Testing Peel Strength of Repaired Circuit Traces and Pads
BEST Inc
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Abstract: *There are several suggested repair techniques for repairing lifted pads, traces and conductors. Two of the most widely used techniques rely on different bonding media to adhere the replacement copper to the PCB surface. A third new technique relies on the use of a slightly different formulation of the widely-used "dry film" while bringing back control to the bonding process. The bond strength immediately after bonding between these techniques, namely the dry film adhesive technique (IPC 7721 4.1.2 Lifted Conductor Repair, Film Adhesive Method), the 2-part epoxy-resin technique technique (IPC 7721 4.1.1 Lifted Conductor Repair, Epoxy Seal Method) and the newer dry film adhesive clamping technique are compared. In addition, a comparison of peel strengths between the (2) different types of dry film formulation and bonding methods were investigated.*

Purpose of Study:

The purpose of this study is to provide a comparison of the relative bond strengths of copper circuit frame bonded with (3) different materials and bonding methods:

A. Resin/hardener- HYSOL 0151-IPC 7721 epoxy seal method
B. BEST phenolic film- New Method
C. Phenolic Butral "dry" Film – IPC 7721 film adhesive method

Test Vehicle and Components:

BEST tin coated 1 oz copper circuit frame
BEST phenolic dry film
Company "C" phenolic butral film
HYSOL™ 0151 resin and hardener system
FR-4 PCB laminate materials

Preparation of Specimens:
BEST-certified repair technicians adhered circuit frame material to an FR4 substrate using 3 different bonding techniques and materials.

In the case of the **2-part HYSOL™ 0151 resin/hardener** 1" wide sample strips (with the last ½" not adhered to accommodate the peel strength testing machine grippers) were adhered to the substrate using the following process:

A. Copper sample strips were cut into approx 3" x 1" strips.

B. The site areas were cleaned prior to bonding in accordance with IPC 7721 Land Repair, Epoxy Method 4.5.1. procedures.

C. The HYSOL 0151 resin / hardener was volumetrically mixed as per the manufacturer's instructions

D. The epoxy was applied to the FR-4 surface.

E. Polyimide tape was then used to secure the cut frame pieces in place. Pressure was applied to the surface being bonded for the curing phase.

F. The epoxy was cured as per the manufacturer's guidelines.

G. The specimens were visually inspected after curing.

In the case of the **Company "C" phenolic butral film** 1" wide sample strips (with the last ½" not adhered to accommodate the peel strength testing machine grippers) were adhered to the substrate using the following process:

H. The site areas were cleaned prior to bonding in accordance with IPC 7721 Land Repair, Epoxy Method 4.5.1. procedures.

I. The copper sample strips were cut and trimmed into 3" x 1" sample sizes.

J. The bonding tip was pre-heated to 475ºF.

K. The samples were placed into position on the FR4 surface

L. Polyimide tape was then used to hold the cut samples into position.

M. A firm load was applied to the bonding iron as prescribed by the manufacturers' instructions. (48 oz or the resting weight of your arm).

N. The specimens were visually inspected after curing.

In the case of the BEST **phenolic "dry" film** 1" wide sample strips (with the last ½" not adhered to accommodate the peel strength testing machine grippers) were adhered to the substrate using the following process:

O. The site areas were cleaned prior to bonding in accordance with IPC 7721 Land Repair, Epoxy Method 4.5.1. procedures.

P. The copper sample strips were cut into 3" x 1" sample sizes.

Q. The curing oven was pre-heated to 150ºC

R. The samples were placed into position on the FR4 surface.

S. Polyimide tape was applied over the surface of the cut pieces of circuit frame material to hold them into place. Pressure was applied using small clamps with popsicle sticks over the area to distribute the pressure evenly.

T. The epoxy was cured as per the manufacturer's recommended guidelines (1 hour @150ºC in an oven)

U. The specimens were visually inspected after curing

Measuring peel force

The strength of the adhesive bond made between the FR-4 and the circuit frame was measured using industry standard test methods. (IPC TM-650 , paragraph 2.4.9-method B Testing Methodology for peel strength) A TL 151 A/B Instron universal test machine using Instron dead weights calibrated January 18, 2005 was used to make the measurements. Measurements were made under 22ºC 40% relative humidity conditions at an outside laboratory (TRACE Laboratories, Schaumburg, IL) . The results were calculated based on a 1" wide copper strip.

Results:
The results of the peel testing for both of the dry film formulations as well as the BEST dry film versus 2-part resin/hardener system are listed below:

	Normalized Peel Strength (lb-inches)	
Trial #1	1.219	
Trial #2	0.976	
Trial #3	1.298	
Trial #4	1.946	
	5.439	**Total**
	1.36	**Mean**
	0.41	**Std Dev**
Phenolic Butral Film		

Trial #1	2.932	
Trial #2	2.806	
Trial #3	2.401	
Trial #4	2.450	
	10.589	**Total**
	2.65	**Mean**
	0.26	**Std Dev**
BEST Adhesive Phenolic Film		

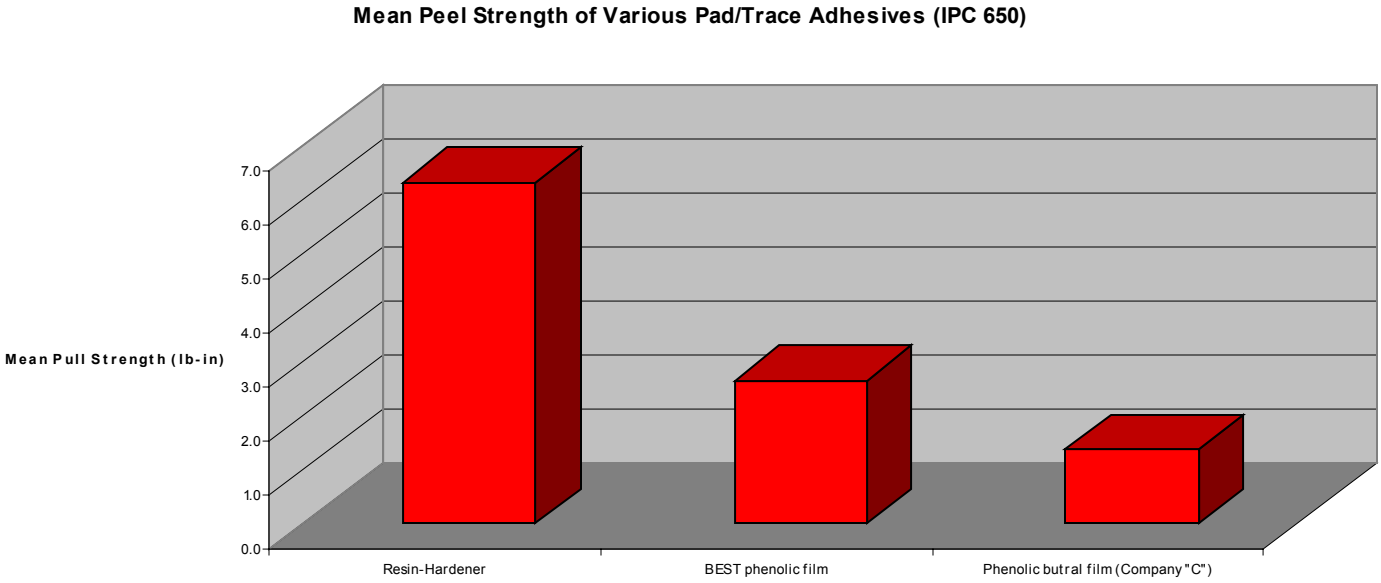
Table 1

As the results indicate, the BEST adhesive phenolic film had a greater overall mean peel strength when compared to the phenolic butral film. In addition, the results of the BEST Adhesive phenolic film were more consistent as evidenced by a lower standard deviation of the peel strength results.

	Normalized Peel Strength (lb-inches)	
Trial #1	6.478	
Trial #2	6.216	
Trial #3	6.563	
Trial #4	6.006	
	25.263	Total
	6.32	**Mean**
	0.25	**Std Dev**
Epoxy-Resin		
Trial #1	2.932	
Trial #2	2.806	
Trial #3	2.401	
Trial #4	2.450	
	10.589	**Total**
	2.65	**Mean**
	0.26	**Std Dev**
BEST Adhesive Phenolic Film		

Table 2

Furthermore, the results indicate that the resin-hardner adhered circuit frame material had a greater overall mean peel strength then either the BEST adhesive phenolic film or the phenolic butral film. In addition, the results of the resin / hardener adhered circuit frame material were as consistent as those using the BEST adhesive phenolic film.



Conclusion: Based on these test results one can conclude the following:

1. The BEST phenolic film exhibited more consistent, stronger peel strength then the phenolic butral film from Company "C".
2. The 2-part resin-hardener system exhibited the best overall adhesive strength of the systems and techniques tested.

In terms of trying to achieve the greatest bond strength in PCB land and conductor repair, the use of IPC method 7721 4.1.1 Lifted Conductor Repair, Epoxy Seal Method was demonstrated to be the best. If a dry film process is preferred by the repair facility, the BEST phenolic dry film adhered using the modified dry film adhesion technique exhibits a greater bond strength then its phenolic butral counterpart.

For multilayered PCBs there are some defined standards (IPC-4101A) with respect to the peel strength of copper foil on a given laminate material. For instance, on a standard FR-4 board (IPC4104/24, FR-4) using a standard copper land/pad thickness, a minimum of 6 lb-inches of peel force between the copper and the laminate material is specified. The resin-hardener adhesive exhibits the minimum peel force specified for "new" boards as outlined in IPC-4101A, regardless of the type of material.

These test results demonstrated the superiority of the resin-hardener system for land/pad repair. A (6) month "shelf life" of the dry film, the multitude of heating tips required and the uncontrolled pressure during the curing of the film for the *IPC 7721 4.1.2 Lifted Conductor Repair, Film Adhesive Method*, make the superiority of using the epoxy resin system for lifted land repair technique very distinct.