A Printed Circuits White Paper

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The Problem with UL Approval of Rigid Flex Circuits

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Introduction

Greater acceptance of rigid flex circuit boards in medical and other high reliability electronic packaging has created a demand for UL recognition for flame rated packaging, primarily to meet product liability insurance carrier requirements.

The Problem

The difficulty lies in getting a UL rating on rigid flex constructions due to the overwhelming number of configurations that must be represented in the test vehicles.

Previous Options

Designers and fabricators wishing to resolve this issue have used two primary methods – specifying UL rated materials and/or submitting individual constructions for UL recognition. The first solution does not meet the requirements of UL or insurance carriers, and the second solution is limited, expensive and time consuming.

The Printed Circuits, Inc. Solution

Printed Circuits has undertaken the task of obtaining UL 94 V-0 flame rating for a large sampling of popular constructions representing most of the possibilities that rigid flex designers would use.

Benefits

PWB designers and buyers now have a source for fully compliant UL 94 V-0 rated boards to satisfy their insurance carrier's requirements. Printed Circuits UL certifications eliminate the cost and time required to test individual boards – most popular constructions can be certified immediately.

Summary

Printed Circuits UL recognition eliminates the cost and time required for electronics designers and buyers to qualify their rigid flex boards.

Introduction

In the early 1980's the first rigid flex circuit board concepts came into use. We use the word concept, because they were developmental efforts at marrying flex circuit boards and rigid circuit boards to eliminate connectors, improve reliability, or achieve connectivity and density in a small space. They were very similar to flex with stiffeners, except that the stiffeners had circuits as well, and through holes provided connection between the two formats.

These early attempts were for military and space applications. The military had its own PWB specifications and had a history of electronics built with both rigid boards and flexible boards – so they had a good basis for understanding how to design and specify these hybrid products.

In the 1990's DuPont introduced their line of adhesiveless flexible laminate called AP for Adhesiveless Pyralux. Eliminating the adhesive in the flexible laminate provided for greater reliability, by reducing z axis CTE forces on vias, caused by the high z axis CTE values of acrylic adhesive used to laminate the copper to the Kapton base material. The new materials improved the reliability of flexible circuit designs, but were particularly valuable in the manufacture of higher layer count rigid flex. Specifications were developed and rigid flex quickly became an accepted packaging medium whenever designers were looking for higher reliability and/or increased connection density.

The use of rigid flex in military, avionics and aerospace applications has grown steadily since then, and it is particularly valuable in high stress, high vibration, or thermal excursion environments that would disrupt connectivity in traditional rigid boards with flex/connector junctions.

Rigid flex also found acceptance in high reliability medical applications in implantable devices, and dynamic flex applications that require never fail reliability. It has also proven invaluable in packaging a lot of functionality in very small spaces, such as digital cameras, video cameras and miniaturized medical electronics.

Rigid flex has continued to expand into the commercial markets, consumer electronics and industrial applications for many of the same reasons. Although more expensive than traditional packaging methods, it provides unmatched reliability that often provides OEM's and designers with product differentiation and greater reliability, particularly in environmental stress applications.

The Problem

The growth and acceptance of rigid flex in the commercial sector, has created a unique problem. The difficulty lies in getting a UL rating on rigid flex constructions due to the overwhelming number of configurations that must be represented in the test vehicles.

Many electronics designers and manufacturers are required to have their products recognized and rated by UL, usually mandated by their insurance carriers. This rating signifies that the product can sustain a certain level of exposure to a flame, without igniting. Products that meet this requirement have much lower chances of starting a fire, and thus reduce chances of product liability claims.

To meet this requirement, PWB fabricators manufacture and submit samples of their boards to UL for a rating approval. The most popular approval rating for manufacturers of PWB's is 94 V-0. Most fabricators have a file with UL that designates what constructions they may put their UL logo on, to designate that a board has met UL's 94 V-0 test requirements.

The sample requirements call out dielectric thicknesses, copper thicknesses, circuitry dimensions, etc. in order to encompass as broad a range as possible, so that the fabricator can apply their UL logo to as many parts as possible for their customers. Compliance is verified by UL auditors that visit fabricators, looking for violations. UL letters of recognition specifically state that any violations can lead to immediate revocation of the fabricator's UL recognition.

For a fabricator to obtain UL recognition, they typically start with one supplier's materials and build their test sample base from there. A typical test submission might be 10 to 20 test coupons, $ 10,000 to $ 14,000, and take 12 to 16 weeks for testing and approval. UL recognition gives the fabricator the ability to put their UL logo on PWB's manufactured with that suppliers material, as long as it fell within the parameters represented in the coupons they originally submitted.

Once approved, the fabricator must use the same materials as were submitted in the original sample. To use another suppliers laminate or prepreg within a PWB, and apply their UL logo, would be a violation. It would also be a violation even if the fabricator had UL recognition on the other supplier's material. The fabricator cannot mix and match (even if both materials were approved by UL separately) two material suppliers without specifically achieving a recognition from U.L. by submitting mix and match samples.

Mix and match approvals are obtained whenever a fabricator wants the flexibility to mix and match materials within their UL qualification. Those approvals can get large and expensive due to the larger sample sets required. UL needs to verify that regardless of material combinations, thicknesses, or copper constructions that all combinations will pass their flame rating tests. The sample set increases exponentially, as does the cost and the timeline for building, submitting and testing the sample set. Mix and match qualifications are not attempted very often because it is hard to recoup the investment in the original qualification.

These same constraints are true for both rigid board fabricators as well as flexible circuit fabricators. However, with rigid flex things get much more difficult.

Rigid flex fabricators use materials that are similar to rigid board fabricators, and materials that are similar to flex fabricators. When you combine the two material sets in making a rigid flex, you create a combined material library that is so large, that it is hard to adequately cover all of the possible material combinations. It would be somewhat similar to attempting a UL recognition on a mix and match build, but instead of using two suppliers, you would be attempting a mix and match on three suppliers with complete interchangeability. And that would be to get just one material qualification, such as an FR4 rigid flex qualification. If you wished to add polyimide rigid materials, that doubles the material library again.

Rigid flex manufacturers build their product with rigid laminate, flex laminate, prepreg, flexible coverlayer and bondply – in all the thickness variations and copper configurations. A basic UL qualification now requires well over 100 sample coupons, months of building and submitting for testing, and an exponential increase in cost. The cost alone is difficult to ever recoup, let alone the manufacturing time and expense of building the samples. Thus fabricators have little incentive to undertake the task.

Previous Options

The difficulty of certifying PWB's to UL 94 V-0 hasn't deterred designers from incorporating rigid flex designs increasingly into medical and commercial applications. It's viability as a robust packaging medium continue to bring value to electronics designers and users.

The problem arises when the requirement is communicated to the board fabricator. The requirement generally elicits one of three responses.

Many rigid flex fabricators offer to submit their customer's constructions to get UL recognition one material set at a time. The samples submitted represent only one construction – any change in materials, even adding a sheet of prepreg, automatically disqualify the part from UL recognition and the new build must be resubmitted. The problem with this approach is that it is still expensive in its own right, and still a lengthy process to get qualified, and in the end it is very limited in scope. Few board designers/buyers want to pay the cost to get UL recognition on their parts at all, let alone on a board by board basis.

Some designers have worked around the requirement by specifying that the board be built with materials that are recognized by UL to 94 V-0. This eliminates the sampling and testing requirement, and the associated costs. However, it does not represent UL certification of the board, and would not be in compliance with insurance carrier agreements for product liability. It leaves the board buyer exposed to claims, should anything occur with their end product.

The third attempt to fix the problem is not much of a solution. Many board fabricators, particularly the less informed and/or off shore manufacturers, have little or no understanding of the testing requirements for UL recognition. Often they assume that if

they have recognition of flexible circuit constructions, and separately rigid board constructions, then they are legitimately allowed to mix and match. This is erroneous and UL's letter of recognition states directly:

> *"Products that bear the UL Mark shall be identical to those that were evaluated by UL and found to comply with UL's requirements. If changes in construction are discovered, appropriate action will be taken for products not in conformance with UL's requirements and continued use of the UL Mark may be withdrawn."*

Some fabricators think that if they have UL recognition on a rigid flex submission, then they are qualified to build all rigid flex boards with that material set. That is also erroneous. The error, if discovered by an auditor leaves the board fabricator vulnerable to losing their UL recognition, and leaves the board buyer exposed to product liability claims should something go wrong.

The Printed Circuits Solution

In 2004 Printed Circuits looked at the problem from their customers' perspective. Printed Circuits has specialized in the manufacture of rigid flex boards since 1997, and had been building rigid flex since 1982 – one of the first pioneers of the technology. Printed Circuits saw that many of their customers were coming to rigid flex from either a hard board or flex background and could not accept the cost, testing requirements or limited applicability of UL recognition by individual constructions.

Implementation

Printed Circuits undertook a two year project to build, submit and qualify a set of rigid flex samples that would represent over 90% of the designs then on the market. The project required 138 samples that took a year and a half to build six months of testing to build the largest UL 94 V-0 qualification of rigid flex in the world.

Interestingly in the first round of testing a couple of the samples failed, even though they were manufactured with UL 94 V-0 approved materials. This serves to validate UL's requirement that each construction must be tested before UL certification is awarded, and that specifying and using 94 V-0 materials alone is not enough.

After receiving the UL Qualification, Printed Circuits also added color coded travelers for all manufacturing lots that required UL certification. The color coded travelers allow the UL Auditor to easily verify which lots require UL certification, and to quickly determine compliance to their qualification listing. Printed Circuits is also adding to their file to include additional material sets and technology.

Benefits

Printed Circuits UL 94 V-0 recognition on rigid flex constructions eliminates the cost and time required to test individual boards – most popular constructions can be certified

immediately at no cost to the board designer or buyer. PWB designers and buyers now have a source for fully compliant UL 94 V-0 rated boards, and can be assured that their boards are rated 94 V-0.

Summary

As the demand for rigid flex enters the mainstream electronics packaging arena – designers and buyers will increasingly require UL 94 V-0 rating on their components to maintain their own UL compliance. Printed Circuits has undertaken the cost and testing requirements so that their customers are compliant from the very first build and through every revision and material set required to bring their products to market.

About Printed Circuits, LLC

Printed Circuits is a US manufacturer of multilayer flex and rigid flex printed circuit boards, with 40 years experience building circuits that are typically used in high reliability applications, such as medical, military and commercial electronics, where customers place a premium on reliability, package density, and weight. For more information, visit us at www.printedcircuits.com, or at: