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SUBJECT

Test On Insulating Material

NAVAL RESEARCH LABORATORY

BELLEVUE, D. C.

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Buships Problem M84

NAVY DEPARTMENT

Report of

Test on Insulating Material

Submitted by

Porcelain Enamel and Manufacturing Company

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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Date of Test: March 10, 1943 to April 21, 1943

Prepared by: M. W. Crabb for
J. E. Martin, Contract Employee

Reviewed by: Warren B. Burgess
W. B. Burgess, Principal Radio Engineer
Head, Measurement & Direction Finder Section

A. Hoyt Taylor
A. Hoyt Taylor, Chief Physicist
Superintendent, Radio Division

W. L. Pryor
W. L. Pryor, Jr., Commander, U.S.N.

Approved by: A. H. Van Keuren
A. H. Van Keuren, Rear Admiral, U.S.N., Director

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APPENDICES

AUTHORIZATION

1. This problem was authorized by Bureau of Ships letter, reference (a). Reference (b) is also pertinent.

References: (a) Buships problem let. S67/61 (933-2) of March 6, 1943 to NRL

(b) 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 of Pemque submitted by the Porcelain Enamel and Manufacturing Company comply with reference (b) for Grade L-1, L-2, L-3, L-4, L-5 or L-6 insulating material.

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 (b). Dry measurements were also made on the samples. The dry loss factors were calculated and included in this report. Measurements were made in an atmosphere of 25% relative humidity at 26° Centigrade.

4. The $\frac{1}{4}$" diameter by 6" test specimens were not tested for flexural-strength or resistance to thermal change because reference (b) requires that the samples be at least 0.7 inches in diameter.

5. Dielectric strength tests were conducted twice on the same set of samples. The first time, a maximum voltage of only 30,000 volts was available, and the samples did not break down. The second time the samples were tested, a week after the first test, sufficient voltage was applied to break down the oil around the edge of the samples. When the first test was made, the samples were immersed in transformer oil for a few minutes. Before the second tests were made, the samples were cleaned by rubbing a cloth, previously dipped in acetone, over the surface of the samples. In spite of this cleaning, it is believed that some of the transformer oil may have become impregnated in the samples. This would tend to increase the dielectric strength.

CONCLUSIONS

It is concluded:

(a) That this material submitted by the Porcelain Enamel and Manufacturing Company complies with reference (b) with respect to Loss Factor and Dielectric Strength for Grade L-3 insulating material.

(b) That more samples of proper size will have to be submitted to see whether the material complies with reference (b) with respect to Thermal Shock and Modulus of Rupture.

RECOMMENDATIONS

It is recommended:

(a) That samples of Pemque which comply with the dimensional requirements of reference (b) for Modulus of Rupture and Thermal Shock test specimens be submitted by the Porcelain Enamel and Manufacturing Company and tested by this Laboratory before the material is recommended as Class L insulating material of any grade.

DESCRIPTION OF MATERIAL UNDER TEST

6. The six samples numberes 628 through 633 inclusive by NRL were approximately 5.5 inches square and 0.25 inches thick. Those numbered D-1 through D-6 inclusive were approximately 2 inches in diameter and 0.25 inches thick. The material is glass bonded mica designated as "Pemque."

METHOD OF TEST

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

8. 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

9. 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.

10. 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 ω^2LCs, negligible as compared to unity.

11. 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 (b).

12. The Modulus of Rupture tests were conducted in accordance with paragraph F-4 of reference (b). 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.

13. The tests for Resistance to Thermal Change were conducted in accordance with paragraph F-5 of reference (b). 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).

14. The final tests for Dielectric-Strength were conducted in accordance with paragraphs F-3a, F-3b and F-3c of reference (b) 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 (ASTM 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.

DATA RECORDED DURING TEST

15. The data recorded during test are given in Tables I and II.

PROBABLE ERROR IN RESULTS

16. 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 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

17. Results of tests are given in Tables I and II and may be summarized as follows: The data recorded in Table I show that the samples comply with paragraph E-1 of reference (b) for Grade L-3 insulating material. Table II shows that the samples comply with reference (b) with respect to Dielectric Strength. The last column of Table II gives the potential gradient applied to the test specimen at the time the oil broke down around the edge.

CONCLUSIONS

18. It is concluded:

(a) That this material submitted by the Porcelain Enamel and Manufacturing Company complies with reference (b) with respect to Loss Factor and Dielectric Strength for Grade L-3 insulating material.

(b) That more samples of proper size will have to be submitted to see whether the material complies with reference (b) with respect to Modulus of Rupture and Thermal Shock.

TABLE I

Dielectric Properties

NRL No.	Dielectric Constant Dry	Dielectric Constant Wet	Power Factor Dry	Power Factor Wet	Loss Factor Dry	Loss Factor Wet
628	7.02	7.01	0.0018	0.0026	0.0123	0.0184
629	7.07	7.02	0.0020	0.0028	0.0145	0.0193
630	7.04	6.99	0.0020	0.0030	0.0141	0.0206
631	7.34	7.26	0.0020	0.0028	0.0148	0.0200
632	7.00	6.96	0.0019	0.0029	0.0134	0.0204
633	7.06	7.02	0.0019	0.0027	0.0133	0.0187
Average Value For 6 Specimens	7.09	7.04	0.0019	0.0028	0.0137	0.0196

TABLE II

Dielectric Strength

NRL No.	Breakdown Voltage of Oil in Kilovolts	Thickness in Mils	Dielectric Strength at Breakdown of Oil in Volts per Mil
D-1	60.3	254	237
D-2	57.2	251	228
D-3	57.2	254	225
D-4	61.0	251	243
D-5	61.0	255	239
D-6	57.2	254	225
			Ave. = 233