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Booster dipole block fabrication

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BOOSTER DIPOLE BLOCK FABRICATION

Test to determine gamma radiation effect on wedge plate and end block lamination bonding adhesive strengths.

INTRODUCTION

The current proposal for bonding Booster dipole wedge plate and end block laminations with a two part thermosetting epoxy (Bondmaster #E645) requires a curing cycle time of approximately 8 hours. This cycle consists of 3 hours for heating and approximately 5 hours ambient air cooling for the wedge plate. End block heating and cooling require somewhat longer cycle times.

As an alternate to using this thermosetting epoxy, representatives of the Loctite Corporation have recommended four types of industrial adhesives. These are Loctite adhesives #324, #326 and "Depend" which are all "off the shelf" adhesives and an experimental type identified as FMD-93B. These adhesives require no heating or cooling cycles and their cure time is approximately 3 to 4 hours.

If these Loctite adhesives prove equal to the thermosetting epoxy, considerable time and cost savings can be realized with their use.

PURPOSE

To determine the effect of gamma radiation on strength and adhesion properties of the Bondmaster E645 thermosetting epoxy and the four industrial adhesives supplied by Loctite.

PROCEDURE

Lamination material of .025 thick Armco M45 steel having a C4 insulation coating on both sides will be used. The material will be taken from stampings received from the stamping vendor. This material will have had evaporating type stamping lubricant applied to it and evaporated from the surface of the material by the vendor identically to the process specified for the production run stampings.

This material will be sheared into 0.5" wide strips. (270 strips will be required for testing the five adhesives.)

The approximate Loctite activator and adhesive will be applied to a 0.5" x 0.5" area of two strips then another strip will be sandwiched between these strips (Fig. 1) and clamped using 35 pounds force over the 0.25 square inch area until dry. (This clamping force duplicates stacking fixture pressures).

Strips with Bondmaster E645 applied to them will be made in the same manner to permit them to be irradiated with each of the Loctite adhesive samples to assure identical levels of radiation exposure.

There will be six tests conducted for each type adhesive, each test having a sample population of three pieces.

One test will be conducted on a population of unexposed samples for each type adhesive to generate a baseline of strengths for the test.

A population of each type adhesive will be exposed to the following levels of gamma radiation and tested for strength and adhesion;

1×10^2 Rads	1×10^8 Rads
1×10^4 Rads	1×10^9 Rads
1×10^6 Rads	

OBSERVATIONS

Application of Adhesives: The Bondmaster E645 epoxy is currently applied using a glue applicating machine that utilizes doctor rollers to evenly distribute a thin film of adhesive. The Loctite adhesives required application with a stiff brush to enable spreading them thinly due to their high viscosity (fixotropic). They could not be applied using the glue applicating machine.

Activators: The Loctite adhesives require activators be applied to material surfaces to start adhesive cure. With the proper activator applied the "Depend" adhesive cured before the material could be assembled. Without the activator the "Depend" adhesive did not cure after 4 hours.

This pre-assembly curing seems also to have occured to some lesser degree with the other Loctite adhesives also. This based upon a .005" thick adhesive layer for all the Loctite adhesives as compared to an adhesive layer thickness of approximately .0002" for Bondmaster E645. An attempt to lessen the Loctite adhesive layer thickness by increasing the clamping pressure was unsuccessful.

Adhesive Curing: Although heating is required for epoxy curing it is not required for the Loctite adhesives, though the addition of heat (to 225°F) can increase their strength. As an alternate to ambient temperature curing, heat was applied to additional samples to determine its effect on strength. Testing these samples reflected some small changes in strength but still resulted in lower strengths than the epoxy adhesive.

RESULTS

Although the Loctite adhesives increased in strength with exposure to gamma radiation up to 10^8 Rads as expected, their strength proved to be less than or nearly equal that of the epoxy.

At 10^9 Rads all adhesives strengths deteriorated severely and only Loctite #324 exceeded the epoxy in strength. (See Table 1 for test results).

Also at 10^9 Rads the bonds of all the adhesives became brittle and samples fell apart upon impact when dropped on a hard surface from a height of four feet.

All adhesives maintained physical integrity through 10^9 Rads.

RECOMMENDATIONS

Continued use of Bondmaster E645 is recommended for the following reasons:

1. Loctite adhesives begin to cure too rapidly for application and lamination stacking speeds.

2. The Loctite adhesive film thickness of .005" compared to .0002" of that of the epoxy film is detrimental to our specified 98% packing factor.

3. The high viscosity of the Loctite adhesives tested resulted in cumbersome and time consuming application and makes application with our existing equipment impossible.

Table 1.

Test Results (Shear Strength PSI)

Radiation Level	Loctite FMD-938	Loctite 325	Loctite 326	Bondmaster E645
0	886	752	783	920
10^2	900	716	518	917
10^4	840	798	552	901
10^6	866	790	779	874
10^8	361	824	591	826
10^9	78	360	165	259

Figure 1.

Test Sample Assembly