABSTRACT OF TEST

3. The test numbers used throughout this report, correspond to those of paragraph 13-1 of reference (b), and are distinguished by enclosure in parentheses. Complete tests were not conducted because these resistors failed in the salt water immersion test. The following tests were made:

(1) Compliance with mechanical requirement of reference (b) including dimensions, workmanship and markings.
(6) Resistance at 20°C.
(9) Strength of finished resistor.
(10) Power dissipation at a hot spot temperature of 275°C.
(11) Resistance to thermal shock.
(12) Momentary Overload.
(13) Salt water immersion.
(14) Strength of ferrule securing.

CONCLUSIONS

It is concluded:

(a) That these resistors do not comply with reference (b) in the following respects.

(1) The salt water immersion test weakened the winding tubes and salt water penetrated to the windings.

(2) The resistance at 20°C of four of the six resistors was more than 5% above the nominal value.

(b) That these resistors are not suitable for Naval use as Grade 1, Class I, units.

RECOMMENDATIONS

It is recommended that these resistors be considered not suitable for Naval use as Grade 1, Class I units.

COMMENTS

These resistors were so weakened by the salt water immersion test that it is difficult to compare their electrical merits with those reported on in reference (c). However, the appearance of spots and streaks of molten enamel burning on the surface of the resistor was largely eliminated in this group. Unit #5 burned out in that manner, and a few sparks were seen on the surface of unit #4 during one cycle only.

MATERIAL UNDER TEST

4. Six 25,000 ohm, Navy Style A, wire wound fixed resistors manufactured by Hardwick, Hindle, Inc., were submitted for restricted Grade 1, Class I qualification tests in accordance with reference (b). Each resistor was a single layer winding on a ceramic tube with the ferrules secured over the ends of the tube. The winding between the ferrules was covered by a very thin coat of blue vitreous enamel. (See Plate 1)

METHOD OF TEST

5. The following instruments were used in making these qualification tests.

Voltmeter, d-c, Weston Electrical Instrument Corp. Model 45 - Serial #42522.

Millivoltmeter, d-c, with 100 ma shunt, Weston Electrical Instrument Corp., Model 1 Serial #19864.

Pyrometer - Potentiometer, Lewis Engineering Co., Model 14 PO Serial #220.

Wheatstone Bridge, Leeds and Northrup Co., Type S, Serial #374910.

Universal Strength Tester, 60,000 lb., Southwark-Emery.

6. Test (1) The dimensions of each resistor were measured and the markings and workmanship were inspected.

Test (5) The resistance of each unit was measured on a wheatstone bridge at room temperature and corrections were made for the difference between the room temperature and 20°C. The maximum permissible temperature-coefficient of 0.026 per cent per degree centigrade was used in the absence of a known or measured value.

Test (9) The strength of the resistors, after the salt water immersion test, was determined by supporting a unit within one-eight of an inch of each end, and applying a measured force at the midpoint of the top of the resistor. This load was applied by a hydraulic testing machine, and was gradually increased until the resistor was broken.

Test (10) The wattage dissipated by each resistor while operating at a hot spot temperature of 275°C was measured with a voltmeter and ammeter. The hot spot temperature was measured by calibrated thermocouples applied to the surfaces of the resistors at their midpoints.

Test (11) Thermal shock was administered by raising the hot spot temperature of the resistors to 275°C by applying the proper potential and then plunging them into 0°C tap water. After approximately five minutes, the resistors were removed from the water, thoroughly dried with compressed air, and inspected for mechanical damage. Potential was then reapplied and the hot spot temperature returned to 275°C. The resistance of each unit was then compared with its resistance before thermal shock.

Test (12) For the momentary overload test, 2500 volts was applied across each resistor until its hot spot temperature reached 275°C. Any change in resistance was noted.

Test (13) All units were subjected to a six hour preheat period prior to the salt water immersion test. During this period sufficient voltage was applied to each resistor to maintain its full rated load, which is that load which produces a hot spot temperature of 275°C. At the end of this six hour period the resistors were started on the first cycle of the salt water immersion test. Each cycle consisted of two hours in 100°C saturated salt water, two hours in 0°C saturated salt solution, and two hours at full rated load in free air. All resistors were thoroughly washed in fresh water and dried with compressed air, before the load was applied. The resistance of each unit was measured by the voltmeter ammeter method at the end of each cycle.

Test (14) A torque of over 5 inch pounds was applied to the ferrules of the resistors not broken in the salt water immersion test.

DATA RECORDED DURING TEST

7. The data recorded during the tests, or values computed therefrom, are given under "Results of Tests" and in Table I.

DISCUSSION OF PROBABLE ERRORS

8. The errors in the values measured are not greater than the following:

Resistance at 20°C	± 1/2%
Resistance at 275°C hot spot	± 1%
Power dissipated at 275°C hot spot	± 1%
Hot spot temperature	± 2%
Strength of finished resistors	± 5%
Bath temperatures	± 3°C

RESULTS OF TESTS

9. Test (1) The resistors comply with reference (b), for dimensions and markings and the workmanship is good, except for a few pinholds in the vitreous enamel at the edge of the ferrules.

Test (6) The resistance at 20°C of four of the six resistors was more than the permissible 5% above the nominal value. (See Table I for specific values.)

Test (9) Only two units remained unbroken after the salt water immersion test. These two units number 2 and 5, were given the strength test. Unit #5 fell apart when less than 10 pounds pressure was applied. Unit #2 broke at 145 pounds load.

Test (10) The average power dissipation for each resistor at 275°C hot spot was 131.4 watts. Individual figures are given in Table 1. A potential of 1920 volts across each resistor was required to maintain the 275° hot spot.

Test (11) Thermal shock effected no apparent damage to the resistors either electrically or mechanically.

Test (12) The momentary overload test did not damage any of the units.

Test (13) All of the resistors failed completely in the salt water immersion test. Two of the units were disqualified because of resistance changes, and four units were so weakened mechanically by the salt water and temperature cycling that they literally fell apart during the test. Before Unit #5 showed an open circuit during the 14th cycle, the load current was being carried by molten enamel on the surface of the resistor. The resistance element in the unit had been broken before the load run of the 14th cycle, and continuity was maintained only by the salt water that had penetrated to the winding and the molten enamel which carried the current after the moisture had dried out.

Test (14) The application of a torque of over 5 inch pounds did not loosen the ferrules of the two units tested.

CONCLUSIONS

10. It is concluded:

(a) That these resistors do not comply with reference (b) in the following respects:

(1) The salt water immersion test weakened the winding tubes and salt water penetrated to the windings.

(2) The resistance at 20°C of four of the six resistors was more than 5% above the nominal value.

(b) That these resistors are not suitable for Naval use at Grade 1, Class I units.

TABLE I

Chronological Summary of Measurements

Resistance in Kilohms

	Date	Time	Unit #1	Unit #2	Unit #3	Unit #4	Unit #5	Unit #6
Resistance at 20°C	13 Apr	1600	26.9	26.57	25.65	26.43	26.73	25.55
End of 1st Preheat	14 Apr	1400	28.15	27.95	26.75	27.95	28.1	26.9
Watts Dissipation at 275°C hot spot	14 Apr	1400	129.	129.9	135.7	129.9	129.2	134.9
After overload at 2500 volts	14 Apr	1440	28.15	27.95	26.75	27.95	28.15	26.87
After thermal shock	14 Apr	1520	27.95	27.9	26.85	27.85	28.1	26.87
End of 2nd Preheat	14 Apr	2100	28.1	27.9	26.85	27.83	28.2	26.73
Salt Water Immersion Test								
1st Cycle	15 Apr	0300	26.6	27.28	25.7	27.28	27.4	25.67
2nd Cycle	15 Apr	0900	28.45	36.2	25.95	26.92	27.58	25.88
3rd Cycle	15 Apr	1500	27.05		25.47	26.97	27.50	25.88
4th Cycle	15 Apr	2100	26.62		25.00	26.92	27.42	25.63
5th Cycle	16 Apr	0300	26.67		Broken	26.92	27.42	25.60
6th Cycle	16 Apr	0900	26.25			26.52	27.05	25.35
7th Cycle	16 Apr	1500	Broken			26.20	26.92	25.20
8th Cycle	16 Apr	2100				26.30	26.67	25.00
9th Cycle	17 Apr	0300				26.20	26.40	24.53
10th Cycle	17 Apr	0900				Broken	26.40	24.68
11th Cycle	17 Apr	1500					26.30	24.93
12th Cycle	17 Apr	2100					26.65	24.77
13th Cycle	18 Apr	0300					25.95	Broken
14th Cycle	18 Apr	0900					Open	

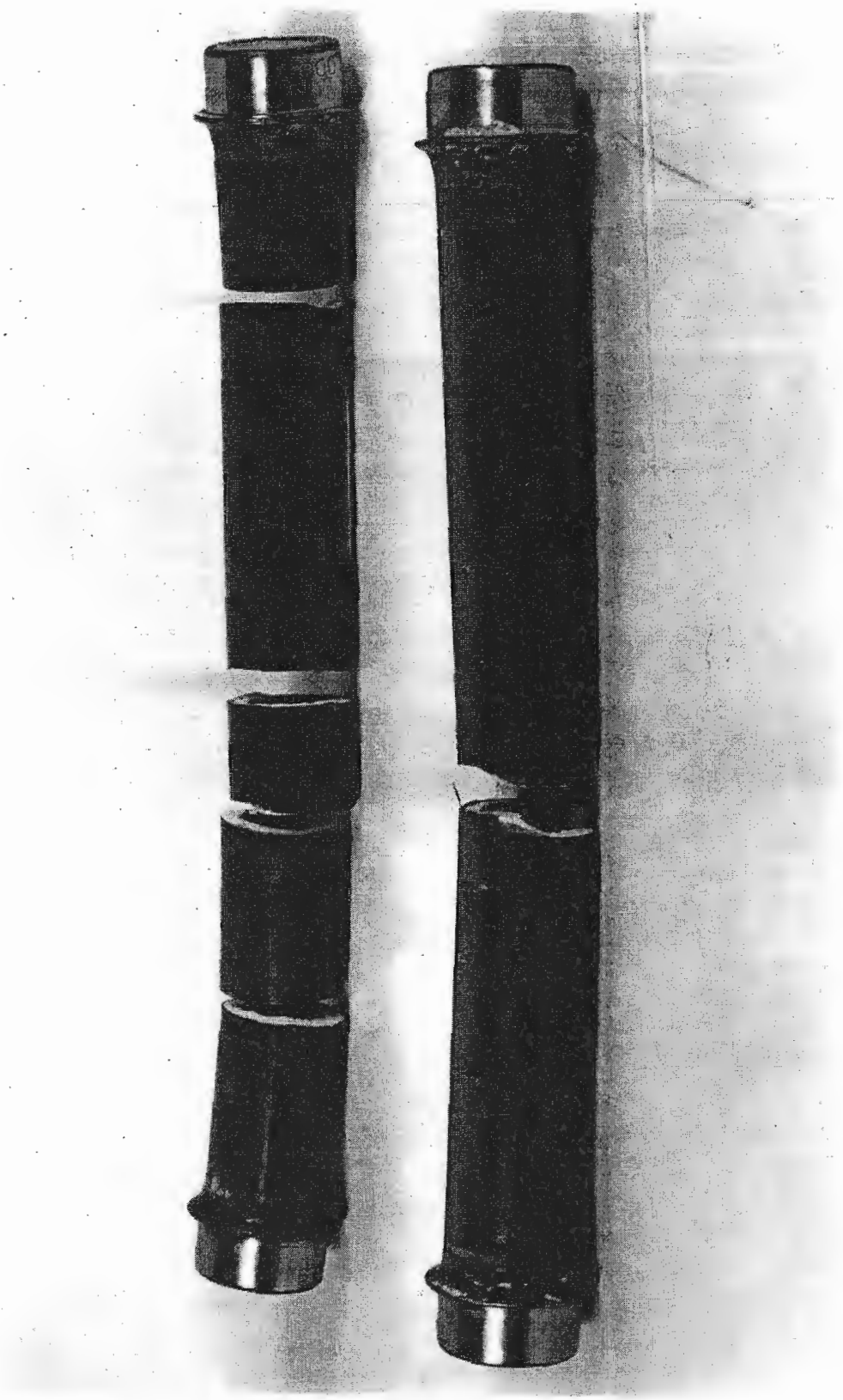

PLATE I