UL PCB Recognition – what is it & why do you need to know about it

Presented by Emma Hudson

NCAB Customer Event – March 2015
Agenda

- What is UL and what are its aims
- Drivers for UL PCB Recognition
- Purpose of UL PCB Requirements
- Benefits of buying UL Recognized PCBs
- Types of UL PCB Recognition
- Elements controlled for a Recognized PCB
- Where to view UL PCB Recognition
- Considerations when specifying a PCB that needs to be UL Recognized
- UL Marking Requirements on the PCB
Your presenter – Emma Hudson

• Lead PCB Engineer for Europe & Latin America at UL
• With UL for 9 years
• Formerly Process & Materials Laboratory Manager for an Automotive Electronics manufacturer
• BEng (Hons) in Materials Technology, gained at Coventry University in 1999

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Tel: +44 1483 40 20 37
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What is UL?

Underwriters Laboratories (UL)

• A global independent safety science company with more than 10,000 employees and more than 150 laboratories

• Over a century of expertise in innovating safety solutions

• A global leader in standards development, testing and certification
The aims of UL?

Working for a Safer World Since 1894

• Promote safe living and working environments for people by the application of safety science and hazard-based safety engineering

• Support the production and use of products which are physically and environmentally safe and to apply our efforts to prevent or reduce loss of life and property

• Advance safety science through research and investigation
What do UL do?

Certify
Validate
Test
Inspect
Audit
Advise & Educate
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Recognition Leads to Product Safety Listing

UL Recognition of components is driven by end product safety concerns around:

- **Fire**: added fuel; ignitability

- **Electric Shock**: reduced spacings; insulation breakdown, mechanical strength
Recognition Leads to Product Safety Listing

Many end-product Standards require UL Recognized PCBs to be used

Each standard will have different requirements for the PCB based on the application within the end-product

For example:

- **IEC 60065 (Audio & Video Equipment)**
  - V-0 or V-1 based on power requirements*

- **IEC 60950 (Information Technology Equipment)**
  - V-1, MOT for application, and Direct Support compliant*

- **IEC 60601 (Medical Equipment)**
  - V-2 min, MOT for application*

- **IEC 61010 (Equipment for Laboratory Use)**
  - V-1, 105C MOT*

- **UL 508 (Industrial Control Equipment)**
  - V-2 min, MOT for application, and Direct Support compliant may also be needed*

* Requirements are always APPLICATION DEPENDENT and should be verified before defining what PCB type is required
## Demand Driver for UL PCB Certification

<table>
<thead>
<tr>
<th>End Product Hazard</th>
<th>Failure Mechanism</th>
<th>Board Feature</th>
<th>Test</th>
<th>Test Method</th>
<th>PCB Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric Shock</td>
<td>Reduce Spacings</td>
<td>Metal type conductor adhesion</td>
<td>Bond strength</td>
<td>UL 796</td>
<td>MOT</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Blistering/Delam</td>
<td>UL 796</td>
<td>MOT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Paste type conductor adhesion</td>
<td>Conductive Paste Adhesion</td>
<td>UL 796</td>
<td>MOT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Silver conductors</td>
<td>Silver Migration</td>
<td>UL 796</td>
<td>MOT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Plating adhesion</td>
<td>Plating adhesion</td>
<td>UL 796</td>
<td>MOT</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Warping / Cracking</td>
<td>Delamination</td>
<td>UL 796</td>
<td>MOT</td>
</tr>
<tr>
<td></td>
<td>Insulation Breakdown</td>
<td>Environmental Contamination</td>
<td>CTI</td>
<td>UL 746E/UL746A</td>
<td>DSR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Board thickness</td>
<td>Dielectric Strength</td>
<td>UL 746E/UL746A</td>
<td>RTI / MOT / DSR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Volume Resistivity</td>
<td>UL 746E/UL746A</td>
<td>DSR</td>
</tr>
</tbody>
</table>

MOT – Maximum Operating Temperature  
DSR – Direct Support Requirement  
RTI – Relative Thermal Index
## Demand Driver for UL PCB Certification

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<th>End Product Hazard</th>
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<th>Board Feature</th>
<th>Test</th>
<th>Test Method</th>
<th>PCB Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Flammability</strong></td>
<td>Fuel for the fire/burn time</td>
<td>Board thickness</td>
<td>Self Extinguishing or Slow burn</td>
<td>UL94</td>
<td>RTI / Flame</td>
</tr>
<tr>
<td></td>
<td>Coatings</td>
<td>Self Extinguishing or Slow burn</td>
<td>UL94</td>
<td>Flame</td>
<td></td>
</tr>
<tr>
<td><strong>Ignitability</strong></td>
<td>Hot wire Ignition Or Glow wire</td>
<td>Hot wire Ignition (HWI)</td>
<td>UL 746E/UL746A</td>
<td>DSR</td>
<td></td>
</tr>
<tr>
<td></td>
<td>High Arc Ignition</td>
<td>High Arc Ignition (HAI)</td>
<td>UL 746E/UL746A</td>
<td>DSR</td>
<td></td>
</tr>
<tr>
<td><strong>Mechanical Strength</strong></td>
<td>Ability to support components</td>
<td>Board thickness</td>
<td>Flexural Strength</td>
<td>UL 746E/UL746A</td>
<td>RTI</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tensile Strength</td>
<td>UL 746E/UL746A</td>
<td>RTI</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Inner layer Delamination</td>
<td>UL 746E/UL746A</td>
<td>RTI / MOT</td>
<td></td>
</tr>
</tbody>
</table>

MOT – Maximum Operating Temperature  
DSR – Direct Support Requirement  
RTI – Relative Thermal Index
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• Drivers for UL PCB Recognition
• **Purpose of UL PCB Requirements**
  • Benefits of buying UL Recognized PCBs
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• UL Marking Requirements on the PCB
Purpose of UL’s PCB Requirements

• Provide data characterising the behaviour of materials and PCBs
  - Physical, electrical, flammability, thermal, and other properties
• To be used as guidance in the design for safety
  - By the material manufacturer, the PCB fabricator, and the end product manufacturer
• For use as components in devices or appliances
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Benefits of UL PCB Recognition

PCBs are Recognized under UL’s Component Recognition Program

• Type Testing
  – Provides user with confidence component initially complies with requirements
  – Pre-selection allows for less testing by OEMs, data compared against requirements
  – UL Recognized PCBs may be used Globally
Benefits of UL PCB Recognition

To maintain UL Recognition each manufacturer is subject to an on-going compliance program – Follow-Up Services (FUS)

- Audit Surveillance of materials and PCBs during production
  - Each manufacturer and subcontractor is inspected four times per year
  - For Full Recognition PCBs, production boards are subject to on-going testing, a % of board types collected annually

- Provides confidence the component continues to meet standard requirements moving forward
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Types of PCB Recognition

• Two levels of PCB Recognition that manufacturers can apply for
  
  - Full Recognition
  - Flammability-Only Recognition

• PCB Recognition type required will depend on the application of the PCB in the end product
## Types of PCB Recognition

<table>
<thead>
<tr>
<th>Feature</th>
<th>Full Recognition</th>
<th>Flame-Only Recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flame Rating</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Solder Limits</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Maximum Operating Temperature (MOT)</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Direct Support (DSR)</td>
<td>✓</td>
<td>✗</td>
</tr>
<tr>
<td>Comparative Tracking Index (CTI)</td>
<td>✓</td>
<td>✗</td>
</tr>
</tbody>
</table>
Categorisation of PCB Constructions

Along with the level of Recognition, PCBs are also categorised by construction type –

<table>
<thead>
<tr>
<th>PCB Category</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singlelayer</td>
<td>External Cu layers only, on one or both sides (single-sided or double-sided)</td>
</tr>
<tr>
<td>Multilayer</td>
<td>One or more internal Cu layers present</td>
</tr>
<tr>
<td>Mass Laminated</td>
<td>PCB manufacturer creates a multilayer PCB using a pre-laminated material.</td>
</tr>
<tr>
<td>Singlelayer Metal Base</td>
<td>PCB employs a metal base or core that is not electrically connected to the circuit board, typically used for thermal applications. No internal circuitry layers.</td>
</tr>
<tr>
<td>Multilayer Metal Base</td>
<td>PCB employs a metal base or core that is not electrically connected to the circuit board, typically used for thermal applications</td>
</tr>
<tr>
<td>High Density Interconnect (HDI)</td>
<td>The PCB employs a resin coated copper (RCC) or build-up material (BUM) layer on top of the rigid dielectric material. Does not include HDI constructions made using traditional rigid laminate and prepreg only.</td>
</tr>
<tr>
<td>Flexible</td>
<td>This category is broken down into multiple sub-categories</td>
</tr>
</tbody>
</table>
Categorisation of Flexible PCB Constructions

Flexible PCBs are categorised not only by construction but by application too

• Application options are
  - Flexible – assessed for dynamic and repeated bending applications
  - Flex-to-Install – assessed for flexing during installation and servicing
  - Rigid – not assessed for any flexing or bending properties

• Construction types are
  - Singlelayer, single or double-sided
  - Multilayer
  - Multilayer mass-laminated

• Also have Multilayer Rigid-Flex Composite constructions that are made up of multiple elements and different sections of the board can be assessed for different applications
Categorisation of PCB Constructions

Technological advances may see some additional terms being used when categorising the PCBs, for example

• Multilayer with embedded chip components
  - UL are seeing more and more requests for Recognition of PCBs with embedded components in them

• Multilayer rigid-flex composite constructions also employing HDI materials

When a PCB includes a unique feature, such as embedded components, it will be referenced as part of the PCB Recognition
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Elements Controlled for a Recognized PCB

Material + Construction + Parameters + Manufacturing Process

||

Recognized PCB
Materials

Control the following materials for a UL Recognized PCB –

• Dielectric material
• Solder resist
• Hole-plugging ink
• Marking ink used for decorative purposes
• Conductive pastes
• Adhesives
• Coating materials
• Stiffener materials &
• Embedded Components

Dielectric & Coating materials are typically Recognized for the material manufacturer to minimise the testing the PCB manufacturer needs to conduct

& - Only controlled for Flexible boards Recognized under ZPMV, not controlled for ZPXK category
**Construction**

Control the following construction features for a UL Recognized PCB –

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Full Recognition</th>
<th>Flame-Only Recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Singlelayer</td>
<td>• Min laminate thickness</td>
<td>• Min laminate thickness</td>
</tr>
<tr>
<td></td>
<td>• Min starting Cu foil thickness (and max if &gt;102microns)</td>
<td>• Single or double-sided</td>
</tr>
<tr>
<td></td>
<td>• Single or double-sided</td>
<td></td>
</tr>
</tbody>
</table>

![Diagram](image-url)
## Construction

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Full Recognition</th>
<th>Flame-Only Recognition</th>
</tr>
</thead>
</table>
| **Multilayer**    | • Min dielectric build-up thickness  
                    • Min laminate and prepreg sheet thickness  
                    • Min starting external Cu foil thickness (and max if >102microns)  
                    • Max internal Cu thickness | • Min dielectric build-up thickness  
                    • Min laminate and prepreg sheet thickness |
| **Mass Laminate** | • Min dielectric build-up thickness  
                    • Min starting Cu foil thickness (and max if >102microns)  
                    [Min laminate and prepreg sheet thicknesses and maximum internal Cu thickness is controlled for the material manufacturer] | • Min dielectric build-up thickness  
                    [Min laminate and prepreg sheet thicknesses controlled for the material manufacturer] |

![Diagram of construction types](image)

- **Cu Plating**
- **Ex. Cu Foil**
- **Prepreg**
- **Core Laminate**
- **Cu**
- **Solder Resist**
- **Surface Finish**
- **PTH**
# Construction

<table>
<thead>
<tr>
<th>Construction Type</th>
<th>Full Recognition</th>
<th>Flame-Only Recognition</th>
</tr>
</thead>
</table>
| Metal Base, Singlelayer | • Min and max dielectric thickness  
• Min metal thickness  
• Min starting Cu foil thickness (and max if >102 microns)  
• Single or double sided | • Min and max dielectric thickness  
• Min metal thickness  
• Single or double sided |

**Single Sided (SS) Example**

![Single Sided (SS) Example Diagram](image)

- **Surface Finish**
- **Solder Resist**
- **Cu**
- **Insulation**
  - May be glass fibre reinforced
  - May be unreinforced like HDI
## Construction

<table>
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<tr>
<th>Construction Type</th>
<th>Full Recognition</th>
<th>Flame-Only Recognition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Metal Base, Multilayer</td>
<td>• Min and max dielectric build-up thickness</td>
<td>• Min and max dielectric build-up thickness</td>
</tr>
<tr>
<td></td>
<td>• Min individual sheet thickness</td>
<td>• Min laminate and prepreg sheet thickness</td>
</tr>
<tr>
<td></td>
<td>• Min starting external Cu foil thickness (and max if &gt;102microns)</td>
<td>• Min metal thickness</td>
</tr>
<tr>
<td></td>
<td>• Max internal Cu thickness</td>
<td>• Single or double-sided</td>
</tr>
<tr>
<td></td>
<td>• Min metal thickness</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• Single or double-sided</td>
<td></td>
</tr>
</tbody>
</table>

**Single Sided (SS) Example**

- Holes filled with resin during lamination
- PTH on core
- Surface Finish
- Solder Resist
- Ext. Cu + Plating
  - May be glass fibre reinforced
  - May be unreinforced like HDI
- 2\(^{\text{nd}}\) Insulation
  - May be glass fibre reinforced
  - May be unreinforced like HDI
- Laminate
- Internal Cu
- 1\(^{\text{st}}\) Insulation
  - May be glass fibre reinforced
  - May be unreinforced like HDI
# Construction

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<th>Construction Type</th>
<th>Full Recognition</th>
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</tr>
</thead>
<tbody>
<tr>
<td><strong>HDI</strong></td>
<td>Core:</td>
<td>Core:</td>
</tr>
<tr>
<td></td>
<td>• Min dielectric build-up thickness</td>
<td>• Min dielectric build-up thickness</td>
</tr>
<tr>
<td></td>
<td>• Min laminate and prepreg sheet thickness</td>
<td>• Min laminate and prepreg sheet thickness</td>
</tr>
<tr>
<td></td>
<td>• Min external Cu foil thickness when no HDI material applied (and max if &gt;102microns)</td>
<td>• Min and max HDI layer thickness</td>
</tr>
<tr>
<td></td>
<td>• Max internal Cu thickness</td>
<td>• Min and max number of HDI layers that can be applied</td>
</tr>
<tr>
<td></td>
<td>HDI:</td>
<td>HDI:</td>
</tr>
<tr>
<td></td>
<td>• Min and max HDI layer thickness</td>
<td>• Min and max HDI layer thickness</td>
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</table>

• Need to understand whether blind or buried vias are included within any build-up
Construction

HDI Rigid PCB Example:

- Blind Via (L1–L2)
- Through Hole Filled with plugging material
- Buried Via for L3–L6 Filled with plugging material
- Blind Via (L1–L3)
- PTH
- Surface Finish
- Solder Resist
- HDI
- HDI Prepreg
- Core Laminate
- Prepreg
- HDI
- HDI
- HDI

L1, L2, L3, L4, L5, L6, L7, L8
Construction

Flexible Constructions

- Need to know minimum and maximum thickness of each layer within the construction and all possible build-up options
- For Full Recognition need to know minimum and maximum Cu thickness of each layer
- Need to understand which sections are to be Flexible, Flex-to-Install, and Rigid
- Stack-up diagrams of all possible combinations are key
Parameters

Control the following materials for a UL Recognized PCB –

• Flame Rating
• Maximum Operating Temperature (MOT)
• Pattern Limits
  - Minimum width conductor
  - Minimum edge width conductor
    • edge conductors = any that fall within 0.4mm of the edge of the PCB
  - Maximum area diameter
    • represents the largest unpierced copper area that could be used in a board
• Solder Limits
  - This parameter is meant to simulate the soldering operation(s) the board will be exposed to during the population process
Manufacturing Process

Control the most severe manufacturing process that could be used –

- Any step conducted over 100ºC
  - Specify maximum temperature and maximum time
  - Specify maximum pressure for any lamination step
- Any plating step
- Any final finish step
- Any step where a coating is applied
- Any step conducted at a subcontract facility
  - All steps that are deemed to be critical and are conducted at a subcontract facility have to be identified and that subcontract facility inspected by UL
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Where to View UL PCB Recognitions

All UL Recognized components have a Listing Card documenting the parameters the board is Recognized with.

Two tools available to view this information:

- Online Certifications Directory
- UL iQ Database
Online Certifications Directory

Accessed by going to www.UL.com
Online Certifications Directory

BEGIN A BASIC SEARCH

To begin a search, please enter one or more search criteria in the parameters below.

- **Company Name (options)**
- **City**
- **US State**: Select a state
- **US Zip Code**
- **Country**: Select a country
- **Region**: Select a region
- **Postal Code (non-US)**
- **UL Category Code (options)**
- **UL File Number (help)**
- **Keyword**

SEARCH  CLEAR

ABOUT THE ONLINE CERTIFICATIONS DIRECTORY

You can use the UL Online Certification Directory to:

- Verify a UL Listing, Classification, or Recognition
- Verify a UL Listed product use
- Verify a UL Recognized component use
- Verify a product safety standard

Learn more with the
[Quick Guide to the Online Certifications Directory](#)

SPECIFIC SEARCHES

Select a specific search:

FEATURED LINKS

[UL Alarm Services Search](#)
[UL Code Correlation Database](#)
Search Results for:
UL Category Code = ZPMV2

ZPMV2 is the main UL category code for Recognized PCBs
**Online Certifications Directory**

**ZPMV2.E347105**

Wiring, Printed - Component

For enhanced search functionality, please visit UL's IQ™ Family of Databases.

Click on a product designation for complete information.

**Wiring, Printed - Component**

See General Information for Wiring, Printed - Component

<table>
<thead>
<tr>
<th>Type</th>
<th>Min Width</th>
<th>Max Width</th>
<th>Max Cond</th>
<th>Max Area</th>
<th>Max Solder</th>
<th>Max Opac</th>
<th>Meets UL796</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min Edge</td>
<td>0.10 (0.004)</td>
<td>0.10 (0.004)</td>
<td>1.0 (0.04)</td>
<td>0.85 (32.5)</td>
<td>25</td>
<td>10</td>
<td>105</td>
<td>V-0</td>
</tr>
</tbody>
</table>

**Multi-layer printed wiring boards.**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Thickness</th>
<th>Cond</th>
<th>Area</th>
<th>Solder</th>
<th>OER</th>
<th>UL796</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.10 (0.004)</td>
<td>0.10 (0.004)</td>
<td>17 (0.67)</td>
<td>DS</td>
<td>76.2 (3.0)</td>
<td>25G</td>
<td>10</td>
</tr>
</tbody>
</table>

**Single layer printed wiring boards.**

<table>
<thead>
<tr>
<th>Layer</th>
<th>Thickness</th>
<th>Cond</th>
<th>Area</th>
<th>Solder</th>
<th>OER</th>
<th>UL796</th>
<th>T</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.10 (0.004)</td>
<td>0.10 (0.004)</td>
<td>17 (0.67)</td>
<td>DS</td>
<td>76.2 (3.0)</td>
<td>25G</td>
<td>10</td>
</tr>
</tbody>
</table>

Marking: Company name or trademark or file number and type designation. May be followed by a suffix to denote factory identification or burning test classification.
UL iQ Database

Accessed by going to iq.ul.com

UL iQ™ brings you databases that help you find products that meet your needs with quick, intuitive searches.

please select a database

UL is a global independent safety science company offering expertise across two key strategic businesses: Product Safety, Environment, Life & Health, Knowledge Services and Verification Services. Our breadth, established objectivity and proven history mean we are a symbol of trust and enable us to help provide peace of mind to all.
UL iQ Database

UL iQ™ brings you databases that help you find products that meet your needs with quick, intuitive searches.
UL's iQ for Printed Wiring Boards includes materials covered under the following categories:

- **Component - Printed Wiring Boards (ZPWV2)**
  This category covers printed wiring boards for use as components in devices or appliances. The boards may use organic or inorganic base materials in a single or multilayer, rigid or flexible form. Circuitry construction may include etched, die stamped, press, flex press, additive, and plated conductor techniques. Printed component parts may be used.

- **Component - Laminates (QMT52)**
  This category covers materials that have been tested in accordance with established methods to define their properties in order to facilitate investigation of their use in end-product applications. These materials may consist of filament-wound tubing, industrial laminates, vaporized film, and other materials for use in fabricating recognized printed wiring boards.

- **Component - Flexible Printed Wiring Boards (ZPIK82)**
  This category covers flexible printed wiring boards, consisting of a base material, an interlayer, and a conductor. The construction may consist of one or more layers, and membranes may be included. The materials may be laminated or adhered with additional flexible or rigid materials. Flexible material constructions may employ etched, die-stamped, press, flex, press, additive plated conductors, polymer thin film, dual access, cast and adhesives techniques. Printed component parts may be used.

- **Component - Coatings for use on Printed Wiring Boards (QMU02)**
  This category covers permanent coatings for use on recognized printed wiring boards. These coatings may consist of solder resist, (solder mask) or conformal coatings.
### UL iQ Database

**UL iQ for Printed Wiring Boards**

<table>
<thead>
<tr>
<th>Printed Wiring Boards</th>
<th>Laminates</th>
<th>FR4 Flex PWB's</th>
<th>Coatings for PWB's</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Type Desc</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td><strong>Trade name</strong></td>
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</tr>
<tr>
<td><strong>File Number</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Flame Class</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Board Type</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Nec UL 796 DBR</strong></td>
<td></td>
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<tr>
<td><strong>Max Operating Temprature (°C)</strong></td>
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</tr>
<tr>
<td><strong>Comparative Tracking Index (CTI)</strong></td>
<td></td>
<td></td>
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</tr>
<tr>
<td><strong>Max Conductor Area Diameter (mm)</strong></td>
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<td></td>
</tr>
<tr>
<td><strong>Min Conductor Width (mm)</strong></td>
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<tr>
<td><strong>Max Conductor Edge (mm)</strong></td>
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<td><strong>Min External Conductor TH (mic)</strong></td>
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<tr>
<td><strong>Max External Conductor TH (mic)</strong></td>
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<td></td>
<td></td>
</tr>
<tr>
<td><strong>Min Internal Conductor TH (mic)</strong></td>
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</tr>
</tbody>
</table>

---
## UL iQ Database

### UL for Printed Wiring Boards

![UL for Printed Wiring Boards](image-url)

### Printed Wiring Boards

**Type**: Metal Based

- **Max Operating Temperature (°C)**: 155
- **Comparative Tracking Index (CTI)**:
- **Max Conductor Area Diameter (mm)**:

### Search Results

<table>
<thead>
<tr>
<th>Type</th>
<th>Category</th>
<th>Temp (°C)</th>
<th>Flammability</th>
<th>Solder Time (sec)</th>
<th>Mode</th>
<th>DSR</th>
</tr>
</thead>
<tbody>
<tr>
<td>62</td>
<td>Single layer Metal Based printed wiring boards</td>
<td>155</td>
<td>V-0</td>
<td>120</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>66</td>
<td>Single layer Metal Based printed wiring boards</td>
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<td>V-0</td>
<td>120</td>
<td>All</td>
<td></td>
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<tr>
<td>64</td>
<td>Single layer Metal Based printed wiring boards</td>
<td>155</td>
<td>V-0</td>
<td>120</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>65</td>
<td>Single layer Metal Based printed wiring boards</td>
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<td>V-0</td>
<td>120</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>MI8MN</td>
<td>Multilayer Metal Base Printed Wiring Board, Employing Metal Base Laminates</td>
<td>155</td>
<td>V-0</td>
<td>150</td>
<td>All</td>
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<tr>
<td>22</td>
<td>Metal Based Single Layer Printed Wiring Board</td>
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<td>V-0</td>
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<td>All</td>
<td></td>
</tr>
<tr>
<td>A.T PERFECT CO (E307816) Taiwan</td>
<td>Single Layer Metal Base Pasted Wiring Board, employing metal base laminate</td>
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<td>V-0</td>
<td>200</td>
<td>All</td>
<td></td>
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<tr>
<td>AJ-3</td>
<td>Single Layer Metal Base Printed Wiring Board</td>
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<td>V-0</td>
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<td>PCA-06</td>
<td>Single layer metal base printed wiring boards</td>
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<td>V-0</td>
<td>200</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>KAM Technologies (Zhuhai) Ltd (E420516) China</td>
<td>Single layer Metal Base printed wiring boards</td>
<td>180</td>
<td>V-0</td>
<td>200</td>
<td>All</td>
<td></td>
</tr>
<tr>
<td>RD.A11</td>
<td>Single layer Metal Base printed wiring boards</td>
<td>180</td>
<td>V-0</td>
<td>200</td>
<td>All</td>
<td></td>
</tr>
</tbody>
</table>

10 products met the selected criteria (click on a product to see the complete listing).
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.10</td>
<td>0.10</td>
<td>5</td>
<td>-</td>
<td>210</td>
<td>30.0</td>
<td>270</td>
<td>120</td>
<td>155</td>
<td>V.0</td>
<td>All</td>
</tr>
<tr>
<td>300</td>
<td>60</td>
<td>200</td>
<td>120</td>
<td>200</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Agenda

• What is UL and what are its aims
• Drivers for UL PCB Recognition
• Purpose of UL PCB Requirements
• Benefits of buying UL Recognized PCBs
• Types of UL PCB Recognition
• Elements controlled for a Recognized PCB
• Where to view UL PCB Recognition

• Considerations when specifying a PCB that needs to be UL Recognized
• UL Marking Requirements on the PCB
So what board do you need?

- Just saying a board needs to meet UL might not get you what you need or want.

Could end up with something very different to what you need unless you provide the right details.
Understand What Parameters Your PCB Needs

• It is important to specify the right PCB when asking for UL Recognition

• The parameters required for your PCB will be based on the application of the board in your end product

• May need only a flame rating or could need a flame rating, MOT, DSR compliance and a minimum CTI value

• If you are not sure what parameters you will need the PCB to have please engage with UL and an end product engineer will be able to help you determine this
  - Do this as earlier in the design phase as you can
Parameters to Consider – Do You Need a Specific Flame Rating?

Minimum acceptable flame class is specified by end-product requirements

Classification represents small scale sample evaluation and burn time

- Flame Classes
  - V-0, V-1, V-2
  - VTM-0, VTM-1, VTM-2
  - HB

Determined by performing UL94 burning tests on the PCB
- With and without coatings based on finished PCB
- After thermal shock (thermal stress) exposure
The Flame Tests

HB – **Horizontal Burning**
- Most flammable
- Known as “slow-burning” materials
- Generally materials with little or no flame-retardant added
- Test measures burning rate

V – **Vertical Burning (20mm)**
- Less flammable
- Known as “self-extinguishing” materials
- Generally have flame-retardant added
- A measure of the material’s ability to extinguish itself once removed from the source of ignition

VTM – **Vertical Thin Material**
- For materials that due to their thinness, either distort, shrink and/or are consumed up to the holding clamp when tested under Vertical Flame Test
- PCB manufacturer can chose to conduct VTM test if the samples are less than 0.25mm in thickness and can be formed around the mandrel used for testing
The 20mm Vertical Flame Test

- Vertically oriented sample
- Cotton indicator @ 300 mm
- 2 - ten second flame applications
- Observe
  - flame/glow time
  - cotton indicator
  - extent of burn

- Sample dimensions are 125mm x 13mm x thickness based on product being tested
The Vertical Thin Material (VTM) Flame Test

- Sample dimensions are 200mm x 50mm x thickness based on product being tested
## The Flame Ratings

<table>
<thead>
<tr>
<th>Criteria conditions</th>
<th>V-0</th>
<th>V-1</th>
<th>V-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afterflame time for each individual specimen ( t_1 ) or ( t_2 )</td>
<td>( \leq 10s )</td>
<td>( \leq 30s )</td>
<td>( \leq 30s )</td>
</tr>
<tr>
<td>Total afterflame time for any condition set (( t_1 ) plus ( t_2 ) for the 5 specimens)</td>
<td>( &lt;50s )</td>
<td>( &lt;250s )</td>
<td>( &lt;250s )</td>
</tr>
<tr>
<td>Afterflame plus afterglow time for each individual specimen after the second flame application (( t_2 + t_3 ))</td>
<td>( \leq 30s )</td>
<td>( \leq 60s )</td>
<td>( \leq 60s )</td>
</tr>
<tr>
<td>Afterflame or afterglow of any specimen up to the holding clamp</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Cotton indicator ignited by flaming particles or drops</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Criteria conditions</th>
<th>VTM-0</th>
<th>VTM-1</th>
<th>VTM-2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afterflame time for each individual specimen ( t_1 ) or ( t_2 )</td>
<td>( \leq 10s )</td>
<td>( \leq 30s )</td>
<td>( \leq 30s )</td>
</tr>
<tr>
<td>Total afterflame time for any condition set (( t_1 ) plus ( t_2 ) for the 5 specimens)</td>
<td>( &lt;50s )</td>
<td>( &lt;250s )</td>
<td>( &lt;250s )</td>
</tr>
<tr>
<td>Afterflame plus afterglow time for each individual specimen after the second flame application (( t_2 + t_3 ))</td>
<td>( \leq 30s )</td>
<td>( \leq 60s )</td>
<td>( \leq 60s )</td>
</tr>
<tr>
<td>Did the afterflame or afterglow of any specimen progress up to the 125 mm mark?</td>
<td>No</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Was the cotton indicator ignited by flaming particles or drops?</td>
<td>No</td>
<td>No</td>
<td>Yes</td>
</tr>
</tbody>
</table>
Parameters to Consider – Do You Need a Maximum Operating Temperature (MOT)?

Represents PCB maximum continuous use temperature

• End-product exposure under normal operating conditions
• Minimum acceptable MOT specified by end-product requirements
• Cannot exceed base material mechanical or electrical RTI

Simulated on PCBs with short-term thermal conditioning (10 or 56 days)

• Exposure temperature based on PCB manufacturer request
• MOT determined by analysis of PCB physical properties
  - Conductor adhesion and PCB delamination

Not a property Recognized for Flammability-Only PCB types
Bond Strength & Delamination Test Samples

- 10 mm
- 13 mm
- Max diameter

50 mm Needs to be within 0.40 mm from edge of board

100 mm

A: Minimum width conductor
B: 1.60 mm wide conductor
C: Edge conductor

Slide 58
RTI vs. MOT

RTI (Relative Thermal Index) - The temperature below which a critical property will not be unacceptably compromised through chemical thermal degradation, over the reasonable life of an electrical product.

MOT (Maximum Operating Temperature) – The maximum continuous use temperature that the PCB may be thermally exposed to under normal operating conditions.
Parameters to Consider – Do You Need Direct Support (DSR) Compliance?

- Direct Support Requirements (DSR) represent performance characteristics for Recognized laminates in direct contact with current carrying parts at 120V or less

- PCB DSR compliance is determined by the materials available to manufacture it, no tests are done directly on the PCB

- Not a property Recognized for Flammability-Only PCB types

- A PCB type may be able to be manufactured using materials that are DSR complaint and others that are not. In this case the PCB will have the DSR triangle “▲” documented on the Listing Card.
  - When a PCB is Recognized with a ▲ and a DSR compliant material was used for manufacture then this triangle should also be marked on the board
DSR Performance Tests

Comparative Tracking Index (CTI)
• Determine spacing requirements with addition of wet contaminant
• ASTM D3638 test method used for UL Recognition

Dielectric Strength (DS)
• Establish insulation resistance baseline at 5000V or 6.89 kV/mm

High Current Arc Ignition (HAI)
• Simulate loose connections and broken leads

Hot Wire Ignition (HWI)
• Determine ignition properties when adjacent to or supporting an insulated or uninsulated wire
DSR Performance Tests (cont’d)

Volume Resistivity (VR)
• Determine if material is an insulator or a semi-conductive material

Heat deflection
• Identify and restrict the use of low temperature polymeric materials
• Not required for thermoset or film materials
## Direct Support (▲)

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Units or PLC</th>
<th>V-0, V-1, V-2, HB, VTM-0(^f), VTM-1(^f), VTM-2(^f)</th>
<th>Minimum thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>High current arc ignition</td>
<td>Max PLC</td>
<td>3</td>
<td>Actual(^a)</td>
</tr>
<tr>
<td>Hot wire ignition</td>
<td>Max PLC</td>
<td>4</td>
<td>Actual(^a)</td>
</tr>
<tr>
<td>Volume resistivity – dry</td>
<td>Min ohm-cm x 10(^6)</td>
<td>50</td>
<td>1.6 (0.062)(^a)</td>
</tr>
<tr>
<td>Volume resistivity – wet</td>
<td>Min ohm-cm x 10(^6)</td>
<td>10</td>
<td>1.6 (0.062)(^a)</td>
</tr>
<tr>
<td>Dielectric strength – dry</td>
<td>kV per mm</td>
<td>6.89</td>
<td>1.6 (0.062)(^a)</td>
</tr>
<tr>
<td>Dielectric strength – wet</td>
<td>kV per mm</td>
<td>6.89</td>
<td>1.6 (0.062)(^a)</td>
</tr>
<tr>
<td>Comparative tracking index</td>
<td>Max PLC</td>
<td>4</td>
<td>3.0 (0.13)(^a)</td>
</tr>
<tr>
<td>Heat deflection</td>
<td>Degrees C</td>
<td>b</td>
<td>3.0 (0.13)(^a)</td>
</tr>
</tbody>
</table>

\(^{a}\) Actual thickness or minimum thickness of material being evaluated.

\(^{b}\) Not required for thermosets and films; for thermoplastics, at least 10°C (18°F) above rated operating temperature with 90°C (194°F) minimum value.

\(^{c}\) Testing is to be as described in the Standard for Polymeric Materials – Short Term Property Evaluations, UL 746A.

\(^{d}\) Test sample thickness on which the index value is to be based.

\(^{e}\) Test sample representative of all thicknesses.

\(^{f}\) VTM-0, VTM-1, and VTM-2 ratings apply only to de-clad films.
Parameters to Consider – Do You Need A Minimum CTI (PLC) Rating?

- Comparative Tracking Index (CTI) evaluated on laminate materials
- CTI values are reported on the Listing Card as a Performance Level Category (PLC)

<table>
<thead>
<tr>
<th>Range – tracking index (volts)</th>
<th>Assigned PLC</th>
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<tbody>
<tr>
<td>600 ≤ TI &lt; 600</td>
<td>0</td>
</tr>
<tr>
<td>400 ≤ TI &lt; 400</td>
<td>1</td>
</tr>
<tr>
<td>250 ≤ TI &lt; 250</td>
<td>2</td>
</tr>
<tr>
<td>170 ≤ TI &lt; 175</td>
<td>3</td>
</tr>
<tr>
<td>100 ≤ TI &lt; 100</td>
<td>4</td>
</tr>
<tr>
<td>0 ≤ TI &lt; 0</td>
<td>5</td>
</tr>
</tbody>
</table>

- ASTM D3638 test method used for UL Recognition
- Property is not deemed to be thickness dependent
CTI (PLC) Rating

- PCB CTI (PLC) values determined by the materials available to manufacture the board, no tests are done directly on the PCB

- Not a property Recognized for Flammability-Only PCB types

- A PCB type may be able to be manufactured using materials with different CTI (PLC) values. When this is the case a “ * ” will be documented on the Listing Card.
  - When a PCB is Recognized with a “ * ” for the CTI value the CTI value of the material used should be marked on the PCB
Parameters to Consider – What soldering processes will the PCB be exposed to during population?

• Solder limits represent assembly process
  - Maximum surface temperature
  - Cumulative exposure time

• Simulated on PCB samples with thermal shock (thermal stress) test
  - Designed to evaluate the physical fatigue of the anticipated assembly soldering temperatures (solder limits)

• Test with maximum temperature and maximum time, or multiple solder limit specified by PCB manufacturer
Parameters to Consider – Multiple Soldering Processes

• Assembly processes now often use Surface Mount Technology (SMT)
  - Traditional solder float test (single time and temp) does not represent industry practices
  - PCBs exposed to at least three cycles of reflow process
    • One cycle for single-sided; two for double-sided; three for PTH soldering or rework
    • Multiple solder limits are used to represent the temperature profile during the soldering operation

• If your PCB will be exposed to multiple reflow cycles you should be specifying a board with multiple solder limits that represent these processes
Properties to Consider – Does the PCB need to have Canadian Recognition?

• Depending on where the end product will be sold there may be a requirement for the PCB to be both US and Canadian Recognized.

• No additional testing is required to extend Recognition from US to US and Canadian for the PCB.

• A PCB that has both US and Canadian Recognition will be detailed as having both ZPMV2 and ZPMV8 Recognition in the Online Certifications Directory or will have the following mark on the Listing Card from the UL iQ directory.

<table>
<thead>
<tr>
<th>Cond Width</th>
<th>Cond Width</th>
<th>Cond Thk</th>
<th>Cond Thk</th>
<th>Cond Max Int</th>
<th>Cond Max Ext</th>
<th>Max Area</th>
<th>Solder Limits</th>
<th>Solder Limits</th>
<th>Max Oper Temp</th>
<th>Flame</th>
<th>Meets</th>
</tr>
</thead>
<tbody>
<tr>
<td>Min (mm)</td>
<td>Min (mm)</td>
<td>Min (mil)</td>
<td>Min (mil)</td>
<td>Max Int (mil)</td>
<td>Max Ext (mil)</td>
<td>(mm)</td>
<td>(deg C)</td>
<td>(deg C)</td>
<td>(deg C)</td>
<td>(deg C)</td>
<td>UL796</td>
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<tr>
<td>0.10</td>
<td>0.30</td>
<td>5</td>
<td>290</td>
<td>102</td>
<td>5</td>
<td>50.0</td>
<td>200</td>
<td>20</td>
<td>130</td>
<td>960</td>
<td>CTI</td>
</tr>
</tbody>
</table>
Properties to Consider – Does the PCB need to be made using a specific UL/ANSI Material?

- The UL/ANSI grade of the base materials used to manufacture a PCB are not included on the Listing Card and are confidential to the PCB manufacturer.

- All materials that the PCB manufacturer can use are documented in their UL file.

- NCAB have worked with the PCB manufacturers to gather this information and capture it in an NCAB database, so they can source the appropriate boards.
FR-4 UL/ANSI Material – A change to be aware of

- FR-4 UL/ANSI category of material has been split into two different UL/ANSI grades, FR-4.0 and FR-4.1
- Changes to the FR-4 materials had meant that not all FR-4’s were behaving the same and as such we could no longer consider testing of one representative for another.
- To allow continuation of the reduced test programs FR-4 had to be split into FR-4.0 and FR-4.1

<table>
<thead>
<tr>
<th>UL/ANSI type</th>
<th>Resin</th>
<th>Reinforcement Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>FR-4.0</td>
<td>Brominated Epoxy</td>
<td>Continuous filament woven glass fabric</td>
</tr>
<tr>
<td>FR-4.1</td>
<td>Non-Halogenated Epoxy</td>
<td>Continuous filament woven glass fabric</td>
</tr>
</tbody>
</table>

\(^a\) – Total inorganic filler content equal to 45 percent maximum by weight

\(^b\) – Total halogen content equal to 900ppm maximum Bromine or Chlorine and 1500ppm combined Bromine and Chlorine tested in accordance with UL 746E paragraph 8.12 (which references IPC-TM-650 Method 2.3.41)
Do you want the board manufactured in a specific country or factory?

- Each UL PCB file may have one or more manufacturing location detailed in it
  - Every manufacturer of UL Recognized PCBs has been evaluated by UL and is subject to ongoing surveillance
  - Each manufacturing location has to apply a factory mark that identifies which location it was made at, if there is the option of using more than one facility in their UL file

- Manufacturing locations are confidential to the PCB manufacturers UL file and are not shared on the Listing Card

- The company address provided on the UL Listing Card does not have to be a manufacturing location

- NCAB understand what documentation needs to be checked to verify the PCB manufacturing facility is UL Recognized to make that PCB type
Agenda

- What is UL and what are its aims
- Drivers for UL PCB Recognition
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- Where to view UL PCB Recognition
- Considerations when specifying a PCB that needs to be UL Recognized

- **UL Marking Requirements on the PCB**
# UL Marking Requirements – Mandatory Marks

<table>
<thead>
<tr>
<th>Marking</th>
<th>Optional / Mandatory</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Company Identification</td>
<td>Mandatory</td>
<td>This could be the company name, company initials, a trademark, or UL file number. Anything other than the company name or file number needs to be requested as an alternative company marking option by the PCB manufacturer. All marking options are detailed on the Listing Card.</td>
</tr>
<tr>
<td>Factory Identification</td>
<td>Mandatory</td>
<td>If there is more than one manufacturer detailed in the UL file that could have made the board then a factory identification mark should be present. All manufacturer location marks will be detailed in the UL file in the Authorization page.</td>
</tr>
<tr>
<td>Board Type Designation</td>
<td>Mandatory</td>
<td>The board type designation must be applied, so the parameters of the board can be identified. The PCB manufacturer defines the name of the PCB.</td>
</tr>
<tr>
<td>Canadian Recognition Mark</td>
<td>Mandatory *</td>
<td>* Is not applicable to all UL files. Boards must be detailed as having Canadian Recognition for this mark to be applicable for use.</td>
</tr>
</tbody>
</table>

- All mandatory marks MUST be applied to the PCB where there is "sufficient space". UL 796 defines "sufficient space" as "...a space at least 2.5 mm (0.1 inch) high and of sufficient length to accommodate the marking." See section 33 of UL 796 for further information.
## UL Marking Requirements – Optional Marks

<table>
<thead>
<tr>
<th>Marking</th>
<th>Optional / Mandatory</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Recognition Mark</td>
<td>Optional</td>
<td>This mark does not have to be applied to UL Recognized PCBs. It is an optional mark. If you wish it to be applied to the PCBs you purchase this will need to be requested.</td>
</tr>
<tr>
<td>Direct Support (DSR) Compliance Symbol (▲)</td>
<td>Optional</td>
<td>If all base materials detailed for a PCB are considered to be DSR compliant then no DSR marking needs to be applied (indicated as &quot;All&quot; on the Listing Card). If a board contains base materials that are both DSR compliant and not DSR compliant then the DSR triangle “▲” may be detailed on the board to signify the material used in fabrication was DSR compliant. This mark must not be applied if the base material used for fabrication was not DSR compliant. If DSR compliance is a requirement for the PCB you are purchasing and the board is Recognized with the ▲ make sure to request that your board does meet DSR requirements and is marked accordingly.</td>
</tr>
<tr>
<td>Flame Rating</td>
<td>Optional</td>
<td>The flame rating of the board designation may be marked on the board. Each board type may only have a single flame rating assigned to it and as such it is not a mandatory mark.</td>
</tr>
<tr>
<td>CTI (PLC) Value</td>
<td>Optional</td>
<td>The CTI (PLC) rating may be marked on the board. The CTI (PLC) value to be marked is that detailed for the base material used to construct it. If a minimum CTI value is requirement for the PCB you are purchasing and it is Recognized with a CTI value detailed as &quot; * &quot; make sure to request that your board is marked with the CTI value for the material used.</td>
</tr>
</tbody>
</table>
Summary

• UL Recognition of components is driven by end product safety concerns
• PCB requirements will be application dependant
• Understand the requirements your PCB needs to meet before sourcing the board, minimise the chance of problems as early in the design process as possible
• Ask for the appropriate parameters and marks to be applied to your UL Recognized PCB
• UL is here to help you!
THANK YOU.