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BuShips Problem M1-30

NAVY DEPARTMENT

Report of Test

of

M. F. Formica

Submitted by The Formica Insulation Co.

FR-1941

NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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AUTHORIZATION

1. These problems were authorized by Bureau of Ships letters references (a), (b), and (c). References (d), (e), and (f) are also pertinent.

References:

- (a) BuShips letter S67/61 (480V) of May 12, 1942, to NRL
- (b) BuShips letter S67/61 (480V) of July 30, 1942 to NRL
- (c) BuShips letter S67/61 (480V) of Sept. 12, 1942 to NRL
- (d) BuShips letter S67/61 (480-V) of May 23, 1941 to NRL
- (e) BuShips letter S67/61 (480V) of July 17, 1942
- (f) Specification RE 13A 317F

OBJECT OF TEST

2. The object of the test was to determine whether the three lots of samples of MF Formica, submitted by the Formica Insulation Company comply with reference (f) for Grade F or G insulating material.

ABSTRACT OF TEST

3. The dry and wet loss factors were determined by measurements made at 1000 kc in compliance with paragraph 2 of reference (d) and paragraph 6-1 of reference (f), and in accordance with A.S.T.M. Standards on Testing Electrical Insulating Materials of December 1941. The wet loss factor was measured after the samples had been immersed in distilled water for 48 hours.

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

CONCLUSIONS

It is concluded:

(a) That the three samples of MF Formica, numbered 395, 396, and 397 by NRL, and submitted by the Formica insulation Company comply with reference (f) for Grade F insulating material.

(b) That samples numbered 432, 433, and 434; 497, 498, 499 do not comply with reference (f) for either grade F or G insulating material.

(c) That the moisture absorption does not comply with paragraph 6-2 of reference (f) since the moisture absorption was 1.1% for sample numbered 432.

RECOMMENDATIONS

It is recommended:

(a) That MF Formica submitted by the Formica Insulation Company and numbered 395, 396 and 397 be approved as Grade F insulating material.

(b) Samples numbered 432, 433 and 434, 497, 498, 499 do not comply with reference (f) for either grade F or G insulating material.

(c) That the moisture absorption does not comply with paragraph 6-2 of reference (f).

DESCRIPTION OF MATERIAL UNDER TEST

5. The first lot of samples submitted by the Formica Insulation Co. were numbered 395, 396 and 397 by Naval Research Laboratory; the next lot 432, 433 and 434; the next 497, 498 and 499. All samples were approximately 6 in. square and $\frac{1}{4}$ in. thick.

6. The Formica Insulation Company has informed Naval Research Laboratory that it can no longer supply the material represented by the first lot of samples submitted by them. These are the only samples which rate as either Grade F or G insulating material.

7. The six cylindrical samples submitted for the modulus of rupture test were approximately 6 inches long and 1" in diameter.

METHOD OF TEST

8. 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.

9. The standard measuring circuit consists of the following equipment:

1000 kc crystal controlled master oscillator power amplifier, assembled by Naval Research Laboratory

Naval Research Laboratory 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.

10. 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.

11. The dry loss factor was determined by 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 standard capacitor is sufficiently small to make W^2LC s negligible as compared to unity.

12. 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 reference (d).

13. The moisture absorption tests were carried out on samples made by sawing strips the full length of the original sample tested, then fracturing at lengths of approximately 3/4 inches long so that the newly fractured surface plus the newly sawed surface was approximately 50% of the unfractured surface of each sample. They were immersed in distilled water at room temperature for 100 hours. At the end of this period the samples were removed from the water carefully dried with filter paper and immediately weighed. The samples were then placed in a desiccating chamber and allowed to remain there 96 hours after which time the dry weight was taken.

DATA RECORDED DURING TEST

14. The modulus of rupture tests were made by supporting the cylindrical samples on two cylindrical supports, separated a distance of 5.00 inches and applying a direct load midway between these two supports at a rate of approximately 250 pounds per minute. The radius of the supporting members at the point to which the direct load was applied was 1/8 of an inch. This test was made by a Southwalk testing machine.

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

PROBABLE ERROR IN RESULTS

16. The error in the determination of the power factor is not greater than 4%, while that of the loss factor is not greater than 5%. The error in the determination of the weight in the moisture absorption test is approximately 0.00125%. The error in the determination of the modulus of rupture is not greater than 5%.

17. 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 residual errors in the standard measuring circuit have not been applied to this data.

RESULTS OF TEST

18. Results of test are given in Tables I, II and III and may be summarized as follows: The data recorded in Table I show that the loss factor of samples numbered 395, 396, and 397 comply with paragraph 6-1 of reference (f) for Grade F insulating material. That samples numbered 432, 433 and 434; 497, 498, and 499 do not comply with paragraph 6-1 of reference (f) for either F or G insulating material.

19. Table No. II shows that the modulus of rupture for samples numbered 1 to 6 inclusive, range between the limits of 19720 to 20780 lbs per square inch, when the direct load was applied at the rate of 250 lb per minute approximately.

20. Table III shows that sample numbered 432 increased its weight by 1.10% in the moisture absorption test.

CONCLUSIONS

21. It is concluded:

- (a) That the three samples of MF Formica, numbered 395, 396, and 397 by Naval Research Laboratory and submitted by the Formica Insulation Company comply with reference (f) for Grade F insulating material.
- (b) That samples numbered 432, 433, and 434; 497, 498, and 499, by Naval Research Laboratory do not comply with reference (f) for either grade F or G insulating material.
- (c) That the moisture absorption does not comply with paragraph 6-2 of reference (f).

TABLE I

Dielectric Properties of M. F. Formica

Formica Insulation Co.

NRL NO.	Dielectric Constant		Power Factor		Loss Factor		Grade
	Dry	Wet	Dry	Wet	Dry	Wet	
395	4.02	4.08	0.41	0.82	1.65	3.34	F
396	4.02	4.07	.50	.93	2.01	3.78	F
397	4.05	4.15	.50	1.45	2.02	6.0	F
432	4.78	4.80	1.14	2.05	5.45	9.85	-
433	4.78	4.90	1.11	2.32	5.30	11.4	-
434	4.78	4.90	1.14	2.00	5.30	9.8	-
497	4.46	4.45	1.32	1.65	5.89	7.34	-
498	4.46	4.51	1.30	1.72	5.80	7.75	-
499	4.51	4.59	1.31	1.77	5.91	8.12	-

TABLE II

Modulus of Rupture

NRL NO.	Direct	Diam. Ins.	Modulus lbs/ins ²
	Load lbs.		
1	1592	1.00	20,350
2	1550	1.00	19,720
3	1634	1.00	20,780
4	1611	1.00	20,360
5	1580	1.00	20,100
6	1554	1.00	19,770

Direct Load Applied at the rate of 250 lbs/min approx.

TABLE III

Moisture Absorption

NRL NO.	Weight in Grams		Gr. Gain	% Gain
	Dry	Wet		
432	52.090	52.660	0.570	1.1
497	43.735	43.905	0.170	0.389