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NAVY DEPARTMENT

Report of

# Test on Insulating Material, Centralab Cordierite Type 400

Submitted by

Globe Union Company

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NAVAL RESEARCH LABORATORY
ANACOSTIA STATION
WASHINGTON, D. C.

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Prepared by:

J. E. Martin, Contract Employee

Reviewed by:

W. B. Burgess, Principal Radio Engineer
Head of Measurement & Direction Finder Section

A. Hoyt Taylor, Chief Physicist
Superintendent, Radio Division

D. R. Hull, Lieutenant Commander, USN.

Approved by:

A. H. Van Keuren, Rear Admiral, USN

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## APPENDICES

## AUTHORIZATION

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

References:

(a) Buships ltr S67/61 (933) of Nov. 6, 1942 to NRL.
(b) Buships ltr S67/61 (5-23-480) of May 23, 1941
(c) Buships ltr S67/61 (480V) of July 17, 1942
(d) Specifications RE 13A 317F.

## OBJECT OF TEST

2. The object of the test was to determine whether the samples of Ceramic submitted by The Globe Union Co., comply with reference (d) for Grade F or G insulating material and also to determine the modulus of rupture of this material.

## ABSTRACT OF TEST

3. The dry and wet loss factors were determined by measurements made at 1000 kilocycles, in compliance with paragraph two of reference (b), paragraph 6-1 of reference (d), 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. The modulus of rupture test was made on a Standard Southwark Testing Machine.

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

CONCLUSIONS

It is concluded:

(a) That these samples of Centralab Cordierite Ceramic Type 400 submitted by the Globe Union Company, comply with reference (d) for Grade F insulating Material.

RECOMMENDATIONS

It is recommended:

(a) That these samples of Centralab Cordierite Ceramic Type 400 submitted by the Globe Union Company, be approved as Grade F insulating material.

DESCRIPTION OF MATERIAL UNDER TEST

5. The three white, unglazed samples numbered 530, 531 and 532 by NRL were approximately 15 cm. square and 0.42 cm. thick. The seven cylindrical samples numbered 83 to 89 inclusive were approximately 6 inches long and 1.06 inches thick. The manufacturer designates the material as Centralab Cordierite Type 400.

METHOD OF TEST

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

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

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.

8. The factor of merit of the variable capacitor is stated by the manufacturer to be better than $0.003 \times 10^{-12}$ Farads. The factor of merit of the entire test circuit is better than $1.11 \times 10^{-12}$ 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 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 reference (d).

11. The moisture absorption tests were carried out on newly fractured pieces as detailed in paragraph 6-2 of reference (d) and paragraph 3 of reference (c) where the newly fractured surface was approximately 50% of the unfractured surface of each sample. The samples were first immersed in distilled water at room temperature for 96 hours during which time the water was boiled for a period of one hour during the 1st, 25th, 49th and 74th hours. At the end of 96 hours the samples were removed from the water, carefully dried with filter paper and immediately weighed. They were then placed in a desiccator for 96 hours after which time they were again weighed.

12. The modulus of rupture test was made by applying a direct load, at a rate of 250 lbs. per minute, 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.

## DATA RECORDED DURING TEST

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

## 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 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%.

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

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

## RESULTS OF TEST

17. Results of test are given in Table I, II and III. The data recorded in Table I shows the wet loss factor to be Grade F for all samples.

18. Table II shows that the samples comply with paragraph 6-2 of reference (d) for the moisture absorption test.

19. Table III gives the value of the Modulus of Rupture for the samples numbered 83 to 89 inclusive.

CONCLUSIONS

20. It is concluded:

(a) That these samples of Centralab Cordierite Ceramic Type 400 submitted by the Globe Union Company, be approved as Grade F insulating material.

Table I

Globe Union Co.

Dielectric Properties

| NRL No. | Dielectric Constant Dry | Dielectric Constant Wet | Power Factor % Dry | Power Factor % Wet | Loss Factor Dry | Loss Factor Wet | Grade |
|---|---|---|---|---|---|---|---|
| 530 | 5.32 | 5.26 | 0.653 | 0.656 | 3.47 | 3.45 | F |
| 531 | 5.28 | 5.28 | 0.634 | 0.647 | 3.35 | 3.41 | F |
| 532 | 5.42 | 5.47 | 0.597 | 0.623 | 3.24 | 3.41 | F |

Table II

Moisture Absorption

| NRL No. | Weight in Grams Dry | Weight in Grams Wet | Gain in Weight (grams) | Gain % |
|---|---|---|---|---|
| 530 | 39.959 | 39.962 | 0.003 | 0.008 |

Table III

| NRL No. | Diam Inches | Direct Load lbs | Modulus of Rupture lbs/in$^2$ |
|---|---|---|---|
| 83 | 1.065 | 1020 | 10750 |
| 84 | 1.060 | 1090 | 11660 |
| 85 | 1.064 | 1025 | 10850 |
| 86 | 1.063 | 910 | 9660 |
| 87 | 1.063 | 1320 | 14000 |
| 88 | 1.064 | 1220 | 12930 |
| 89 | 1.064 | 1070 | 11330 |