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COMPONENT - WIRING, PRINTED (ZPMV2, ZPMV3, ZPMV8, ZPMV9)

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APPENDIX A - FIELD REPRESENTATIVE'S RESPONSIBILITIES AND INSTRUCTIONS FOR  
EXAMINATION OF THE PRODUCT

GENERAL

The Field Representative's general responsibilities, as part of the Follow-Up Services Procedure, are as noted in the published document titled, "UL Mark Surveillance Requirements", and is available through UL's secure customer portal MyHome@UL.com and/or through UL's internet site www.UL.com. Manufacturers that do not have Internet access may obtain the current version of these requirements from their local UL Customer Service Representative or UL Field Representative.

PROCEDURE IN THE EVENT OF NONCONFORMANCE

When a product does not comply with the Follow-Up Service Procedure, require that the manufacturer implement appropriate action as outlined in the "UL Variation Notice and Corrective Action Requirements" document, which can be found at [www.ul.com/fus](http://www.ul.com/fus).

INSTRUCTIONS FOR INSPECTION OF THE PRODUCT

At each inspection, samples of current production and/or stock shall be examined for compliance with the applicable descriptions and requirements contained in this Procedure and Section General A.

In making this determination, consideration shall also be given to the following general requirements applying to the products covered by this Procedure.

A. MARKINGS - Information required shall be legibly and permanently marked on the product, in the manner and minimum height specified in the Section General Marking statement in the Procedure, such as by etching, printing, solder mask marking or nonconductive ink printing.

B. PARAMETERS - Verify the following as specified for use with the printed wiring board constructions in the Descriptive pages of this Procedure. This may be determined from an audit of the printed wiring board manufacturer's records including cartons, wrappings and/or marking of bulk materials, packing slips, or invoices for incoming materials.

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1. Determine printed-wiring construction Type designation (Table II of the descriptive pages of this Procedure)

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2. Verify the base material manufacturer name and grade designation specified in Table II of the descriptive pages of this Procedure.
3. Verify the thickness of the base material is not less than the minimum thickness specified in Table II for single layer printed wiring boards. Verify the overall build-up thickness of the printed wiring board Type is not less than the minimum build-up thickness specified in Table II for multilayer printed wiring boards. Verify the thickness, per an audit of the manufacturer's records, of the base film and the base film adhesive is within the thickness range in Table IIa, IIb, and IIc of the descriptive pages of this Procedure for flexible printed wiring boards. The thickness of the printed wiring board shall be measured where no external, and if possible no internal, conductor material resides.
4. Verify the conductor pattern resides on one or both sides of the printed wiring board as specified in Table II based on the definitions in Appendix E for Doublesided (DS), Doublesided Only (DSO), and Singlesided (SS). In addition, verify the conductor pattern does not reside on internal layers of the printed wiring board unless the printed wiring board is described as a multilayer printed wiring board.
5. Verify the thickness of the external conductor (copper weight) is not less than the minimum thickness specified in Table II of the descriptive pages of this Procedure. In addition, verify the thickness of the external conductor is not greater than 102 mic or the maximum external thickness specified in Table II of the descriptive pages of this Procedure, whichever is greater. (Table A of this Appendix provides conversions from copper weights to copper thicknesses to be used as an aid in making these determinations.)

The minimum external copper thickness refers to the "as-received" thickness of the coppercladding on the base material and does not refer to the thickness after processing. For a copper additive manufacturing process, the base material is obtained unclad with no copper applied by the base material manufacturer.

The maximum external copper thickness refers to the "as-received" thickness of the copper cladding on the base material plus the copper plating added during processing as determined from an audit of the manufacturer's records. The external copper thickness after plating is allowed a 25 mic tolerance above the maximum thickness listed in Table II of the descriptive pages of this Procedure.



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6. Verify the thickness of the internal conductor (copper weight), where applicable, does not exceed the maximum thickness specified in Table II of the descriptive pages of this Procedure. (Table A of this Appendix provides conversions from copper weights to copper thicknesses to be used as an aid in making these determinations.)

In the case of internal copper thickness, verification can only be made from an audit of the printed-wiring board manufacturer's records.

TABLE A  
PRINTED WIRING BOARD COPPER FOIL  
WEIGHT/THICKNESS CONVERSIONS

Common Industry Terminology	Copper Thickness (Nominal)	
	(mic)	(mils)
5 mics	5.1	0.20
9 mics	8.5	0.34
12 mics	12.0	0.47
1/2 oz	17.1	0.68
3/4 oz	25.7	1.01
1 oz	34.3	1.35
2 oz	68.6	2.70
3 oz	102.9	4.05
4 oz	137.2	5.40
5 oz	171.5	6.75
6 oz	205.7	8.10
7 oz	240.0	9.45
10 oz	342.9	13.50
14 oz	480.1	18.90

7. Verify the following conductor widths as specified for use with the printed wiring board Type in Table IA in the descriptive pages of this Procedure. The conductor width may be determined by taking at least 3 measurements (measured from the top surface and along the entire length of the conductor) using an instrument for measuring conductor widths that shall be supplied by the printed-wiring board manufacturer.

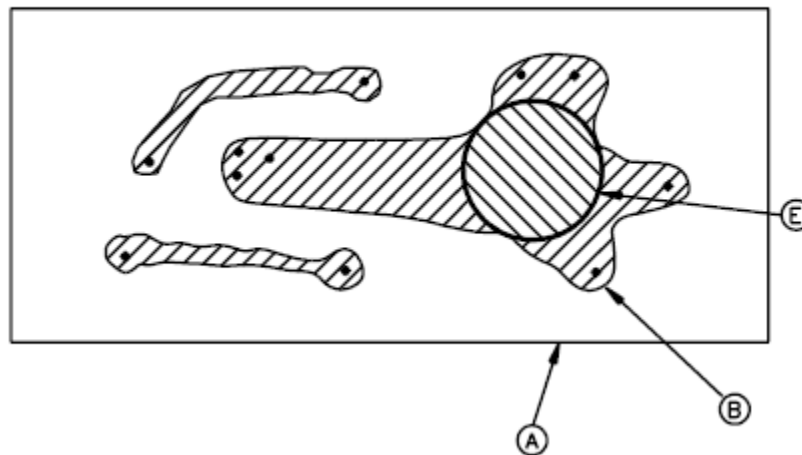


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- a. Verify the mid-board conductor width is not less than the minimum mid-board conductor width specified in Table IA of the descriptive pages of this Procedure.
  - b. Verify the edge conductor width is not less than the minimum edge conductor width specified in Table IA of the descriptive pages of this Procedure.
8. Verify the largest continuous unpierced area of conductor does not exceed the maximum area diameter specified for use with the printed wiring board Type in Table IA in the descriptive pages of this Procedure.

This may be accomplished by determining the largest circle which can be inscribed on the unpierced conductor portion of the printed wiring board as shown below.

**Figure 10.2**  
**Maximum unpierced conductor area measurement**



- A - Production printed wiring board.  
B - Largest unpierced conductor section.  
E - Largest circle that can be inscribed on B.

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C. MANUFACTURING PROCESS - Verify the manufacturing process steps used in the production of the printed wiring board Type comply with the manufacturing process specified in Table II in the descriptive pages of this Procedure.

This determination may be made by tracking the printed wiring board Type through the manufacturing process and/or reviewing the process steps and their sequence based on the printed wiring board manufacturer's traveler.

1. Verify the maximum temperature, time, and pressure (if applicable) settings of the equipment used in the printed wiring board production manufacturing process (e.g., oven and solder process) do not exceed the values specified in the manufacturing process description.
  - a. For operations where it may be difficult to verify the maximum temperature, time, and pressure (if applicable) settings of the equipment used, such as infrared reflow, the printed wiring board manufacturer shall have a documented system in place to control the process (e.g., a process chart which indicates conveyor belt speed, zone times and zone temperatures). There shall be a direct correlation between the manufacturer's documented system and the temperature, time, and pressure (if applicable) specified in the manufacturing process description.
2. Temperatures exceeding 100°C (212°F) or the maximum operating temperature of the board Type, whichever is greater, shall not be applied in the production of printed wiring boards if not specified in the manufacturing process description.
3. Machining, cleaning, rinsing, air-drying and similar operations may be performed by the manufacturer, but may not be specified in the manufacturing process description.
4. Verify the conductive coatings and/or platings used in the production of the printed wiring board Type are specified in the manufacturing process description.
5. Verify embedded components used in the production of the printed wiring board Type are as indicated in the descriptive pages of this Procedure.
6. Verify the nonconductive permanent coatings (solder resists, plugged hole materials, overcoats, undercoats, marking inks, etc.) used for any purpose other than letters, numbers or symbols are specified for use with the printed wiring board Type with manufacturer and grade designation as indicated in the coatings table(s) following the manufacturing process in the descriptive pages of this Procedure. EXCEPTION: HB and non-flame rated boards may be coated with any nonconductive permanent coating.

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7. Unless specified in the coatings table(s) following the manufacturing process in the descriptive pages of this Procedure, multiple layers of permanent coatings (solder resists, plugged hole materials, overcoats, undercoats, marking inks, etc.) may not be used. EXCEPTION: HB and non-flame rated boards may be coated with any nonconductive permanent coating.
8. Unless specified in the manufacturing process in the descriptive pages of this Procedure, the sequence of the process steps may not be changed.
9. Any of the steps in the manufacturing process in the descriptive pages of this Procedure may be omitted from the manufacturing process at the manufacturer's option, unless the process step is noted as a MUST step.
10. There shall be no additions or substitutions to the manufacturing process, as specified in the descriptive pages of this Procedure.

## D. MANUFACTURING OPERATIONS CONDUCTED AT AN OUTSIDE FACILITY (MULTIPLE-SITE PROCESSING/SUBCONTRACTING)

If any manufacturing operations are conducted at an outside facility (i.e. multi-site processor or subcontractor):

1. The field representative at the original board manufacturer's location shall determine that all records are adequately maintained for traceability. This shall take the form of an overall audit of the original board manufacturer's records with specific interest in the areas described in Appendix D.
2. The field representative at the original board manufacturer's location shall verify that the information provided to the outside facility via the service/work (traveler) request is consistent with the requirements contained in the original board manufacturer's Procedure.
3. The field representative at the subcontractor facility shall verify that the subcontractor is:
  - a. following the instructions contained in the service/work (traveler) request,
  - b. complying with the requirements in the Procedure,
  - c. completing and returning the service/work (traveler) request to the original board manufacturer, and
  - d. maintaining the required records.See Appendix D.
4. The field representative at the subcontractor shall verify that the finished boards and the service/work (traveler) request are only returned

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to the original board manufacturer. Subcontractors shall not ship processed boards directly to outside customers or locations.

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PRINTED WIRING BOARDS - RECOGNIZED FOR FLAMMABILITY CLASSIFICATION ONLY

If printed wiring boards are indicated in this Procedure and in the Recognized Component Directory as "FLAMMABILITY ONLY" Recognition, they shall be examined only for the applicable markings and other items stated in Section General, Sectional General A, Appendices A and D, and for the specified features as indicated in the descriptive pages in this Procedure. *Instructions in Appendices B and C are not applicable to Flammability Only constructions.*

EXPLANATION OF TERMS

For the purpose of these Appendix Pages, the terms and definitions included in Appendix E apply.

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## APPENDIX B - INSTRUCTIONS FOR FIELD REPRESENTATIVE'S SAMPLE SELECTION

### GENERAL

On each production visit (visit where units are available for inspection) the field representative shall select a minimum of one model for UL FUS Sample Testing. See Special Appendix B, Table B for models and groups.

#### Exceptions:

- a) Any model already selected during a calendar year does not need to be re-submitted in the same calendar year.
- b) Printed wiring boards recognized for flammability only are not to be selected.

The field representative is to use the following instruction in determining which specific model to select on a given visit:

- 1) First determine the group. If samples from more than one group are available during the visit, select the group which has not had samples selected for the greatest amount of time.
- 2) Next select the specific model. If more than one model is available from the selected group, select the model which has not been selected for the greatest amount of time.

The field representative shall select more than one model in a visit when there is reason to believe (i.e. past history, production schedules, etc.) that such model(s) will be unavailable on future visits.

Once the model(s) to be selected have been determined, use the following to determine the specific units chosen:

- a) Choose two units per model.
- b) Each unit shall be free of components.

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#### SAMPLES

The Field Representative is responsible for selecting the quantity of samples at the stated frequency for Follow-Up testing in accordance with the Sample Selection criteria noted above and as indicated in Table B.

Samples shall be identified and tagged with the applicable information using a Sample Tag (Form 3000-217). Info include: a) type designation, base material manufacturer and grade designation, manufacturing process designation, and whether the samples are of single or multilayer construction. Unless otherwise stated, the Field Representative shall inform the manufacturer that the samples are to be forwarded to the Test Office(s) as designated on the specific Procedure Volume subscriber card.

#### ADDITIONAL SAMPLES FOR RETEST

When a nonconformance to the Bond Strength and/or Delamination Test (Method A) is obtained during Follow-Up testing, the Field Representative will receive a request for additional samples.

The Type and sample parameters will be specified when samples are requested. Upon selection, the samples shall be properly tagged including the word "RESUBMITTAL" and shall include the tag number of the original failure in the field provided. They shall be identified with the board type designation, base material manufacturer and grade designation, manufacturing process designation, and whether the samples are of single or multilayer construction. The sample tag and samples shall be forwarded to the Test Office(s) as designated on the specific Procedure Volume subscriber card.

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#### APPENDIX C - INSTRUCTIONS FOR FOLLOW-UP TESTS AT UL

##### GENERAL

The samples forwarded by the Field Representative to UL in accordance with Appendix B shall be subjected to the applicable tests described below.

##### BOND STRENGTH and/or DELAMINATION TEST

Samples of production printed wiring boards received for testing shall be subjected to Bond Strength and/or Delamination Method A (10-Day) or Method B (56-Day), as indicated in Special Appendix B, Table B, for the particular product. Resubmitted samples due to initial nonconformance results under Method A shall be subjected to Bond Strength and/or Delamination Method B.

##### METHOD A - 10-Day Bond Strength and/or Delamination Test

1. Two samples are to be preconditioned at  $121^{\circ}\text{C} \pm 2^{\circ}\text{C}$  for 1.5 hours, followed by thermal shock at the maximum time(s) and temperature(s) as indicated by the solder limits of the printed wiring board Type specified in Table IA in the descriptive section of this Procedure.

Exception 1: Samples shall be subjected to thermal shock immediately after preconditioning, or samples shall be immediately stored in a desiccator until thermal shock can be performed.

Exception 2: Board types Recognized for hand soldering only shall not be subjected to thermal shock.

2. Following the thermal shock, the two samples shall be placed for 240 consecutive hours in a full-draft circulating-air oven that complies with the Standard Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation, ASTM D5423, maintained at a temperature ( $t_2$ ) determined by the following formula:

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$$t_2 = 1.076 (t_1 + 288) - 273$$

in which

$t_2$  is the 240-hour (10-Day) oven temperature in °C, and

$t_1$  is the assigned maximum operating temperature (MOT) rating of the printed wiring board in °C as specified in Table IA of the Descriptive sections of this Procedure.

See UL796, Table 26.1 for the 240-hour (10-day) oven conditioning temperature  $t_2$ . The calculated oven temperature  $t_2$  shall be rounded up to the next whole integer.

Table 26.1  
Oven Conditioning Temperatures for the Desired (or established) MOT

$t_1$ , Desired (or established) MOT (°C)	$t_2$ , Oven temperature (°C) for 240-hour (10-day) oven conditioning	$t_3$ , Oven temperature (°C) for 1344-hour (56-day) oven conditioning
75	118	98
80	123	103
85	129	108
90	134	113
105	150	128
120	167	144
125	172	149
130	177	154
150	199	174
155	204	179
160	210	184
170	220	195
175	226	200
180	231	205
NOTE - The temperatures represented by $t_2$ and $t_3$ are calculated based on the formulas in Clauses 23.3.1 and 23.3.2 respectively, with the conditioning values rounded up to the next whole integer.		

- Following the thermal aging, the test samples shall be given time to cool to room temperature. A minimum uniform width conductor is to be peeled from the base material for a distance of 6.4 mm (0.25 in.), at a uniform rate of approximately 305 mm/min (12 in/min). The angle between the tested conductor and the base material shall be maintained at not less than 85°, and the force required to separate the conductor from the base material shall be measured.

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4. For each sample, three (3) force determinations are to be made on the minimum conductor width, providing the conductor is at least 38 mm (1.5 in.) long. Two different conductor widths per sample shall be peeled, at least one conductor shall be the minimum conductor width). The average bond strength for each individual conductor shall be determined.

Exception: If a 38 mm (1.5 in.) long conductor is not available on the sample, then there shall be no wrinkling, cracking, blistering, or loosening of any conductor or any delamination of the base material after either the thermal shock or oven conditioning.

## Basis For Acceptability - Method A

There shall be no wrinkling, cracking, blistering, or loosening of any conductor, or any delamination of the base materials, as a result of the thermal shock or oven conditioning.

The average strength of the bond between the conductor and the base material shall not be less than 0.350 N/mm (two (2) pounds force per inch) for each individual conductor width.

## METHOD B - 56-Day Bond Strength and/or Delamination Test

1. Two samples are to be preconditioned at  $121^{\circ}\text{C} \pm 2^{\circ}\text{C}$  for 1.5 hours, followed by the thermal shock at the maximum time(s) and temperature(s) as indicated by the solder limits of the printed wiring board Type specified in Table IA in the Descriptive section of this Procedure.

Exception 1: Samples shall be subjected to thermal shock immediately after preconditioning, or samples shall be immediately stored in a desiccator until thermal shock can be performed.

Exception 2: Board Types Recognized for hand soldering only shall not be subjected to Thermal Shock.

2. Following the thermal shock, the two samples shall be placed for 1344 consecutive hours in a full-draft circulating-air oven that complies with the Standard Specification for Forced-Convection Laboratory Ovens for Evaluation of Electrical Insulation, ASTM D5423, maintained at a temperature ( $t_3$ ) determined by the following formula:

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$$t_3 = 1.02 (t_1 + 288) - 273$$

in which

$t_3$  is the 1344 hour (56-Day) oven temperature in °C, and

$t_1$  is the assigned maximum operating temperature rating of the printed wiring board in °C as specified in Table IA of the Descriptive sections of this Procedure.

See UL796, Table 26.1 for the 1344-hour (56-day) oven conditioning temperature  $t_3$ . The calculated oven temperature  $t_3$  shall be rounded up to the next whole integer.

3. Following the thermal aging, the test samples shall be given time to cool to room temperature. A minimum uniform width conductor is to be peeled from the base material for a distance of 6.4 mm (0.25 in.), at a uniform rate of approximately 305 mm/min (12 in/min). The angle between the tested conductor and the base material shall be maintained at not less than 85°, and the force required to separate the conductor from the base material shall be measured.
4. For each sample, three (3) force determinations shall be made on the minimum conductor width; providing the conductor is at least 38 mm (1.5 in.) long. Two different conductor widths per sample shall be peeled, at least one conductor shall be the minimum conductor width). The average bond strength for each individual conductor shall be determined.

Exception: If a 38 mm (1.5 in.) long conductor is not available on the sample, then there shall be no wrinkling, cracking, blistering, or loosening of any conductor or any delamination of the base material after either the thermal shock or oven conditioning.

## Basis For Acceptability - Method B

There shall be no wrinkling, cracking, blistering, or loosening of any conductor, or any delamination of the base materials, as a result of the thermal shock or oven conditioning.

The average strength of the bond between the conductors and the base material shall not be less than 0.175 N/mm (one (1) pound force per inch) for each individual conductor width.



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#### APPENDIX D - MANUFACTURER'S RESPONSIBILITIES

The Follow-Up Service Procedure covering the product is loaned to the manufacturer and constitutes the basis on which the product is judged for compliance with the applicable requirements.

##### GENERAL RESPONSIBILITIES

The Manufacturer's general responsibilities, as part of the Follow-Up Services Procedure, are as noted in the published document titled, "UL Mark Surveillance Requirements", and is available through UL's secure customer portal [MyHome@UL.com](mailto:MyHome@UL.com) and/or through UL's internet site [www.UL.com](http://www.UL.com). Manufacturers that do not have Internet access may obtain the current version of these requirements from their local UL Customer Service Representative or UL Field Representative.

When a product does not comply with the Follow-Up Service Procedure, the manufacturer shall implement appropriate action as outlined in the "UL Variation Notice and Corrective Action Requirements" document, which can be found at [www.ul.com/fus](http://www.ul.com/fus).

##### MEASURING EQUIPMENT AND STANDARDS CALIBRATION

Maintain an instrument for measuring the conductor width, copper thickness, and board thickness. This instrument shall be made available for the UL field representative's use during the inspection, and shall be calibrated in accordance with UL's published calibration requirements. Please see "UL Calibration Requirements: Equipment Used for UL/C-UL/ULC Mark Follow-Up Services" at [www.ul.com/fus](http://www.ul.com/fus) for more information.

##### MANUFACTURING OPERATIONS CONDUCTED AT AN OUTSIDE FACILITY (MULTIPLE-SITE PROCESSING/SUBCONTRACTING)

If any manufacturing operations are conducted at an outside facility (i.e. multi-site processor and/or subcontractor as defined below), records between the original board manufacturer and the outside facility shall be adequately maintained for traceability.

MULTISITE PROCESSOR - An outside contractor performing defined non-critical board manufacturing steps, including but not limited to, process steps with temperatures below 100°C or the MOT, whichever is greater. The multisite processor shall return the boards to the

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original board manufacturer and may not ship boards directly to the end product manufacturer.

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SUBCONTRACTOR - An outside contractor performing defined critical board manufacturing steps, including but not limited to, process steps with temperatures over 100°C or the MOT, whichever is greater. A split inspection is required for all Subcontractor facilities to verify the manufacturing operations are performed in accordance with the descriptive pages of the Subcontractor Procedure. The subcontractor shall return the boards to the original board manufacturer and may not ship boards directly to the end product manufacturer.

The original board manufacturer shall supply to the outside facility a set of instructions in the form of a service/work (traveler) request. The instructions shall be consistent with the requirements contained in the Procedure (that is, correspond to the Recognized materials and/or process descriptions of the specified printed wiring boards such as type designation, material grade designations, and manufacturing process steps for the specific process), and also include the quantity of the printed wiring boards. In addition, the service/work (traveler) request shall indicate as a minimum the following for each lot of boards.

- a) A statement identifying the boards as UL Recognized components
- b) The outside facility name and address to perform the process steps
- c) The PWB Type designation and number of boards to be processed
- d) A description of the process operation to be performed and the process parameters (including maximum temperature, time, and pressure) to be used for each process step.

Exception: The process step description may not include the temperature, time and pressure if the outside facility will

- perform steps under 100°C or the MOT, whichever is greater; and/or
  - only purchase the materials and not conduct any processing of them.
- e) If the outside facility is required to purchase materials directly from the material supplier, the following additional information shall be supplied:
    - The material supplier UL file number and material grade designation
    - Material thickness
    - Conductor metal thickness for internal and/or external conductor layers

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The subcontractor shall construct/process the boards in compliance with the service/work (traveler) request and the requirements contained in the subcontractor's Procedure, complete the service/work (traveler) request, and return it to the original board manufacturer.

## REQUIRED RECORDS

For each lot of PWBs, the original board manufacturer shall maintain records of the service/work (traveler) requests, and any other production/process records, and make them available to the UL field representative for verification that the PWB constructions and manufacturing processes are as described in the Procedure and in the service/work (traveler) requests.

For each lot of PWBs, the outside facility shall, via the return of the service/work (traveler) request, provide the original board manufacturer with an indication that the lot of PWBs has been processed in accordance with the requirements specified in the service/work (traveler) request.

For each lot of PWBs, the subcontractor shall keep a copy of the service/work (traveler) request, and any other production/process records, and make them available to the UL field representative for verification that the portion of the PWB construction process performed by the subcontractor was done in accordance with the applicable Procedure requirements and the service/work (traveler) request.

A "lot" is defined as products of a specific type, grade, class, size, and composition, manufactured under essentially the same conditions during a single production shift, and during a single continuous production run. Generally, a form record sheet should be used to assist in and expedite the record-keeping task. Records shall be maintained on a ready access basis for review by the Field Representative for at least six months and in storage for at least two years.



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#### APPENDIX E - TERMS AND DEFINITIONS

2.1 For the purpose of these Appendix pages, the following definitions apply.

2.2 ADDITIVE PROCESS - A selective or non-selective process used to deposit a pattern of conductor material(s) on clad or unclad base material.

2.3 ADHESIVE - A substance such as glue or cement used to join, bond, or fasten materials or objects together.

2.4 AS RECEIVED - Specimens or samples in an unconditioned state, prior to being subject to conditioning, or without a history of conditioning.

2.5 BASE MATERIAL - An organic or inorganic material used to support a pattern of conductor material. The base material may be rigid or flexible.

2.5.1 BASE MATERIAL THICKNESS - The thickness of the base dielectric material excluding conductive foil or material deposited on the surface of the base material. If an adhesive is used to adhere the conductor material to the base material, the adhesive thickness and application surfaces (base material sides) is indicated separately.

2.6 BLIND VIA - A via extending to only one surface of the board construction.

2.7 BONDING LAYER - An adhesive layer used to bond discrete layers of multilayer board constructions. Also known as Prepreg.

2.8 BUILD-UP THICKNESS - Overall thickness of a combination of materials. Unless otherwise indicated, the build-up thickness will refer to the overall thickness of a board construction where no internal or external conductor material resides.

2.9 BUILT-UP MULTILAYER (BUM) - Multiple layers of HDI materials.

2.10 BURIED VIA - A via that does not extend to the surface of the board construction.

2.10.1 CAP LAYER - A single sided copper clad laminate bonded to the external surface of the multilayer board with bonding layer material (prepreg (b-stage)).

2.11 CIRCUIT - Electrical devices and elements interconnected to perform a desired electrical function.

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COMPONENT - WIRING, PRINTED (ZPMV2, ZPMV3, ZPMV8, ZPMV9)

APPENDIX E - TERMS AND DEFINITIONS (continued)

2.12 CIRCUITRY LAYER - Conductor layer or plane in or on a printed wiring board.

2.12.1 CLADDING - See Conductive Foil.

2.12.2 CLAD MATERIAL - See Metal Clad Base Material.

2.13 COATING - A nonmetallic substance applied by some process, such as dipping, screening, spraying, or melt-flow.

2.14 COMPONENT - An individual part or combination of parts intended to perform a desired function.

2.15 CONDITIONING - Exposure of test samples to an environment for a period of time, prior to or after testing and prior to evaluation.

2.15.1 CONDUCTIVE (ELECTRICAL) - The ability of a substance or material to conduct electricity.

2.16 CONDUCTIVE FOIL - A thin metal sheet intended for forming a conductor pattern on a base material.

2.17 CONDUCTIVE PASTE - An organic or inorganic paste substance capable of transmitting electricity, used for circuit conductors, including but not limited to carbon, copper, and silver.

2.18 CONDUCTOR - A trace or path for electricity to transmit in a conductor pattern.

2.19 CONDUCTOR ADHESIVE - Adhesive material used to attach conductor material to a base material.

2.20 CONDUCTOR AVERAGE TRACE WIDTH - The average width of a length of conductor trace.

2.21 CONDUCTOR BASE WIDTH - The width of a conductor at the interface of the base material as determined by microsection analysis. This width is used to determine bond strength/peel strength values.

2.22 CONDUCTOR LAYER - A single plane of a conductor material or pattern on a base material.

2.23 CONDUCTOR MATERIAL - An organic or inorganic substance capable of transmitting electricity, used for circuit conductors, including but not

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limited to copper, tin, nickel, gold, carbon paste, copper paste, silver paste, ruthenium oxide paste, etc.

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APPENDIX E - TERMS AND DEFINITIONS (continued)

2.24 CONDUCTOR PATTERN - The path, design, or configuration of conductor material on the base material, including but not limited to conductor traces, lands, through-holes, and vias.

2.25 CONDUCTOR SPACING - The minimum distance between adjacent conductors.

2.26 CONDUCTOR THICKNESS - The thickness of the conductor and additional metallic platings or coatings, excluding non-conductive coatings.

2.27 CONDUCTOR TRACE - See Conductor Thickness.

2.27.1 CONDUCTOR WEIGHT - A linear conductor path of a conductor circuit.

2.28 CONDUCTOR WIDTH - The width of the conductor as viewed from a top view or at the plane of the surface of a base material, whichever is less. See Conductor Base Width.

2.29 CONFORMAL COATING - A protective covering applied on a printed wiring board capable of conforming to the configuration of objects coated, used to increase the dielectric voltage-withstand capability between conductors, and/or to protect against environmental conditions.

2.30 CONSTRUCTION - A variation in laminate materials, including but not limited to base material, laminate, prepreg, dielectric materials, or other insulation materials. Variations include singlelayer, multilayer, and composite constructions.

2.31 CONTACT FINGER - A conductive surface usually located at an edge of a printed-wiring board used to provide electrical connection by pressure contact.

2.31.1 CONTINUITY - An uninterrupted path for the flow of electrical current in a circuit.

2.32 CORE MATERIAL - The innermost material of printed-wiring board which may be used to support a subsequent layer or layers of dielectric material and conductor pattern. Core material may be an organic or inorganic material, with or without integral dielectric material. Core material may be referred to as substrate material.

2.32.1 COUPON - A test vehicle constructed to represent a production printed wiring board to be used for testing. See Sample.

2.33 CRITICAL OPERATION - Production process or fabrication step considered potentially detrimental to the materials subject to the operation.

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APPENDIX E - TERMS AND DEFINITIONS (continued)

2.34 CURRENT - The movement or flow of electrons in a conductor due to a voltage potential difference to the materials subject to the operation.

2.34.1 DECLAD - A dielectric material from which the foil or conductive material has been removed by etching or other means.

2.35 DELAMINATION - A planar separation of materials (i.e. separation between conductor and base material, prepreg, dielectric material, etc.).

2.36 DESSICATOR - A desiccator containing anhydrous calcium chloride, or other drying agent, maintained at a relative humidity not exceeding 20 percent at 23 °C.

2.37 DIELECTRIC - A material capable of high resistance to the flow of electrical current and capable of being polarized by an electric field.

2.38 DOUBLESIDED - A singlelayer board construction with conductor pattern on the two external sides of the base material. Sometimes referred to as di-clad. A board Recognized doublesided (DS) may be manufactured with conductors on one side only unless designated Doublesided only. See Doublesided Only.

2.38.1 DOUBLESIDED ONLY (DSO) - A singlelayer board construction where the conductor pattern shall be on both the external sides of the base material.

2.39 EDGE CONDUCTOR - A conductor parallel with and spaced not more than 0.4 mm (1/64 inch) from the edge of a printed-wiring board.

2.40 ELECTRODEPOSITION - The depositing of conductor material from a plating solution by the application of electrical current.

2.41 ELECTROLESS DEPOSITION - The depositing of conductor material from an autocatalytic plating solution without the application of electrical current.

2.42 ELECTROPLATING - See Electrodeposition, 2.40.

2.43 EMBEDDED COMPONENT - A discrete component integrated into the board construction during fabrication.

2.43.1 END PRODUCT - An individual part or assembly in its final completed state. See End-Use Product.

2.44 END-USE PRODUCT - A device or appliance in which a printed-wiring board is installed as a component.

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COMPONENT - WIRING, PRINTED (ZPMV2, ZPMV3, ZPMV8, ZPMV9)

APPENDIX E - TERMS AND DEFINITIONS (continued)

2.45 ETCHANT - A chemically reactive solution used to remove portions or all material from a base material construction.

2.45.1 ETCHED - A laminate material in which the conductive layer has been removed by a chemical process.

2.46 ETCHING - The action of chemical, or chemical and electrolytic, removal of conductive or resistive material.

2.46.1 EUTECTIC - An isothermal reversible reaction in which on cooling a liquid solution is converted into two or more intimately mixed solids, with the number of solids formed being the same as the number of components in the system.

2.46.2 EUTECTIC SOLDER - The alloy composition at which a solder alloy melts/freezes completely without going through a partially solid (pasty) phase.

2.47 EXTERNAL LAYER - The conductor pattern on the external surface of the board construction.

2.48 FABRICATOR - The manufacturer who forms the pattern of conductive material on the base.

2.48.1 FAMILY - Multiple grades of materials that have identical IR spectra and performance characteristics and are UL Recognized for the manufacturer as a material family (alternate grades separated by a comma) of which one grade is representative of others in the family.

2.49 FILM - A thin coating or membrane material, usually 0.25 mm (0.010 inches) or less in thickness.

2.49.1 FLAMMABILITY RATED ONLY - A printed wiring board intended for use where the construction shall be evaluated for a flammability classification only, and the thermal, mechanical, and electrical capacity of the board is not of concern and only the flammability classification of the resulting printed wiring board is of concern in the end-use product.

2.50 FLAT (PANEL) - Any number of boards assembled together in a sheet, usually with a frame around the side, when shipped from the board factory.

2.51 FLEXIBLE CONSTRUCTION - A sub-category board construction intended for use where some portion of the board construction shall be subject to flexing in the end-use product application. See Standard for Flexible Materials Interconnect Constructions, UL 796F.

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COMPONENT - WIRING, PRINTED (ZPMV2, ZPMV3, ZPMV8, ZPMV9)

APPENDIX E - TERMS AND DEFINITIONS (continued)

2.52 FLEXIBLE PRINTED CIRCUIT BOARD - Printed board produced from flexible base material with or without flexible coverlay and/or electrically nonfunctional stiffeners.

2.53 FLUSH-PRESS METAL CONDUCTOR - A metal conductor, such as copper, positioned and secured in a base material by a heat and pressure process.

2.54 FLUX - A surface oxidation removing and protecting compound, used to promote wetting of the base metal surface during soldering operations. Flux shall include, but not be limited to acid flux, inorganic flux, organic flux, and water soluble organic flux.

2.55 FOIL LAMINATION - A fabrication process for multilayer category board constructions, where the board construction and conductor foil are bonded to the external surface during one operation.

2.56 GRADE - A designation arbitrarily assigned to a base material by the base-material manufacturer.

2.57 GROUND - A common reference point for conductor circuits.

2.58 GROUND PLANE - A conductor plane used as a common reference point for conductor circuits.

2.59 HAND SOLDERING - Hand-held operator controlled soldering, usually with a soldering iron.

2.60 HEATSINK - A device made of high thermal conductivity and low specific heat material capable of dissipating heat generated by a component or assembly.

2.61 HIGH DENSITY INTERFACE MATERIALS (HDI) - Thin insulating materials used to support conductor materials requiring mechanical strength from a separate core material and are intended for the production of microvias using sequential build-up and related multilayer interconnect technologies. Some examples of HDI materials: resin coated copper (RCC), liquid photoimageable (LPI) dielectric coating materials, photoimageable film dielectric coating materials, and other thin insulating materials when used to support conductor material shall be considered HDI material.

2.62 IDENTICAL PROCESSING - Production or fabrication processes with the same manufacturing steps required to fabricate a board.

2.63 IMMERSION SILVER - Consists of a very thin coating typically less than 0.55 microns (0.0217 mils) of nearly pure silver created by galvanic

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displacement and may contain a slight amount of organic material deposited with the silver.

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APPENDIX E - TERMS AND DEFINITIONS (continued)

2.63.1 INDUSTRIAL LAMINATE - See Base Material.

2.64 INFRARED REFLOW (IR) - Melting of tin/lead or remelting of solder using infrared heat as the primary source of energy.

2.65 INTERNAL LAYER - A conductor pattern contained entirely within a multilayer board construction.

2.66 LAMINATE - The product of bonding two or more layers of material.

2.67 LAMINATE THICKNESS - The thickness of the dielectric material in a singlesided or doublesided singlelayer metal-clad base material.

2.68 LAYER-TO-LAYER SPACING - The thickness of dielectric material between adjacent conductor planes (i.e., the physical distance between adjacent conductor planes).

2.69 LEGEND INK - See Marking Ink.

2.70 MARKING INK - A non-conductive permanent coating, resistant to solvents and chemicals, used to provide a means of identification in the form of letters, numbers, symbols and patterns to identify component locations and orientation to aid in printed-wiring board assembly.

2.71 MASS LAMINATING - An assembly of base material layers and bonding layers laminated together, and which is performed by a base material manufacturer or any other source outside the printed-wiring board fabricator's facility. Mass laminating is performed in several ways. Two examples are:

- a) The manufacturer of the base material receives the inner layers etched by the printed-wiring board fabricator and, with a bonding layer supplied by the printed-wiring board fabricator or from his own stock, laminates the boards with a solid metal sheet on the external surfaces.
- b) The manufacturer of the base material receives art work from the printed-wiring board fabricator or generates his own art work to prepare the inner layers, etches the inner layers of his own in-house base material, and with a bonding layer laminates the boards with a solid metal sheet on the external surfaces. After either of the above procedures, the laminator returns to the printed-wiring board fabricator a composite of internal layers and solid metal external layers for final etching of external surfaces and/or plating operations.

2.72 MAXIMUM OPERATING TEMPERATURE (MOT) - The maximum operating temperature is the maximum continuous use temperature that the board may be exposed to under normal operating conditions.

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APPENDIX E - TERMS AND DEFINITIONS (continued)

2.72.1 METAL BASE LAMINATE - A metal core used as the support for insulating material or base material applied to one or both sides of the metal core surface.

2.72.2 METAL BASE PRINTED WIRING BOARD - A printed board produced from metal base laminate material that provides point-to-point connections and printed components in a predetermined arrangement.

2.73 METAL-CLAD BASE MATERIAL - Base material with integral metal conductor material, on one or both sides.

2.73.1 METAL CLAD LAMINATE - See Metal Clad Base Material.

2.73.2 METAL CORE BOARDS - See Metal Base Printed Wiring Boards.

2.73.3 METAL CORE LAMINATE - See Metal Base Laminate.

2.73.4 METAL WEIGHT - See Conductor Weight.

2.74 MIDBOARD CONDUCTOR - A conductor spaced more than 0.4 mm (1/64 inch) from the edge of a printed-wiring board.

2.74.1 MINIMUM CONDUCTOR WIDTH - The minimum width conductor present on the sample or production printed wiring board. See Conductor Base Width.

2.75 MULTILAYER - Consists of alternate layers of conductors and base materials bonded together, including at least one internal conductive layer.

2.75.1 MULTISITE PROCESSOR - An outside contractor performing defined non-critical board manufacturing steps, including, but not limited to, process steps with temperatures below 100°C or MOT. The multisite processor shall return the boards to the original board manufacturer and may not ship boards directly to the end product manufacturer. See Subcontractor.

2.76 PATTERN - An arrangement of conductive material on a printed-wiring board.

2.77 PERFORMANCE LEVEL CATEGORIES (PLC) - An integer defining a range of test values for a given electrical or mechanical property test.

2.78 PERMANENT COATING - See Permanent Materials.

2.79 PERMANENT MATERIALS - Materials intended to be a part of the board, for the life of the product.

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2.80 PERMANENT RESIST - A solder resist or mask material intended to be a part of the board, for the life of the product.

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APPENDIX E - TERMS AND DEFINITIONS (continued)

2.81 PLATED-THROUGH HOLE - A connection by means of a plating process that deposits a conductive material on the side of a hole to connect conductor patterns on or in a two-sided or multilayer printed-wiring board.

2.82 PLATING - A chemically or electrochemically deposited metallic coating.

2.83 PLATING-UP - The addition of plating material onto existing conductor or plating material.

2.84 PLUGGED-HOLE MATERIAL - A nonmetallic substance used to plug through holes, buried or blind vias, etc., and applied by some process, such as dipping, curtain coating, film laminating, screening, spraying, or melt-flow.

2.85 PREPREG - Fibrous reinforcement material impregnated or coated with a thermosetting resin binder, and consolidated and cured to an intermediate stage semi-solid product (B-stage resin).

2.86 PRINTED (CIRCUIT) BOARD - A printed board produced from rigid industrial laminate material that provides point-to-point connections and printed components in a predetermined arrangement.

2.87 PRINTED CONDUCTOR - A conductor applied to a base material, or to an existing conductor on base material, by means of a printing process.

2.88 PRINTED WIRING - A pattern of conductive material formed on the surface of a base material primarily for point-to-point electrical connections or shielding.

2.89 PRINTED-WIRING BOARD - A completely processed combination of a printed-wiring pattern, including printed components, and the base material.

2.90 PRINTING - Reproducing a pattern on a surface by any process.

2.91 PRODUCTION BOARD - A complete fabricated board, intended for shipment.

2.92 PRODUCTION PROCESS - Fabrication process used to produce boards intended for end-use products.

2.93.1 REINFORCEMENT MATERIAL - Any material (i.e. fibrous, continuous, sheet, etc.) capable of enhancing the base material mechanical or physical performance.

2.94 RELATIVE THERMAL INDEX (RTI) - Maximum service temperature for a material, where a class of critical properties will not be unacceptably compromised

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through chemical thermal degradation, over the reasonable life of an electrical product, relative to a reference material having a confirmed, acceptable corresponding performance-defined RTI.

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APPENDIX E - TERMS AND DEFINITIONS (continued)

2.95 RESIN COATED COPPER FOIL (RCF) - Metal foil coated with unreinforced resin using a single- (one pass) or double- (two pass) coated system. Single-coated foils are usually coated with one layer of B-stage resin. Double-coated foils are usually coated with two layers of resin; C-stage resin adjacent to the foil and B-stage resin on the surface of the C-stage resin.

2.96 RESIST COATING - A material supplied in liquid or film form to mask or protect selected areas of a pattern from the effects of an etchant, solder, or plating and which remains on the printed-wiring board after processing.

2.97 RIGID INDUSTRIAL LAMINATE - Fibrous reinforcement material impregnated or coated with a thermosetting resin binder, and consolidated under high temperature and pressure into a dense solid product.

2.97.1 RIGID PRINTED WIRING BOARD - A printed wiring board produced using rigid base dielectric materials.

2.97.2 SAMPLE - A test vehicle which may be a production printed wiring board, or a portion thereof, or a coupon.

2.98 SILVER MIGRATION - The ionic movement of silver due to migration inducing affects.

2.99 SINGLELAYER - Singlelayer board constructions are doublesided constructions with one layer of dielectric materials(s) separating the conductor planes, and singlesided constructions with a single conductor plane on one side of a dielectric materials(s).

2.100 SINGLESIDED - A board with conductor pattern on one side of the dielectric material(s).

2.101 SOLDER - A metal alloy with a melting temperature below 427°C (800°F).

2.102 SOLDER MASK - See Solder Resist.

2.103 SOLDER RESIST - A coating material used to mask or to protect selected areas of the printed wiring board from solder deposition or plating.

2.103.1 SUBCONTRACTOR - An outside contractor performing defined critical board manufacturing steps, including, but not limited to, process steps with

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temperatures over 100°C or MOT, whichever is greater. The subcontractor shall return the boards to the original board manufacturer and may not ship boards directly to the end product manufacturer. See Multisite Processor.

2.104 SUBSTRATE - See Core Material.

2.104.1 SURFACE FINISH - See Surface Plating/Coating.

COMPONENT - WIRING, PRINTED (ZPMV2, ZPMV3, ZPMV8, ZPMV9)

APPENDIX E - TERMS AND DEFINITIONS (continued)

2.105 SURFACE MOUNTING - Electrical connection of components on the surface of the conductor pattern.

2.106 SURFACE MOUNT COMPONENT - A leaded or leadless component capable of being attached to an interconnect construction by surface mounting.

2.106.1 SURFACE PLATING/COATING - The surface plating/coating shall be on the top surface of patterned conductors and shall not create an interface with the dielectric surface.

2.107 TEMPERATURE PROFILE - The temperatures a select point traverses as it passes through a process involving multiple temperatures and dwell times.

2.108 TEMPORARY RESIST - A solder resist or mask material intended to be removed from the printed-wiring board before installation into the end-product.

2.109 TEST PATTERN - The conductor pattern intended for test and inspection purposes.

2.110 TYPE - A designation arbitrarily assigned to a board by the fabricator.

2.110.1 UL/ANSI TYPE MATERIAL - A specific type designation for materials defined in the Standard for Polymeric Materials - Industrial Laminates, Filament Wound Tubing, Vulcanized Fibre, and Materials Used in Printed Wiring Boards, UL 746E, as having certain base material, resin, thermal index and profiles of minimum performance.

2.110.2 UNCLAD - A dielectric or laminate material without foil or conductive material (never copper clad).

2.111 VIA - A conductor plated through-hole, in which there is no intent to insert a component lead or other reinforcement material, for interlayer connection of conductor planes. See also Blind Via and Buried Via.

2.112 VOID - A defect that leaves an area on an element of a printed-wiring board without a metallic or nonmetallic coating.

2.113 X-AXIS - A reference axis, usually horizontal or left-to-right direction in a two dimension coordinate system.

2.114 Y-AXIS - A reference axis, usually vertical or bottom-to-top direction in a two dimension coordinate system. The x and y axis are usually perpendicular to one another, in a two or three dimension coordinate system.

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2.115 Z-AXIS - The axis perpendicular to the plane created by the x and y reference axis. This axis usually refers to the thickness of a board construction.

SECTION GENERAL A

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COMPONENT - WIRING, PRINTED (ZPMV2, ZPMV3, ZPMV8, ZPMV9)

(To Be Filed Immediately After Appendices)

GENERAL REQUIREMENTS:

The products covered by this Procedure shall comply with the following requirements:

I. Visual Inspection:

- A. Printed wiring boards shall show no burning, bubbling or other visible evidence of damage to conductors or substrate material as a result of the fabrication process.
- B. Pattern surfaces (e.g., conductors, terminal pads and tabs) shall be free of blisters, breaks, sections missing or damaged, corrosion, loosening, or lifting of printed wiring conductor pads or tabs from the base material.
- C. Plating of a contact surface shall adhere to the conductor surface and extend to the conductor edges.
- D. For multilayer boards, interlayer connections shall not have inside delamination (separation of base materials) which can be determined by blisters or bubbles in the copper or on the base material surface.
- E. For multilayer boards where the descriptive section of the Procedure identifies the laminate/prepreg for a specific board Type, there shall not be any intermixing of alternate laminates/prepregs (either from the same or different laminate manufacturers) unless specifically described in the Procedure.
- F. Welding of a surface conductor (that complies with the pattern limits specified in Table I of the descriptive pages in this Procedure) is permitted to bridge a crack in the conductor provided the crack size is 0.125 in. (3.18 mm) or less.

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## II. Markings:

The Recognized Marking shall consist of the PWB type designation and the Recognized company name, trademark, or authorized initials or symbols which can include the UL file number. It may also contain a delta symbol (if applicable for direct support), a suffix to denote factory identification, a CTI PLC rating, and/or a flammability classification (as shown in the individual Recognition). These markings should be legible and in close proximity to each other.

EXCEPTION: the Recognized Component Mark is not permitted to be used on products covered under ZPMV3.

### A. PRINTED WIRING BOARDS WITH SUFFICIENT SPACE

Where there is sufficient space as defined as, a space at least 2.5 mm (0.1 inch) high and of sufficient length to accommodate the marking, each printed-wiring board shall be plainly and permanently marked, such as by etching, printing, solder mask marking, or nonconductive ink printing, or screening, to insure traceability between materials, the manufacturing history, and to identify the manufacturer by which the organization responsible for the product is identified. Conductive markings, such as etched copper, shall be considered as electrical elements (unconnected conductive part) of the circuit and shall not reduce the electrical spacing requirements for the end product.

### B. PRINTED WIRING BOARDS WITH INSUFFICIENT SPACE

When there is not sufficient space to accommodate the marking, the marking shall be marked on the smallest unit container. The marking may be marked on the frame of the panel to which the board is attached, if the board will remain in the panel construction when shipped.

### C. DIRECT SUPPORT

As indicated in Table II of the procedure description, if all base materials Recognized under a type designation meet direct support, the boards are not required to be marked with a delta symbol (▲). If only some of the base materials Recognized under a type designation meet direct support, then only those boards employing base materials that meet direct support may be marked with the delta symbol. Boards that utilize base materials that do not meet direct support (indicated in Table II with a dash), shall not be marked with a delta symbol.

### D. FACTORY IDENTIFICATION

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When printed wiring boards are produced at more than one factory, each finished board shall have a distinctive marking (such as a code) by means of which it is identified as the project of a particular factory.

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E. COMPARATIVE TRACKING INDEX

The CTI PLC rating of a printed wiring board may be marked with "CTI-X" where "X" represents the PLC value, or the PLC value only as indicated in the descriptive section of this Procedure.

F. FLAMMABILITY CLASSIFICATION

The flammability classification of the board may be marked with V-0, V0, V-1, V1, V-2, V2, VTM-0, VTM0, VTM-1, VTM1, VTM-2, VTM2, or HB as indicated in the descriptive section of this Procedure.