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CONFORMAL
COATINGS

BDX-613-341

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Project Leader:
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Quarterly Report
FY71-2

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ABSTRACT

Continued work on conformal coatings for a fire set application led to evaluation of a Dow Corning (DC3140) silicone material which produced satisfactory results in initial tests. The Design Agency will evaluate that material further. A polyurethane material and other coating methods will be investigated in an effort to determine the best possible coating material and coating process for the required application. Those efforts will extend through most of FY71-3

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SUMMARY

Work performed during FY71-2 was a continuation of a search for a conformal-coating system capable of withstanding 6000 volts in an atmosphere of 1 millimeter mercury for a fireset application.

Dow Corning DC3140 was applied to a functional transverter subassembly which was then operated in a vacuum chamber and subjected to high-voltage breakdown tests.

On the strength of these and other supporting tests performed during FY71-1, the Design Agency agreed to the use of DC3140 on the fireset. Each board assembly must pass vacuum tests before assembly and encapsulation. Further testing of the encapsulated assemblies will be performed by the Design Agency.

Further work will include evaluation of polyurethane coating materials and development of a method of application which will provide satisfactory coatings on sharp, extended, pc-board and component features.

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DISCUSSION

SCOPE AND PURPOSE

Although the DC3140 material was known to the design agency, its use for the proposed application had not been universally accepted. The decision made at Sandia Albuquerque at a meeting during the first week of the quarter gave BKC the responsibility for producing firesets which would pass the required production tests. Design Agency tests which will finally determine the value of this coating system will be made sometime during FY71-3 and FY71-4.

Production testing of the coating system at BKC will not extend beyond the present level of individual pc-board assemblies tested at 6000 volts and 1 mmHg.

PRIOR WORK

The work of this quarter continues that done in FY71-1. Although considerable success was experienced in finding a material and developing a process of application which would allow an unencapsulated fireset to be operated at an atmospheric pressure of 1 millimeter mercury, it was necessary to review the system with the Design Agency before use on the fireset.

ACTIVITY

A transverter board fireset subassembly was salvaged from Group I production to test the DC3140 application process. This transverter was completely functional and of a mechanical configuration so nearly like the present Group III assemblies that it could be a significant test unit for the later production.

The material was applied in accordance with the procedure designated in the FY71-1 quarterly report. After the prescribed cure time the assembly was sent to D/845-2 for vacuum testing.

Test Procedure

Wire leads were soldered to the oscillator low-voltage supply, the control voltage for the power amplifier, the high-voltage output, and the combination ground connection for both high and low voltage.

The two low-voltage supply wires were each connected to a separate power supply; the high-voltage wire was connected to a digital voltmeter through a high-voltage probe. All power supplies, the voltmeter, and the transverter were connected to a common ground system.

The vacuum chamber was closed, sealed, and evacuated to 1 mmHg.

The oscillator was started and its supply voltage was set at 28 Vdc. The high-voltage output indicated about 150 volts. The control voltage to the power amplifier was increased slowly and the high-voltage output was increased proportionately.

At an output voltage of 1000 volts, the free, rarified air surrounding part of the assembly began to glow a light blue color. (See Figures 1 and 2.) As the output voltage increased, the blue glow became brighter. At about 2500 volts an arc occurred in the vicinity of the capacitors which form the base for the voltage-doubler output of the transformer.

The assembly operation was shut down and the vacuum was broken. The assembly was then removed. Evaluation indicated that the arc had propagated along the surface of a ceramic capacitor to an area of thin coating on its edge and penetrated the coating at that point.

The capacitors were removed from the assembly, and the breakdown was examined further. It was determined that adhesion of the coating to the surface of the capacitor and coating thickness at the edge of the capacitor were both substandard. Two new capacitors were thoroughly cleaned, primed, coated, and installed in the assembly. While the coating material was still fresh, a length of fiberglass tape was pressed into the coating around the edge of the capacitor (Figure 3). After the first coating of material had cured for 4 hours, a second coating of material was added. After a 48-hour cure, the assembly was returned to the D/845-2 laboratory for further testing.

The setup and test procedure, as stated previously, was repeated, and the assembly output rose to 6400 volts at a power-amplifier control of 32 volts. The corona around the ac circuitry of the voltage doubler and rectifier increased to a brilliant purple. As before, this corona first appeared at 1000 volts output. No further arcing was observed; therefore, it was apparent that this corona was caused by the ac voltage, and was not indicative of a coating breakdown.

Figure 1. Electrical Locations of Corona Effects

Figure 2. Physical Locations of Corona Effects

Figure 3. Coating Methods Used on High-Voltage Capacitors Before and After Corona Occurred

The transverter was shut down again, and a dummy load was added across the high-voltage output. The test was repeated with a high-voltage output of 5200 volts at the same low-voltage input as before.

Process Changes

Data from this test and all other tests performed during FY71-1, together with all test samples which were available, were taken to Sandia, Albuquerque, for a meeting to explain progress and evaluation of the coating problems at BKC (See trip report in Appendix A).

The decision reached at the Albuquerque meeting was that BKC would develop the details of coating each board assembly of the MC2546 with DC3140 material in accordance with the basic design requirements of Sandia, Albuquerque, Organization 2312. Those requirements, as understood at that time, were set down as a sequence of goals which BKC would meet in establishing the details of coating each pc-board assembly (See Appendix B).

Shortly after the Albuquerque meeting, Sandia representatives from Organization 5513 visited BKC to review the current coating procedures. They recommended the use of a thixotropic silicone material, Dow Corning 3144. That material is virtually the same as DC3140 except for its precured viscosity. It does not flow. Consequently, it can be used to cover sharp corners and edges of conductors that will not retain DC3140 in sufficient thickness. The DC3144 material was incorporated into the coating procedure with some success. The material performed exactly as it should; however, because of its extremely high viscosity, it was very difficult to apply.

Since the coating of each board assembly presented unusual problems which could not be readily predicted, this activity was retained in the scope of the process development project. Over the three months constituting this quarter, five units of three different pc-board assemblies were coated and tested. The places presenting the greatest problems were determined, and processing was altered to solve those problems.

The first failure occurred between the terminal leads of a high-voltage storage capacitor. The lead end of this component was mounted within 0.100 inch of the surface of a pc board. The second failure was at a splice in the leads of a sprytron tube that was connected to the positive lead of the same capacitor. It was decided that subassembly of the capacitor and the tube prior to mounting the capacitor on the pc board would allow the DC3140 coating material to be applied when these connections were more accessible. It would also be easier to inspect these subassemblies visually, or to give them a separate vacuum test at 6000 volts, before assembly on the pc board.

Another failure occurred at a similar splice in the leads of another sprytron tube. The former procedure could not be followed in this instance. To give extra assurance, the splice was covered with fiberglass loom, and coating material was pumped into the space inside the loom and surrounding the sprytron lead wires. This coating material was worked into the loom to impregnate it from the inside out. After the coating material had cured, another coat was applied to the outside of the loom. This procedure is difficult to follow on the second sprytron because of limited work space. A better way to eliminate this trouble spot is still being sought.

ACCOMPLISHMENTS

During the work which involved fiberglass material, it was determined that the primer used to improve adhesion between DC3140 and the pc board acted to inhibit impregnation of the fiberglass by the DC3140. It was also found that DC3144 was too viscous to impregnate the fiberglass, so the use of both of these materials was discontinued in conjunction with either fiberglass tape or loom.

We now have a different process which can be applied by trained production personnel with predictable and adequate results.

Attention was turned to the fireset another system, which was using a polyurethane coating system, but with little success. BKC Materials Engineering, D/862, was requested to assist in finding a solution to the problem which prevented an adequate voltage standoff of the unencapsulated fireset assembly in an atmosphere of 1 mmHg.

The problem which is preventing success at this time is basically the same as that described in the FY70-4 quarterly report. The coating material migrates away from edges, corners, and points of conductors, especially when the coated assembly is placed in an oven for cure acceleration. The thixotropic mixture of 7 parts of Cab-O-Sil and 100 parts of Adiprene L-100 does an excellent job of coating solder joints on the surface of the pc board opposite the component mounting. The other trouble points shown in Figure 4 were not equally well covered by the addition of this material. The addition of fiberglass or some similar inert material which can be impregnated is difficult. Because the polyurethane is a low viscosity material, it will not hold the tape in place until the coating is cured. For that reason, the use of fiberglass tape and sleeving has not been incorporated into the polyurethane coating system.

Figure 4. Typical Points of Thinnest Coating and Greatest Probability of Electrical Breakdown

FUTURE WORK

Work will be continued to find a method as successful as the use of fiber-glas and which will be more compatible with BKC manufacturing capabilities. A program was instituted by D/862 to determine the specific voltage-standoff properties of Laminar X-500. Materials Engineering will prepare test boards which will be sent to D/845-3 for testing. In addition, D/845-3 will prepare test boards which incorporate the various conductor configurations that are the most difficult to coat. These consist of flat conductors and component leads which do not lie against a flat nonconductive surface and metallic standoff terminals that project well away from the surface of the pc board (Figure 4).

These test boards are more applicable to testing methods of applying polyurethane coatings than to testing the electrical properties of the coating material. The problem of application of DC3144 has not yet been completely resolved. More work will be necessary to utilize that material fully.

Appendix A

BKC MEETING WITH SANDIA ON CONFORMAL COATINGS
ALBUQUERQUE, N. M.
OCTOBER 8 and 9, 1970

(Excerpted from trip report by W. F. Moyle)

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Appendix A

BKC MEETING WITH SANDIA ON CONFORMAL COATINGS

Most of the morning session was allocated to BKC to explain the testing performed and the test results of high-voltage conductors coated with Dow Corning 3140, RTV Silicone material. George Moulton opened the presentation with an explanation of what we were trying to accomplish and a description of some of the specific problems which we have encountered in developing an adequate coating process for fireset pc-board assemblies. Many of those problems arose from the requirement of the coating to stand off a 6 kV-potential in an atmosphere of 1 mmHg absolute pressure.

Wm. Moyle followed this with an explanation of what had been done to test DC3140 coating material and an evaluation and interpretation of the results. Samples of a pc board-to-coating-to-epoxy pull test and sections of a sample multiboard assembly which had been coated and encapsulated were distributed to give visual emphasis to our successful use of this material. Copies of pull-test results and two reports which described the testing in more detail were distributed.

George Moulton gave an explanation of the tests made with a silicone-coated transverter-board assembly. That assembly was operated in a vacuum equal to 1 mmHg absolute pressure. The conditions which were observed during the testing of this assembly were delineated and discussed.

The afternoon session was principally a discussion of the conditions and tests to which the units will be subjected, the benefits of the test results, and the effects of choosing the silicone or the polyurethane method of coating. The factor of the known values of polyurethane against the unknown values of silicone was paramount in the ultimate decision to carry both methods concurrently. This decision will necessitate development of two systems, and will provide a dual capability, as well as the comparative results derived from testing both systems.

The final decision was to use silicone coating on one fireset and the last two units of Group 3 of the other fireset. Nothing definite was decided for units beyond that point, but the possibility of design changes to eliminate coating was discussed.

The writer does not believe that we changed any basic opinions in regard to the relative values of the two coating systems, but our test results answered enough of the doubts and objections about silicones to allow Mr. Hardin and Mr. Yearout to decide to try our proposal of a single-material silicone coating.

Appendix B

**OUTLINE FOR APPLICATION OF DC3140
COATING MATERIAL**

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Appendix B

OUTLINE FOR APPLICATION OF DC3140 COATING MATERIAL

GENERAL

1. All surfaces to be coated (board and component) must be cleaned with toluene. Dry 30 minutes.
2. Surfaces to be coated must be primed with Dow Corning 1203. Primer must be confined to surfaces to be coated. Dry 30 to 45 minutes.
3. Glazed epoxy surfaces must be abraded to break the glaze before cleaning. Do not obliterate marking.
4. The edges of all boards must be free of coating material except the edges of potting holes.
5. Conductive surfaces at ground or low-voltage potential may be coated when their proximity to a high-voltage potential makes it necessary or unavoidable.
6. Insulated-wire to pc-board joints may be strengthened by applying Adiprene L-100 and CAB-O-SIL 7-percent Adiprene mixture.

HIGH-VOLTAGE COMPONENTS

1. Clean, prime, and coat all surfaces. Press fiberglass material into the coating where necessary to insure complete coverage.
2. Coat to a thickness of 0.015 to 0.030 inch.

HIGH-VOLTAGE AREAS

1. Clean and prime the board surfaces that contain HV paths to a line 0.500 inch minimum, from the edge of conductor, except where potting holes interfere.
2. Coat to a thickness of 0.015 to 0.030 inch; apply to primed area only.

3. Fill space between components and board with coating material.
4. High-voltage paths or wires not on a board must be coated to a thickness 0.015 to 0.030 inch. Fiberglas material may be pressed into the coating where necessary to insure complete coverage.
5. Insulated wires carrying high voltage need not be completely covered, provided that the coating material overlaps the insulation at least 0.500 inch.

LOW-VOLTAGE COMPONENTS

1. Clean and prime.
2. Coat components with material 0.015-inch thick (maximum) for mechanical stress and shock protection. Leave board surfaces that do not support components unprimed and uncoated.
3. Fill space between components and board with coating material.

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