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SUBJECT

Test of Insulating Material Submitted by Hartford Faience Company

NAVAL RESEARCH LABORATORY

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Buships Problem M92

NAVY DEPARTMENT

Report of

Test on Insulating Material

Submitted by

Hartford Faience Company

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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Distribution
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AUTHORIZATION

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

References:
(a) Buships problem let. (953-2) of April 1, 1943 to N.R.L.
(b) Buships let S67/61 (5-23-480) of May 23, 1941 to N.R.L.
(c) Buships let S67/61 (480V) of July 17, 1942 to N.R.L.
(d) Specifications RE 13A 317F.
(e) Specification C75.1-1943, Ceramic Radio Insulating Materials, Class L.

OBJECT OF TEST

2. The object of the test was to determine whether the test samples submitted by the Hartford Faience Company comply with reference (e) for Grade L-1, L-2, L-3, L-4, L-5, or L-6 insulating material and to make moisture absorption measurements.

ABSTRACT OF TEST

3. The wet loss factors were determined by measurements made at 1000 Kc, in compliance with paragraphs F-1, F-2a and F-2c of reference (e). Dry measurements were also made on the samples. The dry loss factors were calculated and included in this report.

4. Moisture absorption measurements were made in accordance with paragraph 3 of reference (c) and paragraph 6-2 of reference (d).

CONCLUSIONS

It is concluded:

(a) That this material submitted by the Hartford Faience Company complies with reference (e) for Grade L-1 insulating material and that the moisture absorption is less than 0.1% in compliance with reference (d).

(b) That the material complies with reference (e) with respect to Modulus of Rupture, Thermal Shock and Dielectric Strength.

RECOMMENDATIONS

It is recommended:

(a) That the test samples submitted by the Hartford Faience Company be approved as Grade L-1 ceramic insulating material.

DESCRIPTION OF MATERIAL UNDER TEST

5. The six circular samples numbered 661 to 663 and 681 to 683 inclusive by NRL were approximately 4.5 inches in diameter and 0.2 inches thick. Samples numbered D-8 through D-13 were discs approximately 2 inches in diameter and 1/4 inch thick. Those numbered T-1 through T-6 and 102 through 107 were rods approximately 6 inches long and 1 1/8 inches thick.

METHOD OF TEST

6. Physical measurements of the samples were made with micrometers and a metric rule; the electrical measurements, by the parallel substitution method of susceptance variation. The dielectric properties were determined from these data.

7. The following equipment was used to make the electrical tests:

1000 kc crystal controlled master oscillator power amplifier, assembled by NRL.

NRL standard inductance No. 6.

General Radio quartz insulated, precision condenser, Type 722-Q, serial no. 460.

General Radio vacuum tube voltmeter, Type 726-A, serial no. 1483.

Ballantine voltmeter, Type 300, serial no. 1418.

Wappler transformer, Type A3, no. 8423

8. The factor of merit of the variable capacitor is stated by the manufacturer to be better than 0.003×10^{-12} Farads. The factor of merit of the entire test circuit is better than 1.11×10^{-12} Farads or one C.G.S. electrostatic unit. The effective Q of the entire measuring circuit is approximately 344 units, measured at 1000 kc.

9. The dry loss factor was determined after allowing the test samples to come to a static equilibrium of ambient temperature and relative humidity with that of the standard measuring circuit, which is assumed to occur in about 24 to 48 hours. Each sample was made into a capacitor by applying foil to both surfaces with petroleum oil. The factors of merit of the standard circuit with and without the samples

were measured and each expressed as the ratio of total effective conductance to the resonant angular velocity. The difference between the two factors thus measured is equal to the factor of merit of the sample. When the conductance of the sample is small and can be neglected in comparison with its susceptance, the power factor is equal to the ratio of the factor of merit to the capacitance. The capacitance is equal to the difference in reading of the standard, taken at resonance, with and without the sample; provided, the residual inductance (L) of the standard capacitor is sufficiently small to make W^2LCs, negligible as compared to unity.

10. The dielectric permittivity (K) was determined from physical measurements made upon the sample, as outlined in A.S.T.M. Standards. The loss factor is defined as the product of the power factor and the dielectric permittivity. The wet loss factor was determined in a similar manner after the samples had been immersed in distilled water for a period of 48 hours in compliance with paragraph F-2c of reference (e).

11. The Modulus of Rupture tests were conducted in accordance with paragraph F-4 of reference (e). A direct load of 250 pounds per minute was applied midway between two points of restraint. These points were separated by a distance of 5.00 inches. The radius of curvature of the three points was 0.125 inches. A standard Southwark Testing Machine was used for this purpose.

12. The tests for Resistance to Thermal Change were conducted in accordance with paragraph F-5 of reference (e). The samples were immersed in four gallons of water at approximately 0°C for 10 minutes and transferred as quickly as possible to four gallons of boiling water (temperature approximately 100°C).

13. Tests for Dielectric-Strength were conducted in accordance with paragraphs F-3a, F-3b and F-3c of reference (e) and in accordance with Standard Methods of Testing Electrical Porcelain (ASTM D 116-42). The apparatus conforms to the requirements prescribed in Section 3 of the Tentative Methods of Test for Dielectric Strength of Electrical Insulating Materials at Commercial Power Frequencies (A.S.T.M. Designation D149) of the American Society for Testing Materials. The rate of voltage rise is governed by means of a manually operated variac in the primary of the high voltage transformer. The high voltage was determined by measuring the potential across a 10,000 ohm resistor which was connected in series with a 1000 megohm resistor across the secondary terminals. The needle-point sparking potential was also observed at the same time as a further check. The wave form of the voltage across the 10,000 ohm resistor as seen on an oscilloscope is practically sinusoidal.

14. Samples numbered T-1 through T-6 were first tested for Dielectric-Strength using a transformer of 30 K.V. R.M.S. top rating. This voltage was insufficient, but at the time these tests were conducted, a higher voltage transformer was not available. One week later the Wappler type A-3 transformer was obtained and further tests for Dielectric-Strength were conducted on the same samples. The dielectric strength of these samples may have been increased by immersion in oil during the first tests. After completion of tests, one sample was broken and examined for penetration of oil. No definite conclusions were obtained; however, in all but one of the second tests, the transformer oil broke down before the sample which is a good indication that the samples are of high dielectric strength.

15. The Moisture Absorption tests were carried out on newly fractured pieces as detailed in paragraph 6-2 of reference (d) where the newly fractured surface was approximately 50% of the unfractured surface of each sample. The samples were soaked in distilled water for 100 hours during which time the water was boiled for a period of 1 hour during the 1st, 25th, 49th and 73rd hours. At the end of 100 hours the samples were removed from the water, carefully dried with filter paper and immediately weighed. The samples were then placed in a desiccator for a period of 96 hours after which time they were weighed dry.

DATA RECORDED DURING TEST

16. The data recorded during test are given in Tables I, II, III, IV and V.

PROBABLE ERROR IN RESULTS

17. The error in the determination of the power factor is not greater than 2%, while that of the loss factor is not greater than 3%. The error in the determination of the percent moisture absroption is less than 1%.

The data relating to dielectric properties have been corrected for the fringing of the dielectric flux external to the periphery of the electrodes.

Corrections to include the residual errors in the standard measuring circuit have not been applied to these data.

RESULTS OF TEST

18. Results of tests are given in Tables I through V and may be summarized as follows: The data recorded in Table I show that the samples comply with paragraph E-1 of reference (e) for Grade L-1 insulating material. Tables II, III and IV show that the samples comply with reference (e) with respect to Modulus of Rupture, Resistance to Thermal Change and Dielectric Strength. After being subjected to 20 cycles, the thermal shock samples were in good condition.

19. Table V shows that the samples passed the moisture absorption test as detailed in paragraph 6-2 of reference (d) and paragraph 3 of reference (c).

CONCLUSIONS

20. It is concluded:

(a) That this material submitted by the Hartford Faience Company complies with reference (e) for Grade L-1 insulating material and that the moisture absorption is less than 0.1% in compliance with reference (d).

(b) That the material complies with reference (e) with respect to Modulus of Rupture, Thermal Shock and Dielectric Strength.

TABLE I

Dielectric Properties

N.R.L. No.	Dielectric Constant Dry	Dielectric Constant Wet	Power Factor Dry	Power Factor Wet	Loss Factor Dry	Loss Factor Wet
661	5.86	5.82	0.00736	0.0174	0.0431	0.101
662	5.81	5.81	0.00752	0.0143	0.0438	0.0830
663	5.83	5.84	0.00730	0.0152	0.0425	0.0890
681	5.82	5.90	0.00787	0.0153	0.0458	0.0900
682	5.85	5.88	0.00795	0.0132	0.0465	0.0776
683	5.94	5.94	0.00790	0.0135	0.0469	0.0802
Average Values For Six Specimens	5.85	5.86	0.00765	0.0148	0.0447	0.0868

TABLE II

Modulus of Rupture

NRL No.	Direct Breaking Load	Diameter in Inches	Modulus of Rupture
102	1034	1.090	10,170
103	1026	1.094	9,980
104	1052	1.094	10,220
105	1128	1.116	10,320
106	912	1.096	8,820
107	1040	1.120	9,410

TABLE III

Thermal Shock
Length = 6.25 inches

NRL No.	Diameter in Inches	Cycles Completed
T-1	1.101	20
T-2	1.094	20
T-3	1.103	20
T-4	1.089	20
T-5	1.094	20
T-6	1.101	20

TABLE IV

Dielectric Strength

NRL No.	Breakdown Voltage in Kilovolts	Thickness in mils	Dielectric Strength in Volts per Mil
D-8	61.0	242	252
D-9	50.1	213	235
D-10	56.2	219	257
D-11	55.3	242	227
D-12	59.0	260	244
D-13	36.2	218	166
D-14	55.3	232	238
			Ave. = 231

TABLE V

Moisture Absorption

NRL No.	Weight in Grams		Loss	
	Dry	Wet	In Grams	In Percent
661	30.145	30.174	0.029	0.096