

B

27 December 1937

NRL Report No. R-1414
BuEng.Prob. M3-11

NAVY DEPARTMENT
BUREAU OF ENGINEERING

FR-1414

Report of
Test of Hardwick, Hindle Wire Wound Resistors

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

Number of Pages: Text - 5 Tables - 3 Plates - 2

Authorization: BuEng let.S67/63/L5(9-27-W8) of 2 October 1937.

Date of Test: 2 November to 2 December 1937.

Prepared by: _____
R. B. Owens, Associate Radio Engineer
Chief of Section

Reviewed by: _____
A. Hoyt Taylor, Principal Physicist
Superintendent, Radio Division

Approved by: _____
H. M. Cooley, Captain, U.S.N.
Director

Distribution: BuEng (5)

APPROVED FOR PUBLIC
RELEASE - DISTRIBUTION
UNLIMITED

Table of Contents

Authorization	Page 1
Object of Test	1
Abstract of Test	1
Conclusions	1a
Recommendations	1b
Description of Material	2
Method of Test	2
Data Recorded During Test	2
Discussion of Probable Errors	2
Results of Test	3
Conclusions	5

Test Data on Grade 1, Class I Hardwick, Hindle Resistors - Table 1

Test Data on Grade 1, Class II Hardwick, Hindle Resistors - 2

Porosity Test Data on Tubes for Hardwick, Hindle Resistors - 3

View of Grade 1^{2/} Class I Resistors after
one humidity test cycle - - - Plate 1

View of Grade 1 Class II Resistors after
one humidity test cycle - - - 2

AUTHORIZATION

1. The work reported on herein was authorized by Bureau of Engineering letter, reference (a). Other pertinent correspondence is listed as references (b) and (c).

Reference: (a) BuEng let.S67/63/L5(9-27-W8) of 2 Oct. 1937.
(b) Specifications for wire wound resistors,
RE 13A 372J.
(c) NRL Report No. R-1395.

OBJECT OF TEST

2. The object of the test was to determine whether the wire wound resistors submitted by Hardwick, Hindle, Inc., comply with the requirements of specifications, reference (b).

ABSTRACT OF TEST

3. The samples were subjected to tests to determine the following:

- (a) Compliance with mechanical requirements of these specifications, including tolerances, workmanship, etc.
- (b) Size of wire.
- (c) Winding pitch.
- (d) Wire coverage.
- (e) Temperature coefficient of resistance of the wire.
- (f) Resistance, with respect to the tolerance allowed.
- (g) Strength of the winding tubes.
- (h) Porosity of the winding tubes.
- (i) Strength of the finished units.
- (j) Power dissipation as related to temperature rise.
- (k) Resistance to thermal shock.
- (l) Resistance to effects of excessive humidity.
- (m) Strength of ferrule securing.
- (n) Design acceptability of tabs and taps.

Conclusions

(a) These resistors comply with all of the requirements of the governing specifications except as specified below.

(b) They do not dissipate the specified power at the limiting hot spot temperature. This is believed to be an unavoidable condition and does not indicate unsuitability for Naval use.

(c) With respect to the humidity test, neither the ferrule style nor the tab style resistors of either temperature class complies with the requirements for Grade 1 or Grade 2 units as provided in the specifications.

Recommendations

(a) It is recommended that these resistors be considered as failing to comply with the governing specifications in the important respect of resistance to humidity effects.

DESCRIPTION OF MATERIAL UNDER TEST

4. The material under test consisted of samples of wire wound vitreous enameled resistors manufactured by Hardwick, Hindle, Inc., and submitted for test for compliance with specification requirements for the following grades and classes:

Grade 1, Class I.
Grade ~~1~~₂, Class II.

(Grade 1, Class I units must withstand 9 cycles of humidity exposure and operate satisfactorily at a hot spot temperature of 275° C. Grade 1, Class II units have the same qualifications as above except that the maximum operating temperature is 125° C.)

5. The following samples were submitted:

<u>No.</u>	<u>Style</u>	<u>Grade</u>	<u>Class</u>	<u>Ohms</u>	<u>Mfr's Type</u>	<u>Finish</u>
6	A	² 1	I	50,000	8-1/2 F 10-18	VE
6	A	1	II	50,000	8-1/2 F 10-18	A-2560
6	Z	1	I	14,000	4 L 18	VE
6	Z	1	II	14,000	4 L 18	A-2560
6	Z	1	I		center tapped 4 L 18	VE
1	A	Bare winding tube			8-1/2 F X	
1	Z	"	"	"	4 L	
1	A	Uncoated unit		75,000		
1	Z	" "		13,000		
		Center tapped				

(Style A units are provided with ferrules, while Style Z units have terminals of the tab type.)

METHOD OF TEST

6. The methods employed in conducting the various tests are as required by the specifications, reference (b), and as described in detail in reference (c), paragraphs 6 and 7.

DATA RECORDED DURING TEST

7. The data recorded during the tests or values computed therefrom are given under RESULTS OF TEST and in the appended tables.

DISCUSSION OF PROBABLE ERRORS

8. The error in determination of the temperature coefficient of resistance is believed to be less than 5%. The resistance of the units at 20° C was measured to within $\pm 0.2\%$. The strength of the tubes and of the finished units was determined to within 5 pounds of the pressure necessary to damage the units. The gain in weight of

the winding tubes as a result of immersion in water was determined to within ± 0.002 gram. The hot spot temperature was measured with an error of less than $\pm 5^\circ$ C. The power dissipated at the maximum hot spot temperature was measured with an error of less than 1%. The torque applied to the ferrules to determine the strength of the ferrule securing was accurate to within 1/2 pound of the specified value.

RESULTS OF TEST

9. As previously stated, samples were submitted for qualification tests for the two following classifications:

Grade ²1, Class I, represented in specifications, reference (b), paragraph 2-8(3), by the letter F.

Grade 1, Class II, represented in specifications, reference (b), paragraph 2-8(3), by the letter E.

The latter group is the same as the first except that a coating of baking varnish has been added to these lower temperature units for increased humidity protection. The test data given below apply to both classifications except the data relating to the humidity test and the power dissipated at the maximum hot spot temperature, which are stated separately for the two classifications.

10. The results of the tests are given in the order stated in paragraph 13-1 of specifications, reference (b), and the subparagraph numbers below correspond to those used in that paragraph of the specifications. (The center tap units were not subjected to test.)

(1) Both the Style A and Style Z resistors comply with the mechanical and dimensional requirements of the specifications. The workmanship appears to be of the best quality.

(2) The size of the wire was measured to be .0025" ($\pm .002$ ") which is as required.

(3) The winding pitch of the two uncoated units complies with the requirements of paragraph 6-7 of the specifications.

(4) The wire coverage of the same two units conforms to the requirements of paragraphs 6-8 to 6-10 of the specifications.

(5) The temperature coefficient of resistance of the wire was measured to be 0.013% per degree Centigrade which is 1/2 the maximum allowed value.

(6) The resistance of the samples at a temperature of 20° C is given in Tables 1 and 2, from which it will be noted that the resistance of all units lies within the 5% tolerance of the rated value.

(7) The breaking load of the Style A bare winding tube was 810 pounds, while that of the Style Z tube was 430 pounds. (The specifications require that they withstand a force of 25 pounds without damage.)

(8) The fragments of both of the bare tubes were weighed both wet and dry as specified in paragraph 13-3(8) to determine the gain in weight due to moisture absorption after immersion in water. From the results given in Table 3, it will be noted that the average gain in weight of the two tubes is within the allowed limit of 0.1%, although that of one tube exceeds the limit slightly. This material is considered satisfactory for tube forms.

(9) In the test of the strength of the finished resistors, two Style A and two Style Z units were subjected to a measured load after the humidity exposure. The ferrule of one Style A unit loosened upon the application of a force of 80 pounds at the center, while the ends were supported at a point 1/8" in from the extreme ends of the ferrules. The form of the other Style A unit broke at a pressure of 240 pounds. The forms of the Style Z units broke at 190 and 215 pounds, respectively. Since the required load which must be borne without damage is 25 pounds, all of these finished resistors satisfactorily pass this strength test.

(10) The power dissipated by the Style A, Grade 1, Class I units was approximately the same as that stated in reference (c), paragraph 10(10). For example, the power dissipated corresponding to a hot spot temperature rise of 220° C was approximately 116 watts. As stated in reference (c), the fact that the resistors do not fully comply with the requirements of paragraph 4-14 of reference (b) does not render them unsuitable for Naval use.

(11) As a result of the thermal shock (consisting of suddenly putting the heated units in an ice water bath), no chipping, crazing, or other visible damage was noted in any of the units of either style, and the change in resistance was negligibly small. These tests were applied to the samples numbered 1 to 3 in Tables 1 and 2.

(12) No power overload was applied to any of these units. No voltage in excess of 2500 volts was applied to Style A units, and none exceeding 790 volts was applied to the Style Z units.

(13) The results of the humidity test consisting of salt water immersion of the units as detailed in paragraph 13-3(13) of reference (b) are shown in Tables 1 and 2. A change in resistance of more than 10% following immersion indicates failure of the unit. The results of the humidity test are summarized as follows:

Grade 1, Class I, Style A units - None withstood the first immersion.

Grade 1, Class I, Style Z units - None withstood the first immersion.

Grade 1, Class II, Style A units - Only one withstood the first immersion and it failed on the second immersion.

Grade 1, Class II, Style Z units - Only one withstood the first immersion and it failed on the second immersion.

The specifications require satisfactory completion of an average of 9 immersion cycles by the units tested, for Grade 1 qualification and of 2 cycles for Grade 2 qualification. It follows that none of the groups of samples qualify for any grade under these specifications. In Plate 1 is shown a view of several Grade 1 Class I samples after the completion of one humidity test cycle. The Style A unit whose surface is interlaced with fine white lines is unit #5 in Table 1, the resistance of which dropped to 10% of its previous value as a result of one immersion. The vitreous enamel coating of the Style Z units shown is broken in several places. In Plate 2 a view of Grade 1 Class II units shows that the varnish coating did not withstand one humidity test cycle. The coating blistered on being heated after immersion and in the case of several Style A samples the varnish peeled off as shown.

(14) The ferrules of the Style A units withstood a torque of 5" pounds without loosening, as required. Of the 4 ferrules subjected to this test, 3 withstood a torque of 10" pounds, while the fourth became loose when this 100% overload was applied. It must, of course, be borne in mind that these units had been subjected to only one or two salt water immersions previous to the test.

(15) The tabs and taps of the Style Z units are satisfactory in design and assembly.

CONCLUSIONS

11. These resistors comply with all of the requirements of the governing specifications except as specified below.

12. They do not dissipate the specified power at the limiting hot spot temperature. This is believed to be an unavoidable condition and does not indicate unsuitability for Naval use.

13. With respect to the humidity test, neither the ferrule style nor the tab style resistors of either temperature class complies with the requirements for Grade 1 or Grade 2 units as provided in the specifications.

Table 1
 Test Data on Grade ^a Class I
 Hardwick, Hindle Resistors

(Resistance in Kilohms)

<u>Sample and Style</u>	<u>Resistance at 20° C.</u>	<u>Resistance hot before immersion</u>	<u>Resistance after first immersion</u>	<u>% change in resistance</u>
1A	51.28	53.3	13.1	75
2A	50.86	52.7	14.7	72
3A	50.96	52.7	20.6	61
4A	51.89	53.6	26.2	51
5A	50.29	51.7	5.	90
6A	51.43	52.7	22.5	57
1Z	14.37	14.9	4.0	73
2Z	14.51	15.0	4.4	70
3Z	14.35	15.0	10.5	30
4Z	13.93	14.6	11.7	19
5Z	13.93	14.6	11.5	21
6Z	14.27	15.0	4.4	70

Note: (1) After lying idle for 2 weeks the resistance of all units was practically the same as given in column 4, except that unit 5A measured 18 kilohms.

(2) Sample 5A is pictured in Plate 1.

Table 2

Test Data on Grade 1 Class II
Hardwick, Hindle Resistors

(Resistance in kilohms)

Sample and Style	Resistance at 20° C	Resistance hot before immersion	After 1st immersion Resistance	%Change	After 2nd immersion Resistance	%Change	After four weeks idle (20° C)
1A	49.54	50.38	29.5	-41	-	-	Open
2A	50.99	50.38	35.0	-30	-	-	"
3A	51.34	51.38	31.5	-38	-	-	"
4A	51.38	51.38	50.2	-2	43.5	15	40
5A	51.18	51.80	36.9	-29	-	-	32
6A	51.16	51.80	43.2	-16	-	-	40
1Z	14.27	14.78	11.8	-20	-	-	Open
2Z	14.27	14.78	8.0	-46	-	-	10
3Z	14.16	14.48	11.6	-20	-	-	Open
4Z	14.64	15.08	9.7	-36	-	-	10
5Z	14.36	14.78	14.0	-5	11.8	20	10
6Z	14.13	14.60	12.6	-14	-	-	10

Table 3

Porosity Test Data on Tubes for
Hardwick, Hindle Resistors

<u>Style of Tube</u>	<u>Weight in Grams</u>		<u>Gain in Weight</u>	
	<u>Dry</u>	<u>Wet</u>	<u>Grams</u>	<u>%</u>
A	33.016	33.068	0.052	0.157
Z	29.773	29.782	0.009	0.030
Mean	- - - - -	- - - - -	- - - - -	0.093

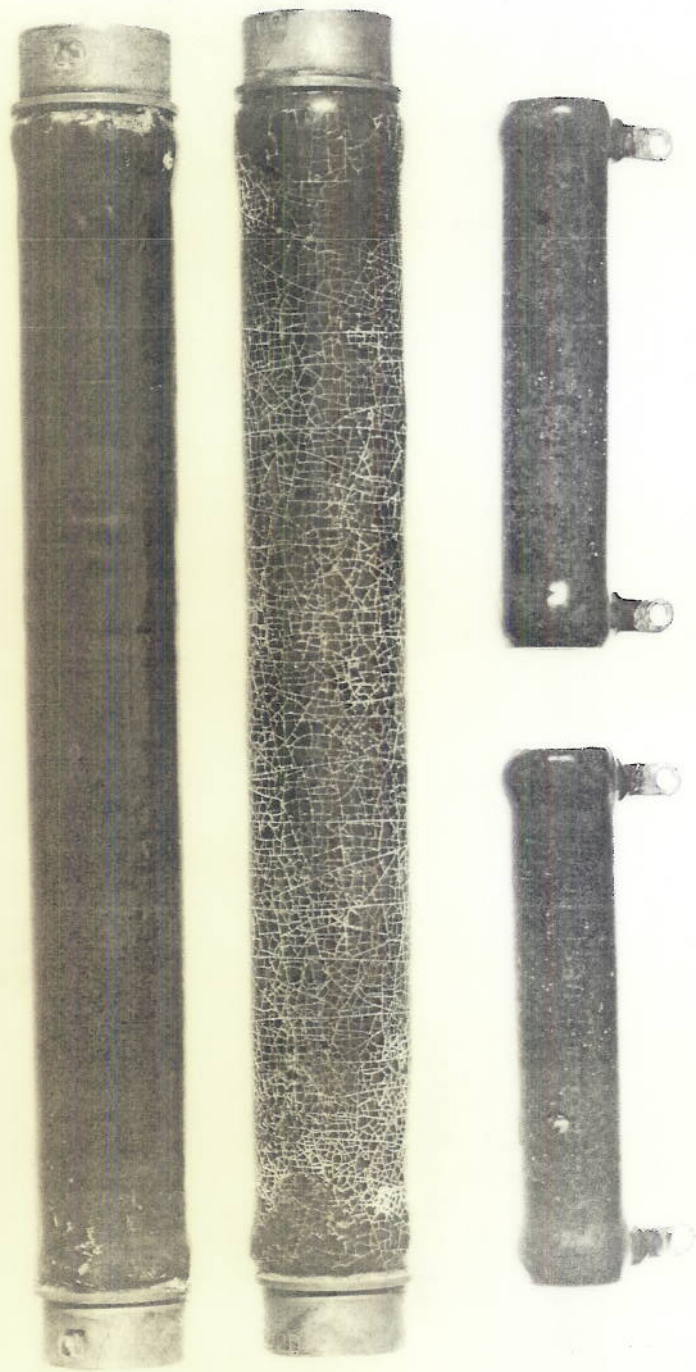


PLATE I

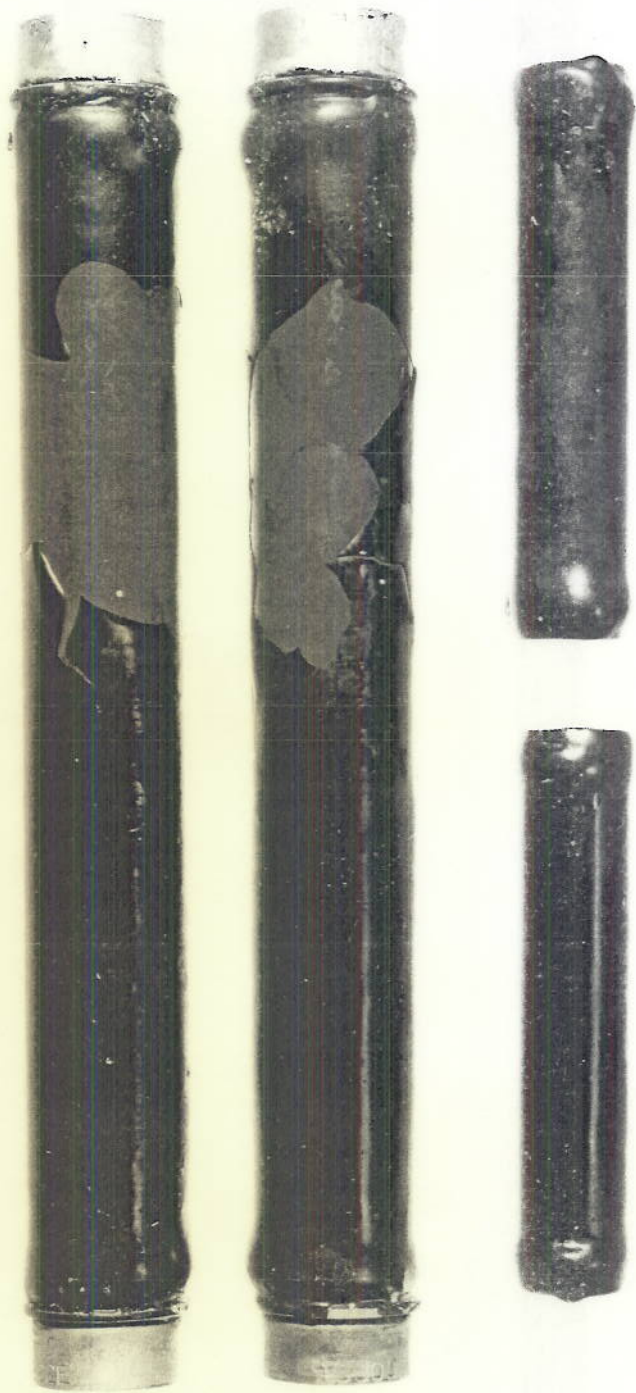


PLATE 2