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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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?

WE

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

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

MOT – Maximum Operating Temperature
DSR – Direct Support Requirement
RTI – Relative Thermal Index

Demand Driver for UL PCB Certification

End Product Hazard	Failure Mechanism	Board Feature	Test	Test Method	PCB Parameter
Flammability	**Fuel for the fire/burn time**	Board thickness	Self Extinguishing or Slow burn	UL94	RTI / Flame
		Coatings	Self Extinguishing or Slow burn	UL94	Flame
	Ignitability	Hot wire Ignition Or Glow wire	HWI	UL 746E/ UL746A	DSR
		High Arc Ignition	HAI	UL 746E/ UL746A	DSR
Mechanical Strength	**Ability to support components**	Board thickness	Flexural Strength	UL 746E/ UL746A	RTI
			Tensile Strength	UL 746E/ UL746A	RTI
			Inner layer Delamination	UL 746E/ UL746A	RTI / MOT

MOT – Maximum Operating Temperature
DSR – Direct Support Requirement
RTI – Relative Thermal Index

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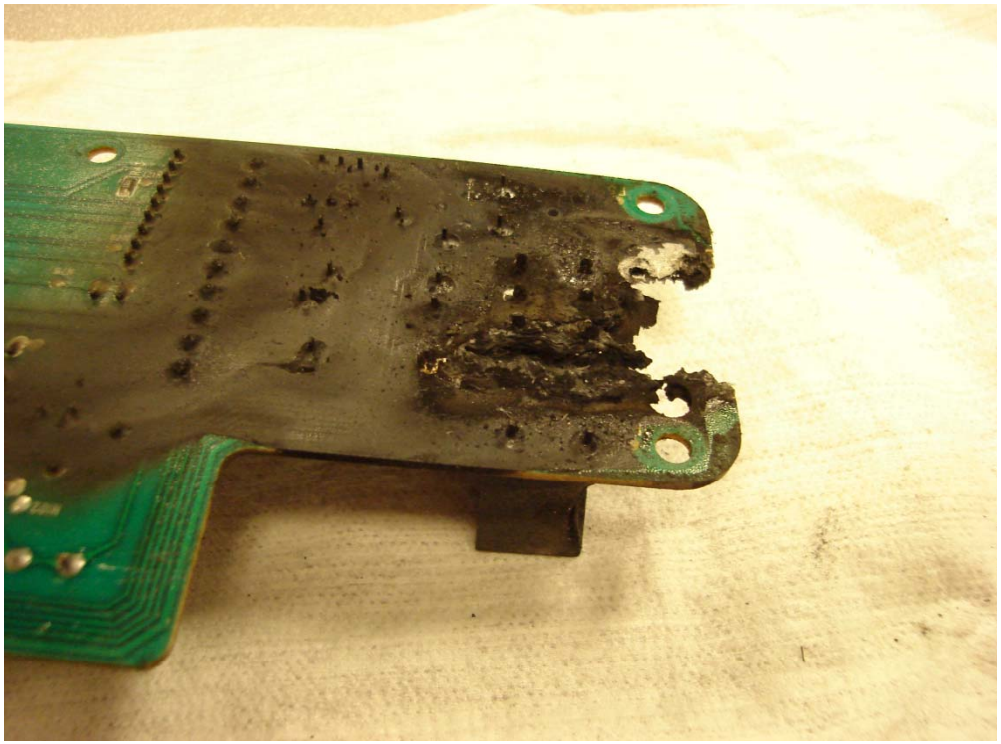
Purpose of UL's PCB Requirements

- 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

	Full Recognition	Flame-Only Recognition
Flame Rating	✓	✓
Solder Limits	✓	✓
Maximum Operating Temperature (MOT)	✓	✗
Direct Support (DSR)	✓	✗
Comparative Tracking Index (CTI)	✓	✗

Categorisation of PCB Constructions

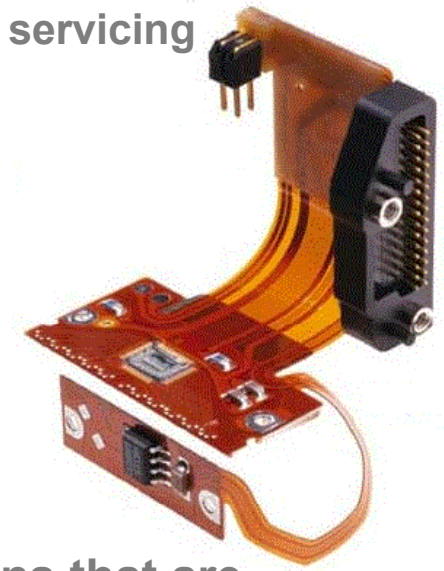
- Along with the level of Recognition, PCBs are also categorised by construction type –

PCB Category	Features
Singlelayer	External Cu layers only, on one or both sides (single-sided or double-sided)
Multilayer	One or more internal Cu layers present
Mass Laminated	PCB manufacturer creates a multilayer PCB using a pre-laminated material.
Singlelayer Metal Base	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.
Multilayer Metal Base	PCB employs a metal base or core that is not electrically connected to the circuit board, typically used for thermal applications
High Density Interconnect (HDI)	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.
Flexible	This category is broken down into multiple sub-categories

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 instillation 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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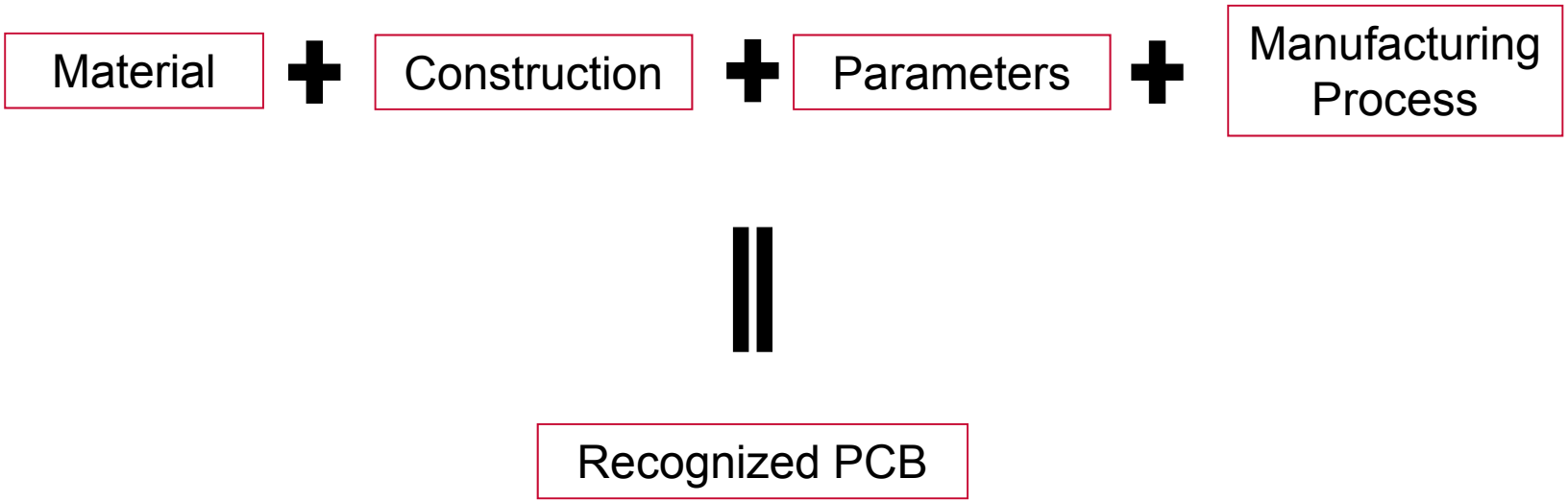
Elements Controlled for a Recognized PCB



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

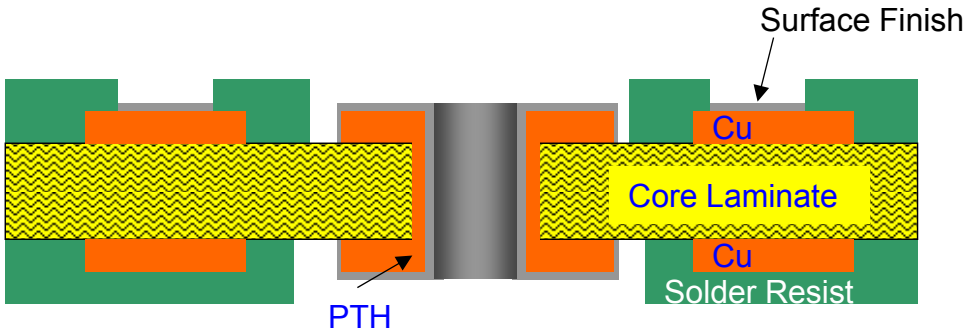
Dielectric & Coating materials are typically Recognized for the material manufacturer to minimise the testing the PCB manufacturer needs to conduct

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

Construction

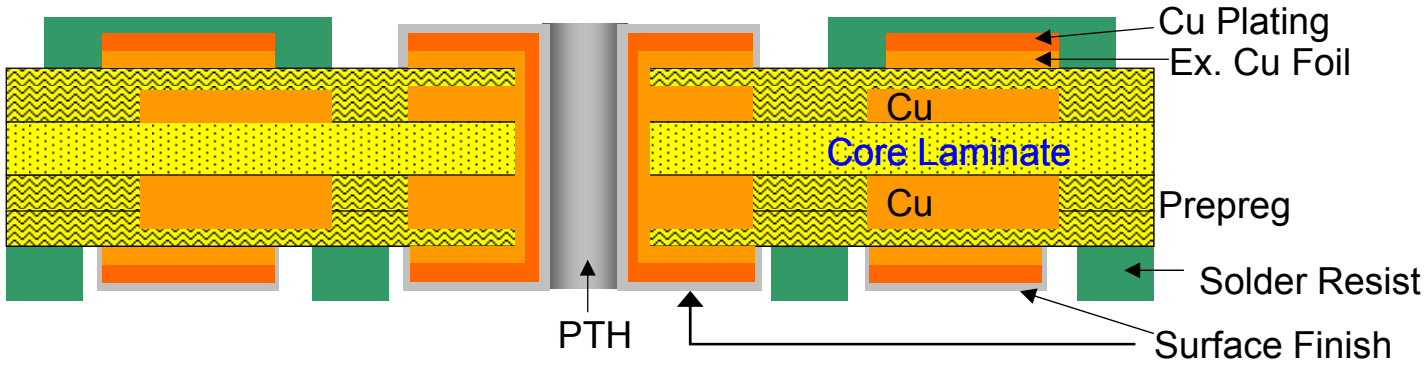
Control the following construction features for a UL Recognized PCB –

Construction Type	Full Recognition	Flame-Only Recognition
Singlelayer	• Min laminate thickness • Min starting Cu foil thickness (and max if >102microns) • Single or double-sided	• Min laminate thickness • Single or double-sided



Construction

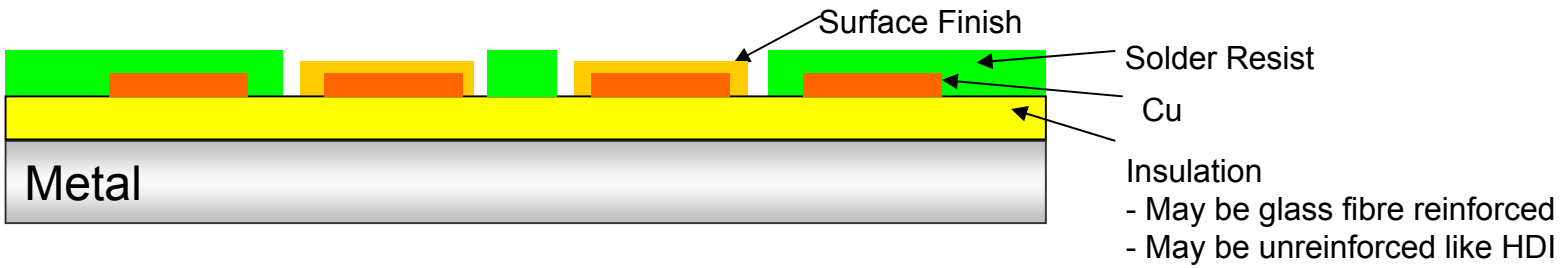
Construction Type	Full Recognition	Flame-Only Recognition
Multilayer	• Min dielectric build-up thickness • Min laminate and prepreg sheet thickness • Min starting external Cu foil thickness (and max if >102microns) • Max internal Cu thickness	• Min dielectric build-up thickness • Min laminate and prepreg 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]



Construction

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

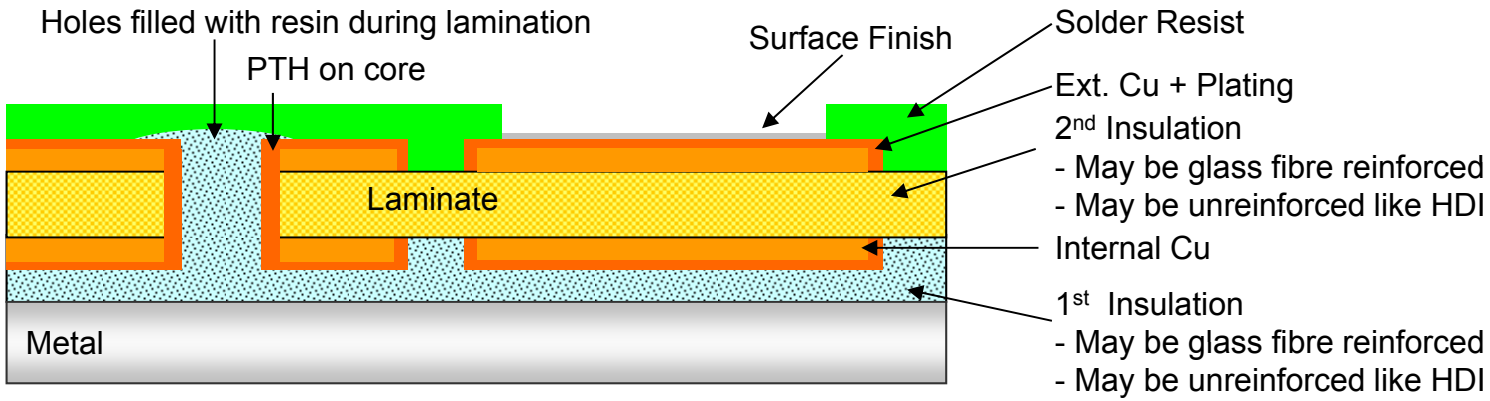
Single Sided (SS) Example



Construction

Construction Type	Full Recognition	Flame-Only Recognition
Metal Base, Multilayer	• Min and max dielectric build-up thickness • Min individual sheet thickness • Min starting external Cu foil thickness (and max if >102microns) • Max internal Cu thickness • Min metal thickness • Single or double-sided	• Min and max dielectric build-up thickness • Min laminate and prepreg sheet thickness • Min metal thickness • Single or double-sided

Single Sided (SS) Example



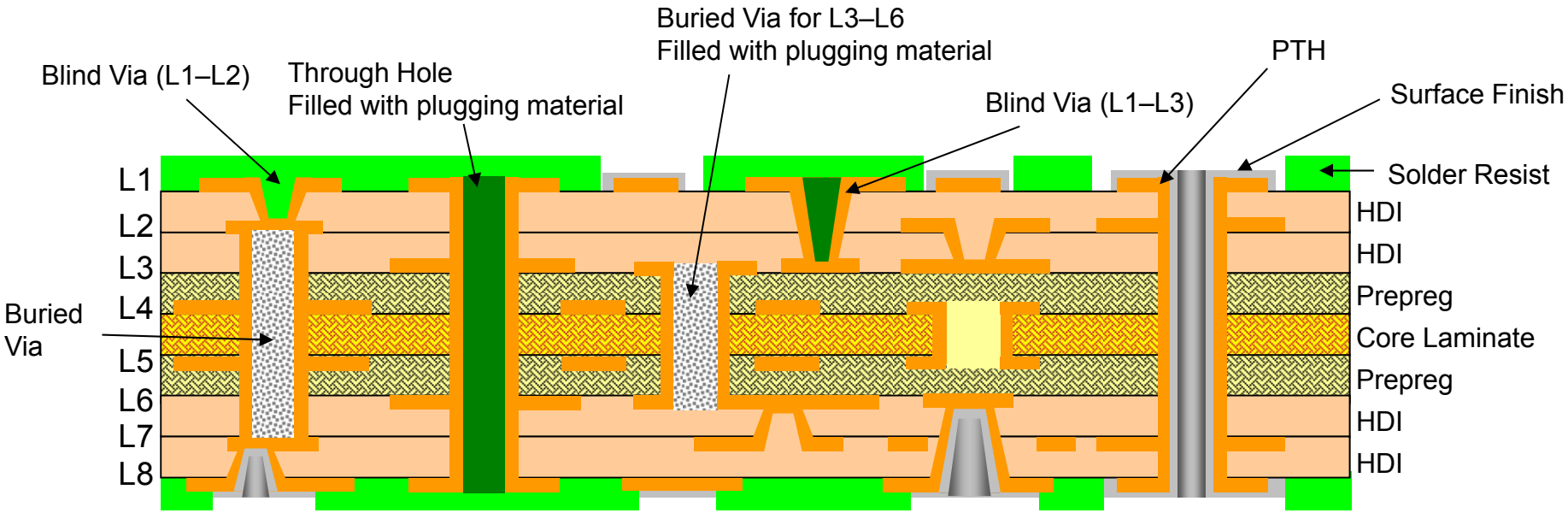
Construction

Construction Type	Full Recognition	Flame-Only Recognition
HDI	Core: •Min dielectric build-up thickness •Min laminate and prepreg sheet thickness •Min external Cu foil thickness when no HDI material applied (and max if >102microns) •Max internal Cu thickness HDI: •Min and max HDI layer thickness •Min and max number of HDI layers that can be applied •Max internal Cu thickness •Min external Cu foil thickness (and max if >102microns)	Core: •Min dielectric build-up thickness •Min laminate and prepreg sheet thickness HDI: •Min and max HDI layer thickness •Min and max number of HDI layers that can be applied

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

Construction

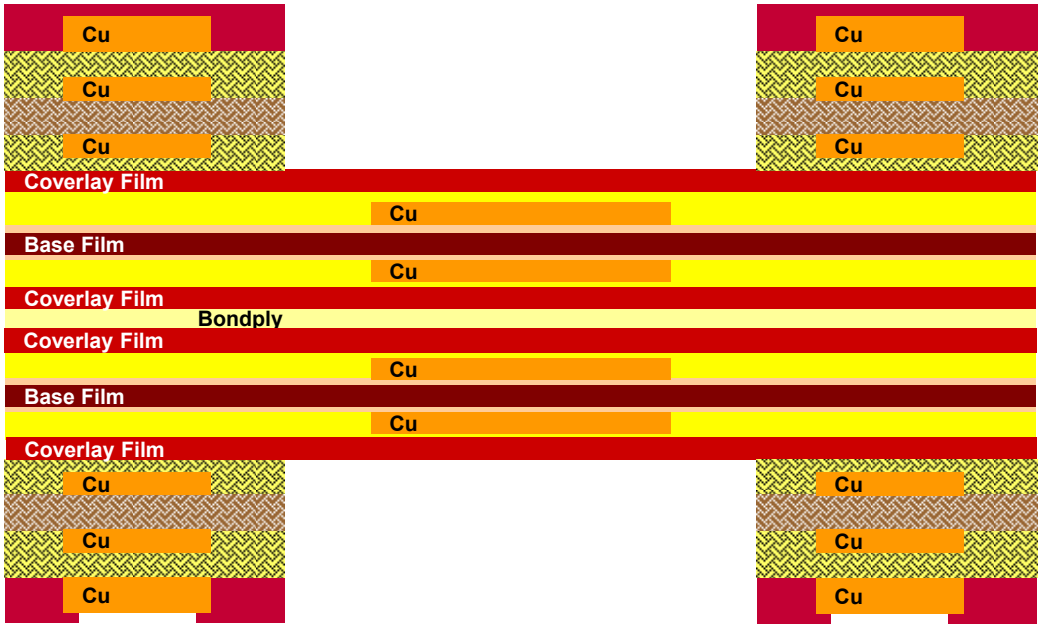
HDI Rigid PCB Example:



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

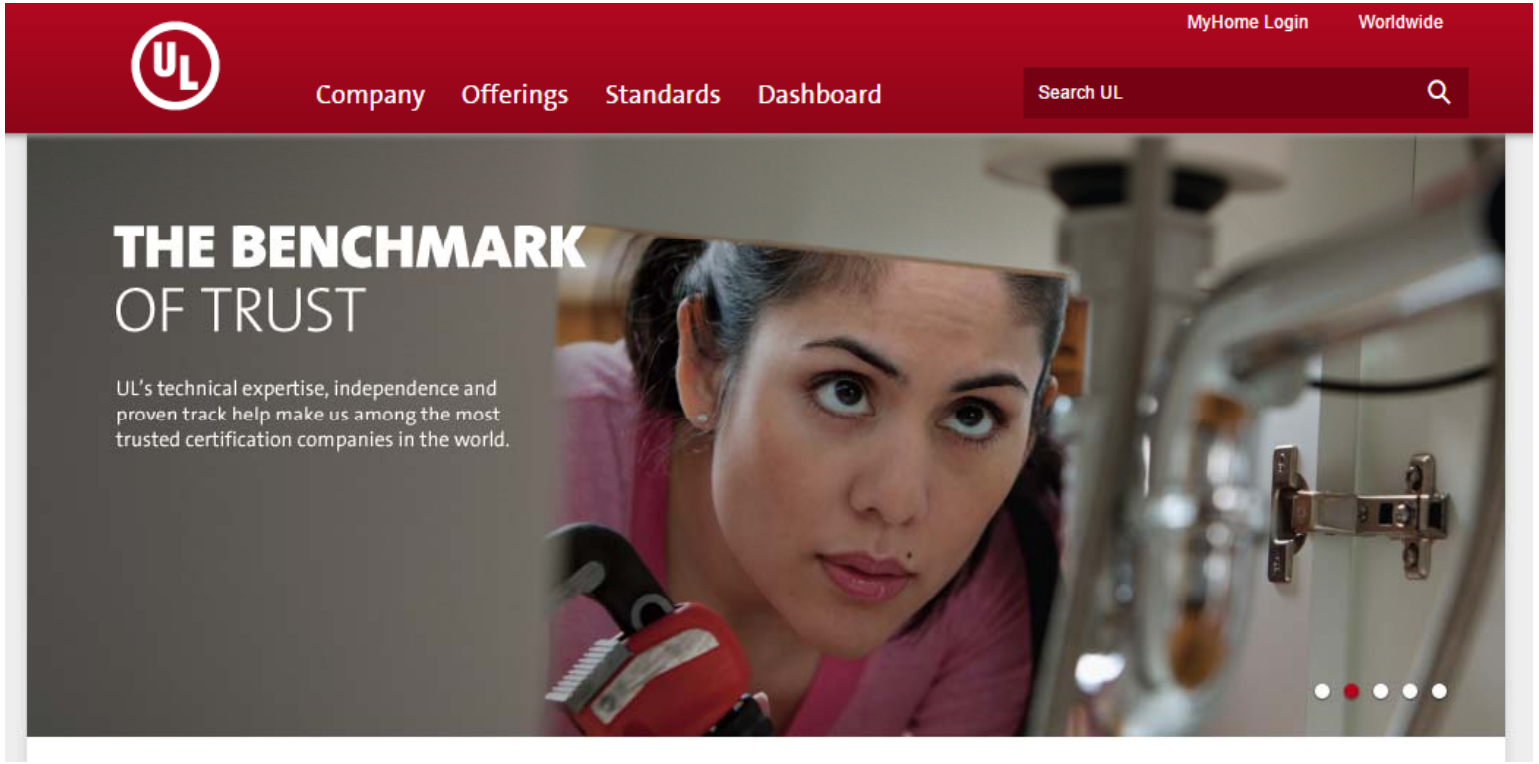
All UL Recognized components have a Listing Card documenting the parameters the board is Recognized with

Two tools available to view this information

- Online Certifications Directory
- UL iQ Database

Online Certifications Directory

Accessed by going to www.UL.com



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You can use the UL Online Certification Directory to:

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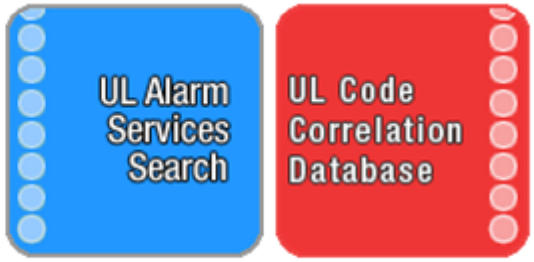

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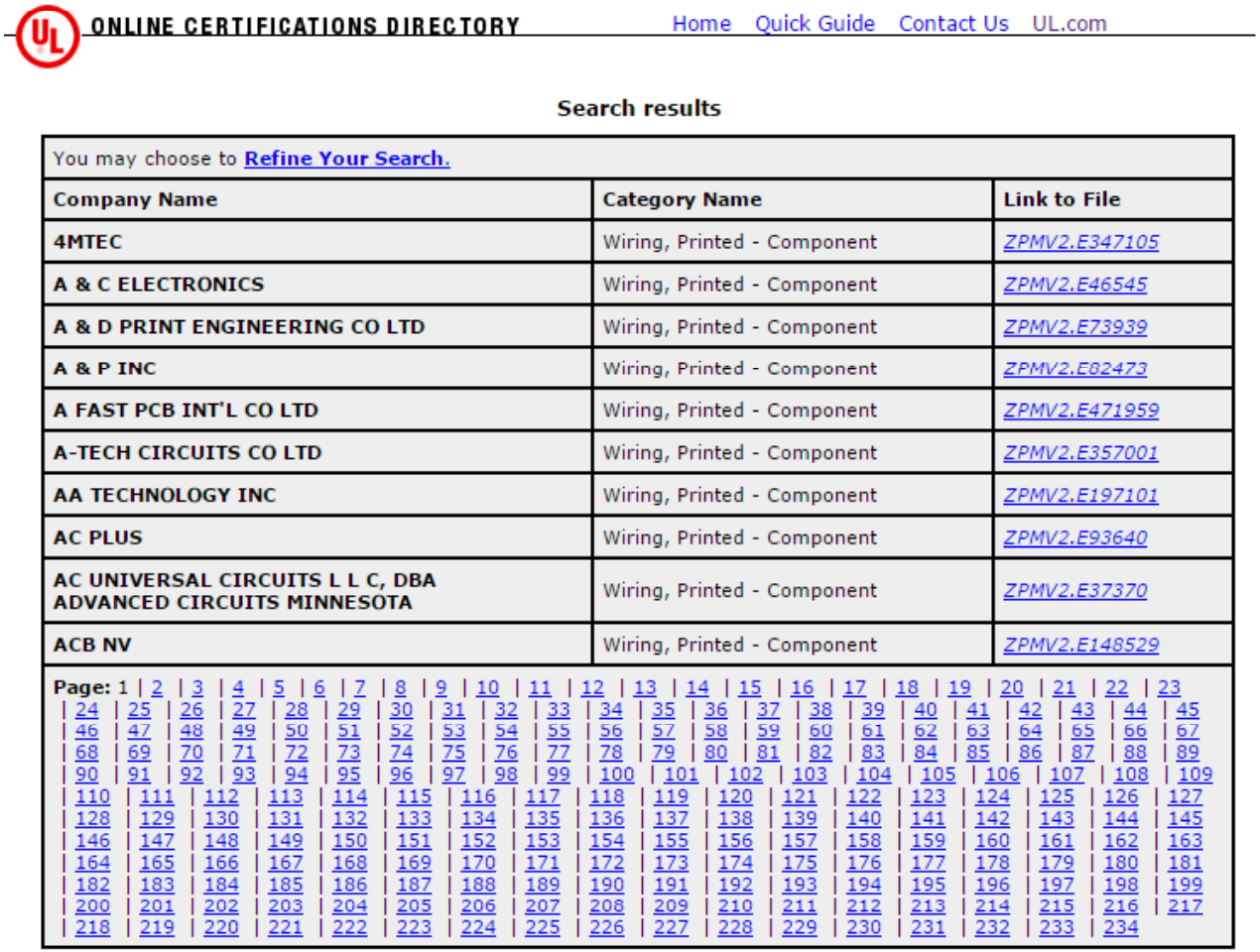

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Search results

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Company Name	Category Name	Link to File
4MTEC	Wiring, Printed - Component	*ZPMV2.E347105*
A & C ELECTRONICS	Wiring, Printed - Component	*ZPMV2.E46545*
A & D PRINT ENGINEERING CO LTD	Wiring, Printed - Component	*ZPMV2.E73939*
A & P INC	Wiring, Printed - Component	*ZPMV2.E82473*
A FAST PCB INT'L CO LTD	Wiring, Printed - Component	*ZPMV2.E471959*
A-TECH CIRCUITS CO LTD	Wiring, Printed - Component	*ZPMV2.E357001*
AA TECHNOLOGY INC	Wiring, Printed - Component	*ZPMV2.E197101*
AC PLUS	Wiring, Printed - Component	*ZPMV2.E93640*
AC UNIVERSAL CIRCUITS L L C, DBA ADVANCED CIRCUITS MINNESOTA	Wiring, Printed - Component	*ZPMV2.E37370*
ACB NV	Wiring, Printed - Component	*ZPMV2.E148529*

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Model number information is not published for all product categories. If you require information about a specific model number, please contact Customer Service for further assistance.

Search Tips Print this page Terms of Use iQ Family of Databases

Search Results for: UL Category Code = ZPMV2

ZPMV2 is the main UL category code for Recognized PCBs

Online Certifications Directory

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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.

Page Bottom

Wiring, Printed - Component

See General Information for Wiring, Printed - Component

4MTEC E347105
606B-1L-1
1057-1 SINGIL-DONG
DANWON-GU
ANSAN SI, GYEONGGI-DO 425-839 REPUBLIC OF KOREA

	Cond Width				Max			Max			
		Min	Cond	SS/	Area	Solder		Oper		Meets	C
	Min	Edge	Thk	DS/	Diam	Limits		Temp	Flame	UL796	T
Type	mm(in)	mm(in)	mic(mil)	DSO	mm(in)	C	sec	C	Class	DSR	I
Multilayer printed wiring boards.											
2	0.10 (0.004)	0.10 (0.004)	17 (0.67) Int:35	DS	76.2 (3.0)	260	10	105	V-0	All	2
Single layer printed wiring boards.											
1	0.10 (0.004)	0.10 (0.004)	17 (0.67)	DS	76.2 (3.0)	260	10	105	V-0	All	2

Marking: Company name or trademark 4MT or file number and type designation. May be followed by a suffix to denote factory identification or burning test classification.

Last Updated on 2013-11-21

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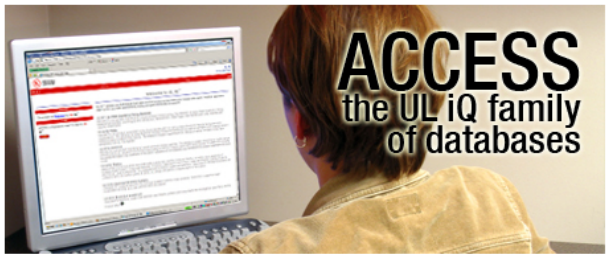

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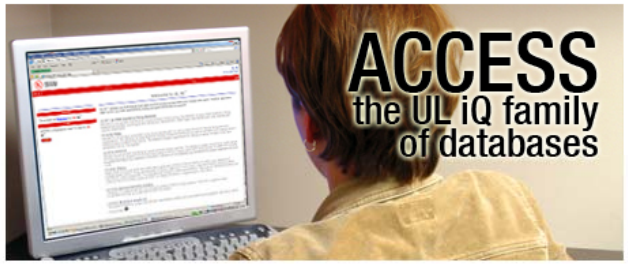

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UL is a global independent safety science company offering expertise across five key strategic businesses: Product Safety, Environment, Life & Health, Knowledge Services and Verification Services. Our breadth, established objectivity and proven history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

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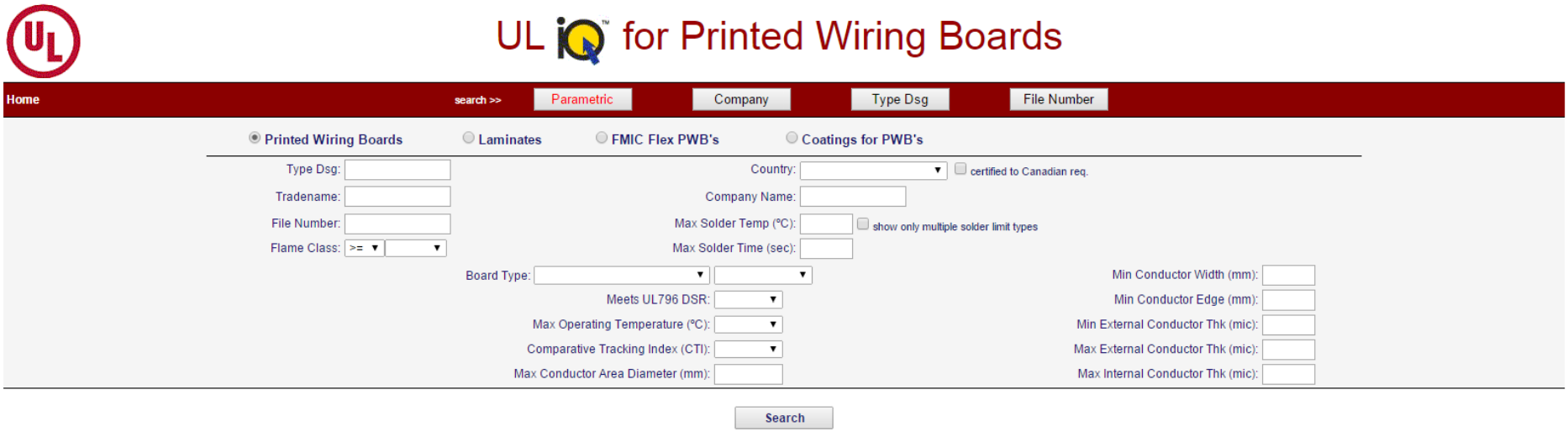

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UL iQ Database

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Type Dsg: | Country: | certified to Canadian req.
Tradename: | Company Name:
File Number: | Max Solder Temp (°C): | show only multiple solder limit types
Flame Class: >= | Max Solder Time (sec):
Board Type: Metal Based | Min Conductor Width (mm):
Meets UL796 DSR: All | Min Conductor Edge (mm):
Max Operating Temperature (°C): 155 | Min External Conductor Thk (mic):
Comparative Tracking Index (CTI): | Max External Conductor Thk (mic):
Max Conductor Area Diameter (mm): | Max Internal Conductor Thk (mic):

Search

10 products met the selected criteria (click on a product to see the complete listing)

Type Dsg	Category	Temp (°C)	Flame Class	Solder Temp(°C)	Solder Time(sec)	Meets DSR
DENKI KAGAKU KOGYO KABUSHIKI KAISHA (E94793) Japan						
62	Single layer Metal Based printed wiring boards	155	V-0	200	120	All
62H	Single layer Metal Based printed wiring boards	155	V-0	200	60	All
63	Single layer Metal Based printed wiring boards	155	V-0	200	60	All
64	Single layer Metal Based printed wiring boards	155	V-0	270	120	All
65@	Single layer Metal Based printed wiring boards	155	V-0	270	120	All
M2MH	Multilayer Metal Base Printed Wiring Board, Employing Metal Base Laminates.	155	V-0	300	60	All
GSPK CIRCUITS LTD (E53704) United Kingdom						
22	Metal Based Single Layer Printed Wiring Board	155	V-0	288	20	All
K T PERFECT CO (E331616) Taiwan						
AL-2	Single Layer Metal Base Printed Wiring Board, employing metal base laminate	155	V-0	260	5	All
PICA Manufacturing Solutions (E464728) United States						
PICA-01	Single layer metal base printed wiring boards	180	V-0	288	20	All
Rayben Technologies (Zhuhai) Ltd (E173761) China						
RB-AL31	Single layer Metal Base printed wiring boards	180	V-0	288	20	All

UL iQ Database

Wiring, Printed - Component — E94793

DENKI KAGAKU KOGYO KABUSHIKI KAISHA

NIHONBASHI MITSUI TOWER, 2-1-1 NIHONBASHI-MUROMACHI, CHUO-KU TOKYO 103-8338 JP

62

Single layer Metal Based printed wiring boards

Cond Width Min (mm)	Cond Width Edge (mm)	Cond Thk Min (mic)	Cond Thk Max Int (mic)	Cond Thk Max Ext (mic)	SS/ DS/ DSO	Max Area Diam (mm)	Solder Limits Temp (C)	Solder Limits Time (sec)	Max Oper Temp (C)	Flame Class	Meets UL796 DSR	CTI
0.10	0.10	5	-	210	SS	30.0	270	120	155	V-0	All	0
							300	60				
							200	120				
							200	60				

Report Date: 1985-04-16
Last Revised: 2009-07-16

Tradenames/Trademarks for File E94793: DENKA HITT PLATE, DENKA HITT PLATE MULTI, DHP, DHPM, HITT, HITT MULTI

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 want you need or want

D2

Multilayer printed wiring boards, flammability only Recognition

Cond Width Min (mm)	Cond Width Edge (mm)	Cond Thk Min (mic)	Cond Thk Max Int (mic)	Cond Thk Max Ext (mic)	SS/ DS/ DSO	Max Area Diam (mm)	Solder Limits Temp (C)	Solder Limits Time (sec)	Max Oper Temp (C)	Flame Class	Meets UL796 DSR	CTI
-	-	-	-	-	DS	-	260	10	-	V-1	-	-

Report Date: 2009-11-04
Last Revised: 2011-07-26

21H1

Multilayer printed wiring boards

Cond Width Min (mm)	Cond Width Edge (mm)	Cond Thk Min (mic)	Cond Thk Max Int (mic)	Cond Thk Max Ext (mic)	SS/ DS/ DSO	Max Area Diam (mm)	Solder Limits Temp (C)	Solder Limits Time (sec)	Max Oper Temp (C)	Flame Class	Meets UL796 DSR	CTI
0.10	0.30	5	210	102	DS	50.8	288	20	130	V-0	All	3

Report Date: 1987-04-28
Last Revised: 2014-12-31

- 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)

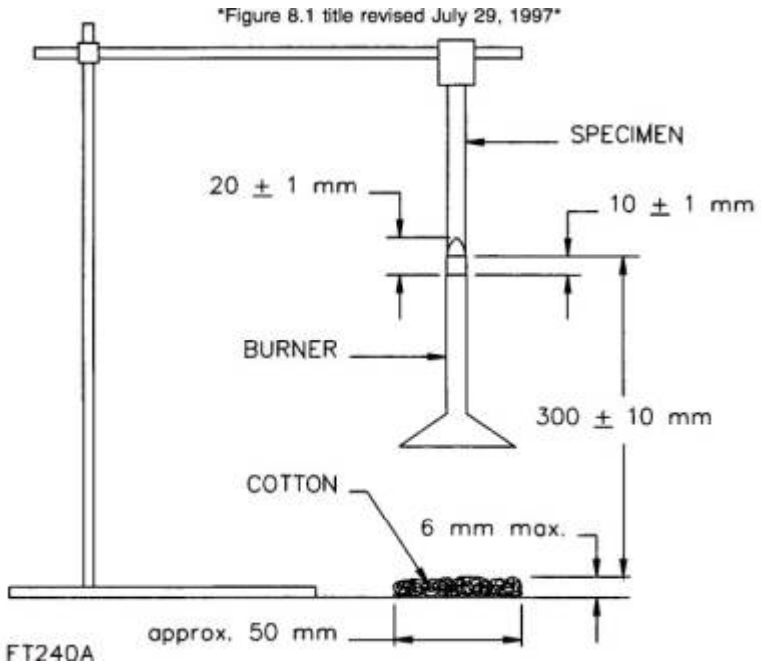
- Less flammable
- Known as “self-extinguishing” materials
- Generally have flame-retardant added
- A measure of the material’s ability to extinguish itself once removed from the source of ignition

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 that 0.25mm in thickness and can be formed around the mandrel used for testing

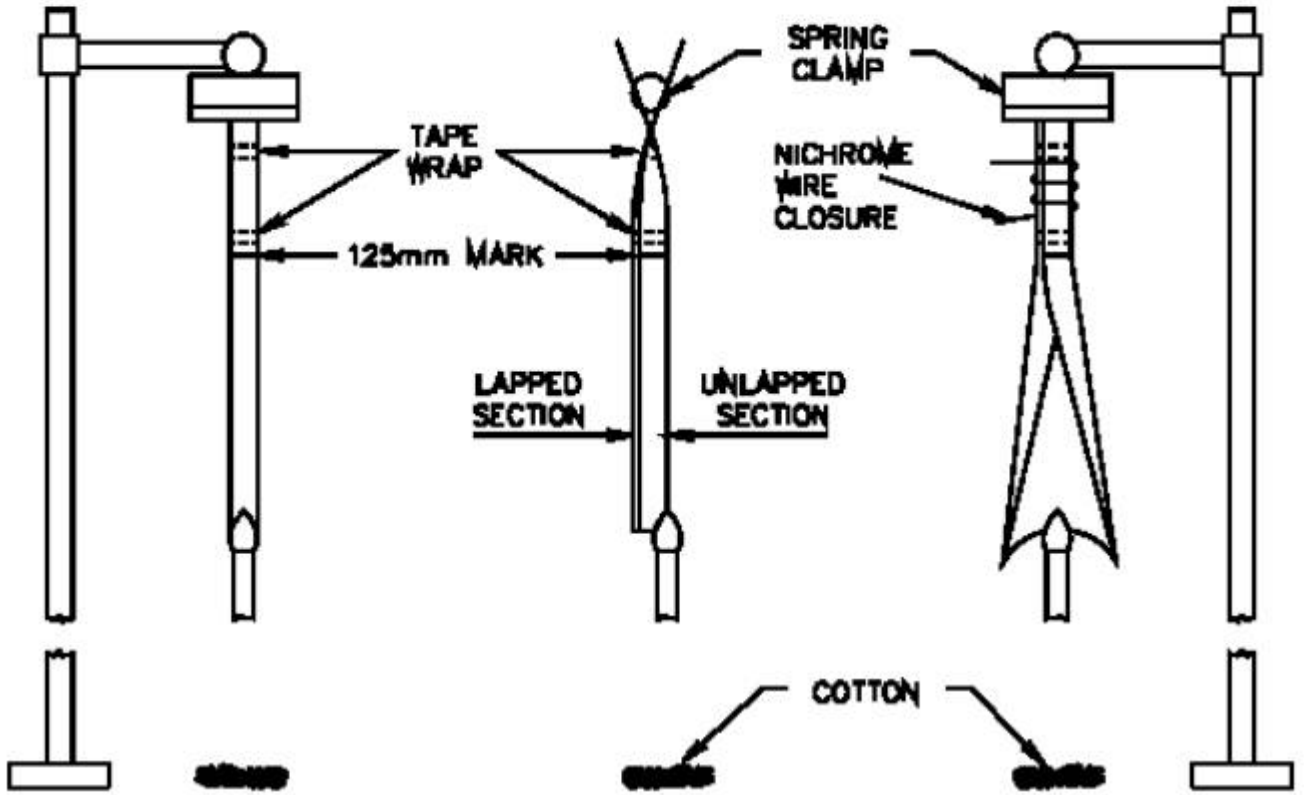
The 20mm Vertical Flame Test

- 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



Front view **Side view** **Back view**

- Sample dimensions are 200mm x 50mm x thickness based on product being tested

The Flame Ratings

Criteria conditions	V-0	V-1	V-2
Afterflame time for each individual specimen t_1 or t_2	≤10s	≤30s	≤30s
Total afterflame time for any condition set (t_1 plus t_2 for the 5 specimens)	≤50s	≤250s	≤250s
Afterflame plus afterglow time for each individual specimen after the second flame application (t_2+t_3)	≤30s	≤60s	≤60s
Afterflame or afterglow of any specimen up to the holding clamp	No	No	No
Cotton indicator ignited by flaming particles or drops	No	No	Yes

Criteria conditions	VTM-0	VTM-1	VTM-2
Afterflame time for each individual specimen t_1 or t_2	≤10s	≤30s	≤30s
Total afterflame time for any condition set (t_1 plus t_2 for the 5 specimens)	≤50s	≤250s	≤250s
Afterflame plus afterglow time for each individual specimen after the second flame application (t_2 + t_3)	≤30s	≤60s	≤60s
Did the afterflame or afterglow of any specimen progress up to the 125 mm mark?	No	No	No
Was the cotton indicator ignited by flaming particles or drops?	No	No	Yes

Parameters to Consider – Do You Need a Maximum Operating Temperature (MOT)?

Represents PCB maximum continuous use temperature

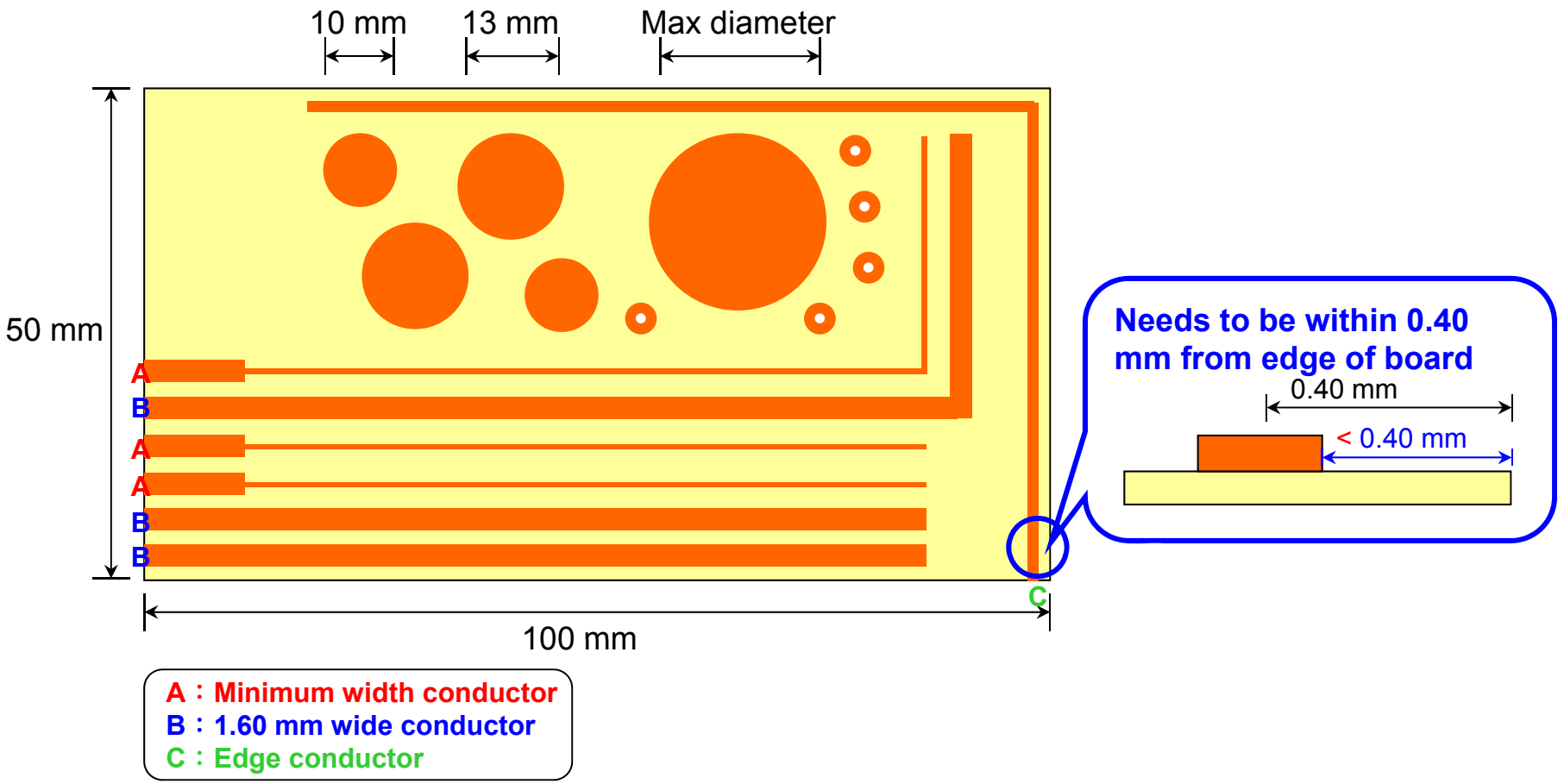
- End-product exposure under normal operating conditions
- Minimum acceptable MOT specified by end-product requirements
- Cannot exceed base material mechanical or electrical RTI

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



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 (▲)

Test[c]	Units or PLC	V-0, V-1, V-2, HB, VTM-0[f], VTM-1[f], VTM-2[f]	Minimum thickness	
			mm	(inches)[d]
High current arc ignition	Max PLC	3	Actual[a]	
Hot wire ignition	Max PLC	4	Actual[a]	
Volume resistivity – dry	Min ohm-cm x 10^6	50	1.6	(0.062)[e]
Volume resistivity – wet	Min ohm-cm x 10^6	10	1.6	(0.062)[e]
Dielectric strength – dry	kV per mm	6.89	1.6	(0.062)[e]
Dielectric strength – wet	kV per mm	6.89	1.6	(0.062)[e]
Comparative tracking index	Max PLC	4	3.0	(0.13)[e]
Heat deflection	Degrees C	[b]	3.0	(0.13)[e]

[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)

Comparative tracking performance level categories

Range – tracking index (volts)					Assigned PLC
600	≤	TI			0
400	≤	TI	<	600	1
250	≤	TI	<	400	2
175	≤	TI	<	250	3
100	≤	TI	<	175	4
0	≤	TI	<	100	5

- 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

21H1

Multilayer printed wiring boards

Cond Width Min (mm)	Cond Width Edge (mm)	Cond Thk Min (mic)	Cond Thk Max Int (mic)	Cond Thk Max Ext (mic)	SS/ DS/ DSO	Max Area Diam (mm)	Solder Limits Temp (C)	Solder Limits Time (sec)	Max Oper Temp (C)	Flame Class	Meets UL796 DSR	CTI
0.10	0.30	5	210	102	DS	50.8	288	20	130	V-0	All	3

Report Date: 1987-04-28
Last Revised: 2014-12-31

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

UL/ANSI type	Resin	Reinforcement Material
FR-4.0 [a]	Brominated Epoxy	Continuous filament woven glass fabric
FR-4.1 [ab]	Non-Halogenated Epoxy	Continuous filament woven glass fabric
[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 on-going 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

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- **UL Marking Requirements on the PCB**

UL Marking Requirements – Mandatory Marks

Marking	Optional / Mandatory	Comments
Company Identification	Mandatory	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.
Factory Identification	Mandatory	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.
Board Type Designation	Mandatory	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.
Canadian Recognition Mark  **If boards have US and Canadian Recognition it is acceptable to apply the joint Recognition mark –** 	Mandatory *	* Is not applicable to all UL files. Boards must be detailed as having Canadian Recognition for this mark to be applicable for use.

• 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

Marking	Optional / Mandatory	Comments
US Recognition Mark 	Optional	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.
Direct Support (DSR) Compliance Symbol (▲)	Optional	If all base materials detailed for a PCB are considered to be DSR compliant then no DSR marking needs to be applied (indicated as "All" 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.
Flame Rating	Optional	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.
CTI (PLC) Value	Optional	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 " * " make sure to request that your board is marked with the CTI value for the material used.

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.