

**UNCLASSIFIED**

---

---

**AD. 297 329**

*Reproduced  
by the*

**ARMED SERVICES TECHNICAL INFORMATION AGENCY  
ARLINGTON HALL STATION  
ARLINGTON 12, VIRGINIA**



---

---

**UNCLASSIFIED**

NOTICE: When government or other drawings, specifications or other data are used for any purpose other than in connection with a definitely related government procurement operation, the U. S. Government thereby incurs no responsibility, nor any obligation whatsoever; and the fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded by implication or otherwise as in any manner licensing the holder or any other person or corporation, or conveying any rights or permission to manufacture, use or sell any patented invention that may in any way be related thereto.

63-2-5

CATALOGED BY ASTIA  
AS AD No. 297329

GHIIIID

GENERAL DYNAMICS | CONVAIR

Report No. 8926-098

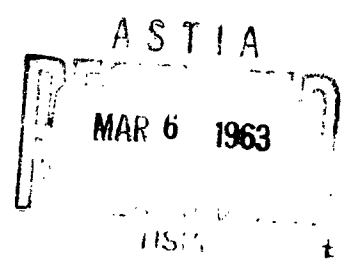
Materials - Finishes and Coatings - Anti-Static -  
For Radio Antennas

Surface Resistivity and Application Characteristics

L. A. Mappus, J. C. George, E. E. Keller

297 329

15 July 1959



Published and Distributed  
under  
Contract AF33(697)-8926



Report No. 8926-098  
Materials - Finishes and Coatings - Anti-Static -  
For Radio Antennas

Surface Resistivity and Application Characteristics

Abstract

Gaco N-15 black neoprene coating applied over Bostick 1007 primer, Gaco N-81 black neoprene electron conductive coating over Gaco N-13 primer and topcoated with Gaco N-82 white ionically conductive neoprene coating and Cat-A-Lac 453-1-1 black epoxy anti-static coating were tested to determine their surface resistivity and application characteristics. The Gaco materials were made by the Gates Engineering Co., Wilmington, Delaware; the Bostik primer by B. B. Chemicals Co., Cambridge, Massachusetts; and Cat-A-Lac by Finch Chemical and Paint Co., Torrance, California. The Gaco N-51 coating had an infinite surface resistivity and was unsatisfactory. Gaco N-81 had a surface resistivity between 10 to 100 megohm per square but a critical recoat time made the material impractical for production use. Gaco N-81 topcoated with Gaco N-82 had infinite surface resistance and was not satisfactory. Cat-A-Lac black epoxy resin material required baking at 250°F and its surface resistivity varied inversely with film thickness, but was within the 10 to 100 megohm per square requirement.

Reference: Mappus, L. A., George, J. C., Keller, E. E.,  
"Anti-Static Coatings for Model 22 Dorsal Antenna,"  
General Dynamics/Convair Report MP59-042, San Diego,  
California, 15 July 1959 (Reference attached).



INTRODUCTION:

The Engineering Electronics Design Group expects a build up of precipitation static charges on the Model 22 dorsal antenna due to the impingement of various particles during flight. When these charges are to ground, they will cause interference in the communications system. Therefore, it is desirable to have a coating on the antenna which will conduct these charges away before they build up and, at the same time, will not interfere with the transmission characteristics of the system. The surface resistivity requirement of a coating for this application has been set at 10 to 100 megohms per square by the Electronics Design Group.

OBJECT:

To test the following finish systems as anti-static coatings for the Model 22 dorsal antenna:

- a. Gaco N-51 black neoprene coating applied over CVAC PRIME 1-3 (Bostick 1007).
- b. Gaco N-81 black neoprene electron conductive coating applied over Gaco N-18 prime and topcoated with Gaco N-82 white ionically conductive neoprene coating.

NOTE: All Gaco coatings were manufactured by the Gates Engineering Company, Wilmington, Delaware.

- c. Cat-A-Lac 453-1-1 black epoxy anti-static coating, manufactured by Finch Paint and Chemical Company, Torrance, California.

CONCLUSIONS:

- a. The Gaco N-51 neoprene coating showed an infinite surface resistivity and is not considered satisfactory for use as an anti-static coating.
- b.
  1. The Gaco N-81 coating gave results within the 10-100 megohm per square surface resistivity requirement. However, a critical recoat time makes this material impractical for use in the production shop.
  2. When the Gaco N-81 was topcoated with the Gaco N-82, the resistance of the system became infinite.
- c. The Finch Cat-A-Lac 453-1-1 black epoxy coating gave results within the 10-100 megohm per square requirement. The surface resistivity of this coating varied inversely with the film thickness and curing time at 250°F. No difficulty was experienced in applying this material in the production shop.

RECOMMENDATION:

It is recommended that the Finch Cat-A-Lac 453-1-1 black epoxy coating be used as an anti-static coating on the Model 22 dorsal antenna.

TEST SPECIMENS:

A. Coatings:

The various coating systems tested are listed in Table I. Individual finishes appear in the order of application. For instance, specimen No. 1, Table I, shows that an epoxy fiberglass panel was first coated with .65 mils of Bostick prime 1007 and then with .82 mils of Gaco N-51.

B. Fiberglass Panels:

All fiberglass specimens were prepared from 3/64 inch thick Mil-P-18177-GEE epoxy-fiberglass laminate.

TEST PROCEDURE:

A. Coatings:

All finishes were applied in accordance with the manufacturers recommendations and Convair standard finishing practices.

B. Resistance Test:

The surface resistivity of the test specimens was determined with a "Megger" Insulation Tester, "Meg" Type, manufactured by James G. Biddle Company, Philadelphia, Penn. This instrument employs an impressed voltage of 1000 volts DC. Polished copper bars were used as electrodes. Leads from the "Megger" were attached to 100 gm weights which were placed on top of the copper bars to give a constant contact pressure. The bars were spaced to measure the surface resistivity across a unit area, which in most cases, was a 3 inch square.

RESULTS:

The specimens tested and the results of the tests are shown in Table I.

In addition to the specimens listed in Table I, eighteen specimens were prepared to determine the effect of film thickness and curing time at 250°F on the resistance of the Finch 453-1-1. The results of this test are shown in Figure 1. Each point on the graph represents an average of two tests.

DISCUSSION:

Gaco N-51 had been used at Convair previously as an anti-static coating. Service performance of this material as an anti-static coating was inconclusive. Tests on the N-51 coating gave infinite resistance readings (reference specimens 1 through 4). The Gaco Company recommended that their N-18, N-81, and N-82 system be used for this application. This system is composed of a prime (N-18), a black neoprene electron conductive coating (N-81), and a white neoprene ionically

DISCUSSION: (Cont'd)

conductive coating (N-82). Theoretically, the white ionically conductive coating is supposed to allow a current to pass transversely through it to the underlying black electron conductive coating. Attempts to make this system function properly were not successful (reference specimens 5-7, and 12). The materials not only failed to perform electrically, but were also difficult to apply because of a critical recoat time. The neoprene coatings were primarily designed for rain erosion protection. Since rain erosion is not a factor on the dorsal antenna, it was decided to try a different type system.

A number of specimens were prepared using Finch 453-1-1 black epoxy anti-static coating. The only problem encountered with this material was the fact that it had to be baked at 250°F before it developed the required electrical properties. The surface resistivity of the Finch 453-1-1 varied inversely with the curing time at 250°F and film thickness (See Figure 1). The resistance of this material did not change after 250 hours of accelerated weathering (reference specimen No. 44). As a result of work done in the laboratory and trials made in the shop, MP3 77.29 was written to cover the application of this material in the production shop.

One problem remained. The Finch 453-1-1 was black and most of the airlines require that the dorsal antenna area be painted white. The Gaco N-82 was applied over the Finch 453-1-1 and was found to work electrically (reference specimen 33). However, the Gaco N-82 would not adhere to the Finch product. When the N-18 primer (reference specimen 34) was interposed, the adhesion was improved, but the desired electrical properties were lost.

During a telephone conversation with Dr. Vogelsang, Director of Research for Gaco, he stated that the ionically conductive properties of the N-82, which permitted it to transmit an electrical charge through to the black N-81, were due to the incorporation of a surface active agent. Tests were conducted at Convair using various surface active agents (reference specimens 29, 30, 35 - 40, 42, 43, 45 - 49, 51). Of the various surface active agents tested, Nalcamine G-11, a cyclic tertiary amine manufactured by the National Aluminate Corporation, Chicago, Ill., gave the best results. Chemically, the G-11 is an alcohol solution of 1-(2-hydroxyethyl) -2-oxo-2-imidazoline. The mechanism by which this material works is not understood. It appeared to function best when added 2% by weight to unthinned Fuller Exterior Hi-Gloss (No. 7574X) and Dupont Dulux (No. 83-508) white enamels. Results were inconsistent in that the same specimen, checked at different times, gave different readings. It did not appear to work at all when added to epoxy enamels. The G-11 worked when added to MIL-L-7178 white lacquer but caused the film to crack on weathering. In all cases, an impressed voltage appeared to be necessary for the Nalcamine G-11 to function as desired.

ANALYSIS  
PREPARED BY Mappus  
CHECKED BY George/Keller/Sutherland  
REVISED BY

**C O N V A I R**  
A DIVISION OF GENERAL DYNAMICS CORPORATION  
SAN DIEGO

PAGE 4  
REPORT NO. MP 59-042  
MODEL 22  
DATE 15 July 1959

DISCUSSION: (Cont'd)

Another approach was to add 1% copper dust to a white lacquer and enamel (reference specimen 41). The copper particles provided scattered paths for the transmission of current through the white topcoat to the black anti-static undercoat. Although this small amount of copper was not noticeable in the film, there are two disadvantages:

1. The copper would settle out rapidly and require constant agitation during application;
2. The copper particles might corrode and cause staining of the white topcoat.

NOTE: Test data from which this report was prepared may be found in Engineering Test Laboratories Data Book No. 3004.

Table I  
 Coating Systems and Results

Coating	Substrate	Cure	Dry Film Thickness (Mils)	Resistance Reading (Megohms/sq.)
1. Bostick Prime 1007 Gaco N-51	Epoxy fiberglass "	Air dry "	.65 .82	Infinite
2. Bostick Prime 1007 Gaco N-51	" "	" "	.89 .96	Infinite
3. Bostick Prime 1007 Gaco N-51	" "	" "	.72 .63	Infinite
4. Bostick Prime 1007 Gaco N-51	" "	" "	.98 1.09	Infinite
5. Gaco N-18 Prime Gaco N-81	" "	" "	.9 5.8	10-15
6. Gaco N-18 Gaco N-81 Gaco N-82	" " "	" " "	1.0 6.9 4.1	Infinite
7. Gaco N-18 Gaco N-81 Gaco N-82	" " "	" " "	.9 5.8 19.7	Infinite
8. Gaco N-18 Gaco N-81	" "	" "	1.0 3.9	50

Table I (Cont'd)

Coating	Substrate	Cure	Dry Film Thickness (Mils)	Resistance Reading (Megohms/sq.)
9. Gaco N-18	Epoxy fiberglass	Air Dry	1.0	
Gaco N-81	"	"	3.9	
Gaco N-82	"	"	1.5	Infinite
10. Gaco N-18	"	"	.9	
Gaco N-81	"	"	3.9	
Convair Spec. O-03021, Type II	"	"	7.6	Infinite
11. Finch Cat-A-Lac 453-1-1	"	"	1.5	
O-03021, Type II	"	"	5.5	Infinite
12. Gaco N-18	"	"	1.0	
Gaco N-81	"	"	3.9	
Gaco N-82	"	"	—	Infinite
13. Gaco N-18	"	"	.9	
Gaco N-81	"	"	5.8	
O-03021, Type II	"	"	—	Infinite
14. Gaco N-82	Aluminum	"	1.3	Non Conducting until broken down by voltage
15. O-03021, Type II	Aluminum	"	1.8	Infinite
16. Finch Cat-A-Lac 453-1-1	Epoxy fiberglass	15 Min. @ 250°F	1.3	7.5

Table I (Cont'd)

Coating	Substrate	Cure	Dry Film Thickness (Mils)	Resistance Reading (Megohms/sq.)
17. Finch 453-1-1	Epoxy Fiberglass	30 Min @ 250° F	1.3	3
18. Finch 453-1-1	"	45 Min @ 250° F	1.3	2.5
19. Finch 453-1-1	"	8 Min @ 250° F	6.0	50
20. CVAC Lac 12-54 (Mil-L-6805 Black)	"	Air dry	—	Infinite
21. Black board lacquer	"	Air dry	—	Infinite
22. CVAC Prime 1-1	"	Air dry	—	Infinite
23. Fuller 137-H-53	"	Air dry	—	Infinite
24. Rinsed Mason Electrical Conducture Coating (J-15168)	"	Air dry	—	150 ohms/sq.
25. O-03021, Type II Black Epoxy	"	Air dry	—	Infinite
26. Finch 453-1-1	"	45 Min @ 250° F	6.0	1.5
27. Finch 453-1-1 443-1-(500)	"	90 Min @ 250° F	6.0	.7
	"	45 Min @ 250° F	1.0	Infinite
28. Finch 443-1-(500)	Aluminum	45 Min @ 250° F	1.7	Infinite

Table I (Cont'd)

Coating	Substrate	Cure	Dry Film Thickness (Mils)	Resistance Reading (Megohms/sq.)
29. Finch 443-1(500) + .2% Oleic Acid	Aluminum	45 Min @ 250°F	1.6	Infinite
30. Finch 443-1(500) + 1 % Oleic Acid	Aluminum	45 Min @ 250 °F	1.0	Infinite
31. Finch 453-1-1 Dulux White Enamel (83-508)	Epoxy Fiberglass " "	45 Min @ 250°F Air dry	2.2 .9	10 Infinite
32. Finch 453-1-1 MIL-L-7178(White Lacquer)	Epoxy Fiberglass " "	30 Min @ 250°F Air dry	2.3 .9	15 Infinite
33. Finch 453-1-1 Gaco N-82	" "	30 Min @ 250°F Air dry	2.3 .9	10 10
34. Finch 453-1-1 Gaco N-18 Gaco N-82	" "	30 Min @ 250°F Air dry Air dry	2.3	10 Infinite
35. Finch 453-1-1 MIL-L-7178(White Lacquer) + 1% Malcolmine G 13	" "	250°F Air dry "	—	7 Infinite
36. Finch 453-1-1 MIL-L-7178(White Lacquer) + 1% Naquat G-8-13	" "	250°F Air dry "	—	2.5 Infinite

Table I (Cont'd)

Coating	Substrate	Cure	Dry Film Thickness (Mils)	Resistance Reading (Megohms/sq.)
37. Finch 453-1-1 Mil-L-7178 + 1% Malocamine G 12	Epoxy Fiberglass "	250°F Air dry	—	20 Infinite
38. Finch 453-1-1 Mil-L-7178+ 1% Malocamine G 11	" "	250°F Air dry	—	7 6-150
39. Finch 453-1-1 Mil-L-7178 + 2% Malocamine G 11	" "	250°F Air dry	—	15 17
40. Finch 453-1-1 Mil-L-7178 + 3% Malocamine G 11	" "	250°F Air dry	—	6.5 7
41. Finch 453-1-1 Mil-L-7178 + 1% Copper Dust	" "	250°F Air dry	—	8 9
42. Finch 453-1-1 O-03021, Type II, + 2% Malocamine G 11	" "	250°F Air dry	—	18 Infinite
43. Finch 453-1-1 Dulux White Enamel 83-508 + 2% Malocamine G 11	" "	250°F Air dry	—	1.7 3.0

Table I (Cont'd)

	Coating	Substrate	Cure	Dry Film Thickness (Mils)	Resistance Reading (Megohms/sq.)
44.	Finch 453-1-1 After 250 Hours in weather-O-Meter	Epoxy Fiberglass	250°F	—	15 15
45.	Finch 453-1-1 Fuller 95-M 500x with 2% G-11	Epoxy Fiberglass " "	250°F Air dry	1 Coat	40 48-100
46.	Finch 453-1-1 Fuller Hi-gloss 7574x + 2% Malonidine G-11	" "	250°F Air dry	1 Coat	40 48
47.	Finch 453-1-1 Fuller Hi-gloss 7574x + 2% Malonidine G-11	" "	250°F Air dry	2 Coats	40 48
48.	Finch 453-1-1 Fuller Hi-gloss 7574x + 2% Malonidine G-11	" "	250°F Air dry	3 Coats	35 41 40
49.	Finch 453-1-1 Fuller Hi-gloss 7574x + 2% Malonidine G-11	" "	250°F Air dry	4 wet coats	100 +
50.	Gaco N-82 " " " " " "	Aluminaum " " " " " "	Air dry " " " " " "	1 Coat 2 Coats 3 Coats 4 Coats	0 0 0-100 Megohms 0

Table I(Cont'd)

Coating	Substrate	Cure	Dry Film Thickness (Mils)	Resistance Reading (Megohms/sq.)
51. Fuller HI-gloss 7574x + 2% G-11 " " "	Aluminum " " "	Air dry " " "	1 Coat 2 Coats 3 Coats 4 Coats	.5 to 3 Megohms 0 to .5 " 0 to .5 " 0 to 50 "
52. Finch 453-1-1 Gaco N-82	Epoxy Fiberglass " "	250°F " Air dry	— —	40 100 to Infinite

Figure 1.  
Effect of Thickness + Curing  
Time on Resistance of  
Finch Cat-A-Lac 453-1-1

