August 6, 1943

NRL Report No. R-2133
Bushiips Problem M106

FR-2133

NAVY DEPARTMENT

Report of

Test on Insulating Material

Submitted by

General Ceramics and Steatite Corporation

NAVAL RESEARCH LABORATORY
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WASHINGTON, D. C.

Number of Pages: Text - 4 Tables - 4

Authorization: Bureau of Ships letter S67/61 (933-1) of June 8, 1943 to NRL

Date of Test 22 June 1943 to 30 June 1943

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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 (933-1) of June 8, 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 submitted by the General Ceramics and Steatite Corporation 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.

CONCLUSIONS

It is concluded:

(a) That this material submitted by the General Ceramics and Steatite Corporation does not comply with reference (b) for Class L insulating material.

RECOMMENDATIONS

It is recommended:

(a) That the test samples submitted by the General Ceramics and Steatite Corporation not be approved as Class L ceramic insulating material.

DESCRIPTION OF MATERIAL UNDER TEST

4. The insulating materials #2499, #2861 and #2532 manufactured by the General Ceramics and Steatite Corporation, Keasby, New Jersey, were numbered by this Laboratory 702 through 707, 708 through 713 and 714 through 719 respectively. Each sample was approximately 6 inches square and $\frac{1}{4}$ inch thick. Samples numbered D-45 through D-62 inclusive were approximately 2 inches in diameter and $\frac{1}{4}$ inch thick. Those numbered H-37 through H-54 and M-37 through M-54 inclusive were approximately 6 inches long and 1 inch in diameter.

METHOD OF TEST

5. 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.

6. 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.

Weppler transformer, Type A3, no. 8423.

7. The factor of merit of the variable capacitor is stated by the manufacturer to be better than 0.003 x 10^{-12} Farads. The factor of merit of the entire test circuit is better than 1.11 x 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.

8. 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 $\omega^2 LC_s$, negligible as compared to unity.

9. The dielectric permittivity (k) was determined from physical measurements made upon the samples, 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).

10. 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.

11. 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).

12. Tests for Dielectric-Strength were conducted under oil in accordance with paragraphs F-3a, F-3b and F-3c of reference (b) 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

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

PROBABLE ERROR IN RESULTS

14. 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

15. Results of tests are given in Tables I through IV and may be summarized as follows: Table I shows that material #2861 does not comply with reference (b) with respect to loss factor. It also shows that material #2499 complies with reference (b) with respect to loss factor for Grade L-3 insulating material and that material #2532 complies for Grade L-4. Tables II and IV show that the three materials comply with reference (b) with respect to Modulus of Rupture and Dielectric Strength. Table III shows that none of the three materials comply with reference (b) with respect to thermal shock for Class L insulating material.

CONCLUSIONS

16. It is concluded:

(a) That this material submitted by the General Ceramics and Steatite Corporation does not comply with reference (b) for Class L insulating material.

TABLE I

Dielectric Properties

NRL No.	Dielectric Constant Dry	Dielectric Constant Wet	Power Factor Dry	Power Factor Wet	Loss Factor Dry	Loss Factor Wet
			Material #2499			
702	5.46	5.44	0.00352	0.00376	0.0192	0.0205
703	5.39	5.45	0.00337	0.00374	0.0182	0.0204
704	5.45	5.43	0.00314	0.00475	0.0171	0.0257
705	5.45	5.44	0.00370	0.00383	0.0202	0.0208
706	5.44	5.41	0.00331	0.00363	0.0180	0.0215
707	5.48	5.46	0.00341	0.00395	0.0172	0.0216
Average Values for 6 Specimens	5.44	5.44	0.00341	0.00394	0.0183	0.0217
			Material #2861			
708	5.78	5.93	0.00138	0.0250	0.00798	0.1482
709	5.73	5.90	0.00153	0.0737	0.00879	0.4348
710	5.76	5.91	0.00185	0.0248	0.01063	0.146
711	5.72	6.25	0.00166	0.0660	0.00949	0.4125
712	5.74	5.90	0.00175	0.0248	0.01004	0.1466
713	5.76	5.91	0.00240	0.0210	0.01380	0.1237
Average Values For 6 Specimens	5.75	5.97	0.00176	0.0392	0.01012	0.2019
			Material #2532			
714	5.81	5.80	0.00133	0.00212	0.00771	0.0123
715	5.82	5.82	0.00169	0.00174	0.00984	0.0101
716	5.81	5.80	0.00126	0.00211	0.00730	0.0122
717	5.82	5.80	0.00137	0.00195	0.00790	0.0112
718	5.81	5.78	0.00141	0.00195	0.00818	0.0113
719	5.81	5.80	0.00143	0.00174	0.00830	0.0100
Average Values For 6 Specimens	5.81	5.80	0.00162	0.00193	0.00820	0.0112

TABLE II

Modulus of Rupture

NRL No.	Direct Breaking Load	Diameter in Inches	Modulus of Rupture
		Material #2499	
M-49	1114	1.020	13,380
M-50	1208	1.020	14,530
M-51	1151	1.020	13,820
M-52	1090	1.020	13,100
M-53	1202	1.020	14,450
M-54	1072	1.020	12,880
		Material #2861	
M-43	1134	1.006	14,150
M-44	1436	1.010	17,750
M-45	1349	1.000	17,180
M-46	1392	1.005	17,410
M-47	1430	1.004	17,930
M-48	1386	1.008	17,240
		Material #2532	
M-37	1432	0.990	18,800
M-38	1359	0.993	17,650
M-39	1362	0.990	17,860
M-40	1440	0.988	19,020
M-41	1486	0.992	19,380
M-42	1465	0.989	19,270

TABLE III

Thermal Shock
Length = 6.25 Inches

NRL No.	Diameter in Inches	Cycles Completed
	Material #2499	
H-43	1.018	4.5
H-44	1.018	20.
H-45	1.018	20.
H-46	1.018	20.
H-47	1.018	20.
H-48	1.018	20.
	Material #2861	
H-37	1.005	20.
H-38	1.005	20.
H-39	1.004	8.
H-40	1.003	20.
H-41	1.003	20.
H-42	1.000	20.
	Material #2532	
H-49	0.990	4.
H-50	0.988	16.5
H-51	0.992	20.
H-52	0.988	20.
H-53	0.990	4.5
H-54	0.992	12.

TABLE IV

Dielectric Strength

NRL No.	Breakdown Voltage in Kilovolts	Thickness in Mils	Dielectric Strength in Volts per Mil
		Material #2499	
D-51	48.8	244	200
D-52	42.0	249	169
D-53	56.3	246	229*
D-54	47.5	243	195
D-55	43.0	247	174
D-56	55.5	244	228
			Ave. = 199
		Material #2861	
D-57	57.0	247	231*
D-58	44.5	246	181
D-59	56.0	247	227*
D-60	56.0	246	228*
D-61	55.5	245	226
D-62	54.5	245	222
			Ave. = 219
		Material #2532	
D-45	56.3	246	229
D-46	56.3	250	225
D-47	57.3	253	226*
D-48	56.3	246	229
D-49	56.3	248	227
D-50	57.3	248	231*
			Ave. = 228

*Indicates sample did not break down.