



Institute of Circuit Technology



# **Solder Limits: Updating Them for the Age of Surface Mount**

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ICT Evening Seminar - Harrogate – December 2017

# Solder Limits: Updating them for the age of SMT

- What are Solder Limits
- How to interpret the Solder Limits
- Why are they so important
- What UL is doing to help the industry
- How to update your Solder Limits
- What is going to happen moving forward



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# What are Solder Limits?

- Solder Limits are one of the parameters used when Recognizing a PCB, a metal clad base material, or a solder resist / permanent coating

Wiring, Printed - Component E53704  
**GSPK CIRCUITS LTD**  
 Wiring, Printed - Component E92182  
**D J CIRCUITS LTD**  
 Wiring, Printed - Component E111321  
**MERLIN CIRCUIT TECHNOLOGY LTD**  
 Materials for Use in Fabricating Recognized Printed Wiring Boards E214381  
**VENTEC ELECTRONICS (SUZHOU) CO LTD**  
 Materials for Use in Fabricating Recognized Printed Wiring Boards E41625  
**VT-47**  
 Coatings for Use on Recognized Printed Wiring Boards - Component E95722  
**ISE-8,**  
**ELECTRA**  
 Resist coat E83564  
**SUN CHEMICAL LTD**  
**XV501T (c)**

	Coating Min Thk	Coating Max Thk	Coating Flame Class	Laminate ANSI Type	Laminate Min Thk (mm)	Solder Temp (C)	Solder Time (sec)
(b) - Fc						288	30
(d) - Fc						288	30
(g) - Nc	15	55	V-0	FR-4.0	0.33	288	30
(h) - cc	15	55	V-0	FR-4.0	0.63	288	30

(c) - The following suffixes may be used to describe finish: G - gloss; SM - semi-matte.

Report Date: 1983-08-11  
 Last Revised: 2012-10-19

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# What Are Solder Limits?

- Solder Limits represent the soldering processes the PCB will be exposed to during the component assembly operations
- Any component assembly time spent over 100°C or the Maximum Operating Temperature (MOT), whichever is greater, is considered to be part of the Solder Limits
  - Exception: If the PCB will only be subject to hand soldering then solder limits do not apply
- Solder Limits can be a single time and temperature or multiple times and temperatures (Multiple Solder Limits – MSL)
- The Solder Limits are used in many test procedures when conducting the SAFETY evaluation of a PCB, so if the Recognized Solder Limits are exceeded in production it invalidates the Recognition (safety assessment)



# Solder Limits: Updating them for the age of SMT

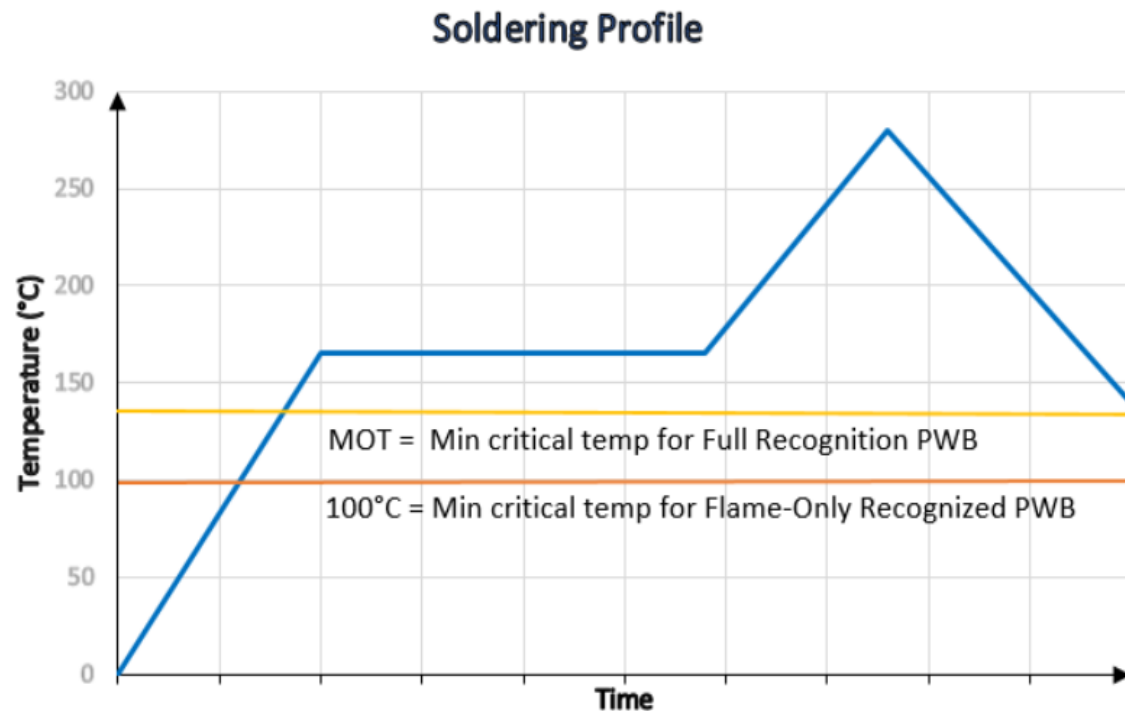
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# How To Interpret Solder Limits?

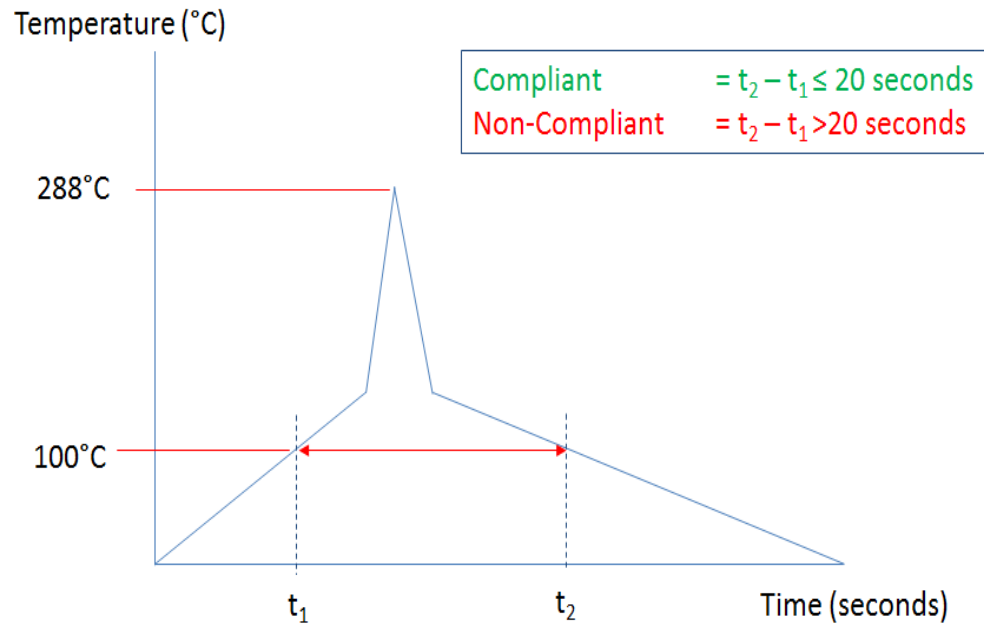
- Need to measure any time spent over 100°C or the Maximum Operating Temperature (MOT), whichever temperature is higher, during component assembly to define the Solder Limits

For example:



# How To Interpret Solder Limits?

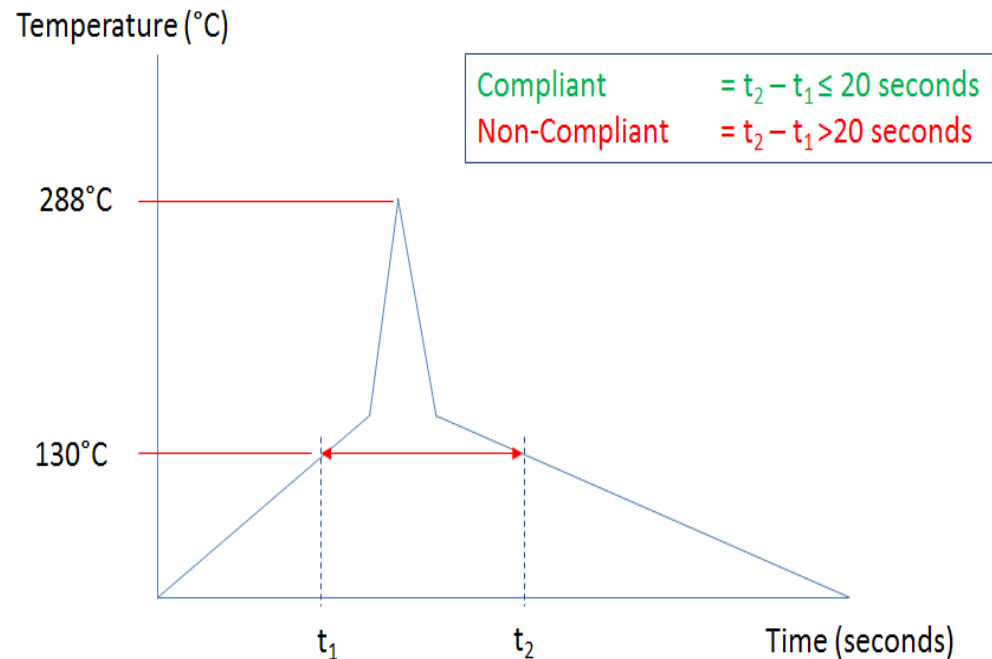
- If a Flame-Only board type is Recognized with solder limits of 288°C for 20 seconds this means that the board is to spend no longer that 20 seconds between temperatures >100°C and ≤288°C.





# How To Interpret Solder Limits?

- If a Full Recognition board with an MOT of 130°C is Recognized with solder limits of 288°C for 20 seconds this means that the board is to spend no longer than 20 seconds between temperatures of >130°C and ≤288°C.



# How To Interpret Solder Limits?

- Flame-Only board Recognized with multiple solder limits of -

**B3**  
Multilayer board, flammability only Recognitions

Cond Width Min (mm)	Cond Width Edge (mm)	Cond Thk Min (mic)	Cond Thk Max Int (mic)	Cond Thk Max Ext (mic)	SS/DSO	Max Area Diam (mm)	Solder Limits Temp (C)	Solder Limits Time (sec)	Max Oper Temp (C)	Flame Class	Meets UL796 DSR	CTI
-	-	-	-	-	DS	-	180 260 270	1800 30 20	-	V-0	-	-

- PCB to spend no longer than -

1800 seconds between  $>100^{\circ}\text{C}$  and  $\leq 180^{\circ}\text{C}$   
 +  
 30 seconds between  $>100^{\circ}\text{C}$  and  $\leq 260^{\circ}\text{C}$   
 +  
 20 seconds between  $>100^{\circ}\text{C}$  and  $\leq 270^{\circ}\text{C}$

**Note** : the 20 seconds between  $100^{\circ}\text{C}$  and  $260^{\circ}\text{C}$  are supplemental to the 1800 seconds between  $100^{\circ}\text{C}$  and  $180^{\circ}\text{C}$ , the same with the 20 seconds between  $100^{\circ}\text{C}$  and  $270^{\circ}\text{C}$ . So, if the board spends 1830 seconds between  $100^{\circ}\text{C}$  and  $180^{\circ}\text{C}$  and only 20 seconds between  $180^{\circ}\text{C}$  and  $260^{\circ}\text{C}$ , this is still acceptable.



# How To Interpret Solder Limits?

- If a Flame-Only board type is Recognized with multiple solder limits of -

**EMC-T**  
Multilayer printed wiring board made from prefabricated type (mass laminated) industrial laminates FLAMMABILITY ONLY Recognitions

Cond Width (mm)	Cond Width (mm)	Cond Thk (mic)	Cond Thk (mic)	Cond Thk (mic)	SS/DSO	Max Area (mm)	Solder Limits (C)	Solder Limits (sec)	Max Oper Temp (C)	Flame Class	Meets UL796 DSR	CTI
-	-	-	-	-	DS	-	180	10800	-	V-0	-	-
							230	80				
							260	10				
							23	300				
							260	10				

- PCB to spend no longer than -
  - 10800 seconds between  $>100^{\circ}\text{C}$  and  $\leq 180^{\circ}\text{C}$
  - +
  - 80 seconds between  $>100^{\circ}\text{C}$  and  $\leq 230^{\circ}\text{C}$
  - +
  - 10 seconds between  $>100^{\circ}\text{C}$  and  $\leq 260^{\circ}\text{C}$
  - +
  - minimum of 300 seconds at ambient
  - +
  - 10 seconds between  $>100^{\circ}\text{C}$  and  $\leq 260^{\circ}\text{C}$ .

**Note** : the 20 seconds between  $100^{\circ}\text{C}$  and  $260^{\circ}\text{C}$  are supplemental to the 1800 seconds between  $100^{\circ}\text{C}$  and  $180^{\circ}\text{C}$ , the same with the 20 seconds between  $100^{\circ}\text{C}$  and  $270^{\circ}\text{C}$ . So, if the board spends 1830 seconds between  $100^{\circ}\text{C}$  and  $180^{\circ}\text{C}$  and only 20 seconds between  $180^{\circ}\text{C}$  and  $260^{\circ}\text{C}$ , this is still acceptable.



# How To Interpret Solder Limits?

- Solder limits may be broken down between more than one process step

Example: Full Recognition PCB with MOT of 130°C Recognized with Solder Limits of

180°C / 10800 seconds,  
230°C / 80 seconds,  
260°C / 10 seconds



## 2 cycles of

5400 seconds between >130°C and ≤180°C

+

40 seconds between >130°C and ≤230°C

+

5 seconds between >130°C and ≤260°C

- ✓ Total time of the two cycles does not exceed the Recognized solder limits of the board



# Solder Limits: Updating them for the age of SMT

- What are Solder Limits
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- **Why are they so important**
- What UL is doing to help the industry
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# Why Are Solder Limits So Important?

- IPC D-32 Thermal Stress task group has shown that PCBs that pass a solder float test can fail during surface mount assembly soldering operations.
- PCB industry has been aware for a long time that the more severe the soldering operations are the greater the degradation of the PCB and this includes the properties evaluated for safety
- To conduct accurate safety assessment of the PCB we MUST use Solder Limits that are representative for the actual soldering processes the PCB will see during assembly operations



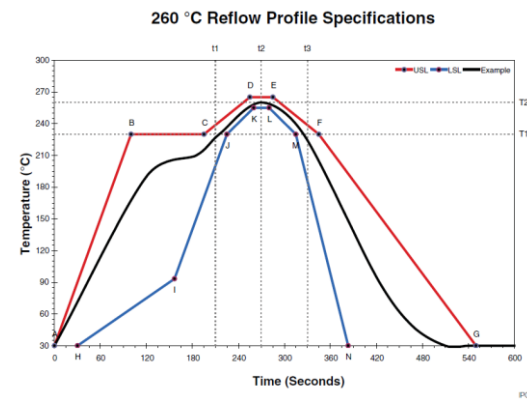
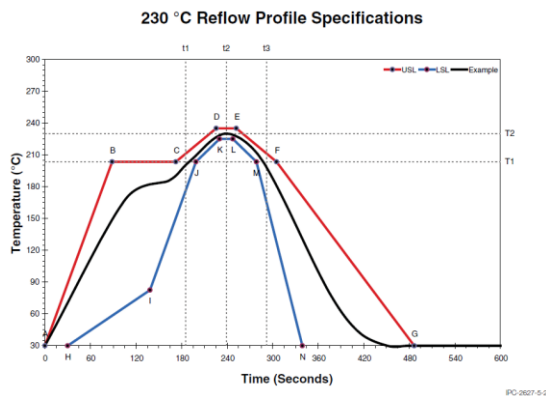
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# What Is UL Doing to Help the Industry?

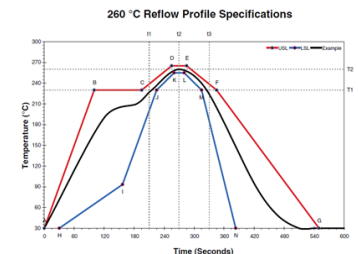
- UL understands there are many different product specific soldering profiles, PCB manufacturers struggle to know which profile(s) to use for Recognition to meet all customer needs
- UL to offer IPC-TM-650 2.6.27 T230 and T260 reflow profiles as a default option to represent SnPb and Pb-Free SMT soldering
  - Will be optional and bespoke reflow profiles can be requested
  - Can also include additional wave solder type soldering limits, e.g. 3x cycles of T260 + 288°C for 30seconds





# What Is UL Doing to Help the Industry?

- Suggesting a default of 3 cycles of desired reflow profile but up to the PCB manufacturer to decide for their Recognition
  - Can have as many or as few cycles as you wish but needs to be representative of the number of cycles it will see in production, which would include any required rework cycles
- UL are attempting to add a reference to these profiles into UL 796 for guidance
  - Due to the way standards are updated, by consensus, UL does not get to chose what goes into the standards so proposed revisions do not always happen
- UL are open to having other standardised profiles added to UL 796
  - Want to make it as easy as possible for the industry to adopt appropriate Solder Limits
  - We do not want plan to “invent” our own UL soldering profiles



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# How to Update Your Solder Limits

- Solder limits are used in nearly all of the testing we conduct on a PCB to grant Recognition, so testing will be required to make them more severe

**Table 24.1**  
**Test methods requiring exposure to the thermal shock test**

<b>Test</b>	<b>Section</b>
Flammability	25
Bond strength	26
Delamination	27
Conductive paste adhesion	30
HDI thermal cycling bond strength	31.3



# How to Update Your Solder Limits

## Base Materials

Example Rigid Multilayer Construction					
	First Base Material		Subsequent Base Materials		
	Full Recognition PCB	Flame-Only PCB	Full Recognition PCB	Flame-Only PCB	
Bond Strength & Delamination	Yes	N/A	Check to see if CCIL Program requirements are met		N/A
			CCIL Met = DOMSA on each material	CCIL Not Met = BDMSA on each material	
Flammability	Yes	Yes	Check to see if CCIL Program requirements are met		V test each material
			CCIL Met = no additional V testing	CCIL Not Met = V testing on each material	

BDMSA - 10/56-day Bond strength and delamination testing with micro-section analysis

DOMSA - 10/56-day Delamination testing with micro-section analysis

V - UL 94 Vertical Flammability testing

- All CCIL Program comparisons include checking the Solder Limits Recognized for the Metal Base Material against those Recognized for the PCB. If the Metal Base Material has less severe Solder Limits than the PCB the CCIL Program cannot be used.



# How to Update Your Solder Limits

## Solder Resists

Example Rigid Multilayer Construction			
First Solder Resist		Subsequent Solder Resists	
Flammability	Yes	Check to see if Permanent Coating Program requirements are met	
		Permanent Coating Program Met = no additional V testing	Permanent Coating Program Not Met = V testing on each material

V - UL 94 Vertical Flammability testing

- All Permanent Coating Program comparisons include checking the Solder Limits Recognized for the Solder Resist against those Recognized for the PCB. If the Solder Resist has less severe Solder Limits than the PCB the Permanent Coating Program cannot be used.



# How to Update Your Solder Limits

- CCIL Program & Permanent Coating Program will be available after initial testing BUT most materials are NOT Recognized with suitable Solder Limits for these no test / reduced test programmes to be used in combination with SMT soldering profiles
- PCB Manufacturers need to push their suppliers to Recognize their materials with suitable Solder Limits, otherwise more testing for the PCB manufacturer
- If CCIL Program & Permanent Coating Program cannot be used we have to test everything
- Strongly recommend Recognizing any new PCB with the new solder limits, whether materials are Recognized with these requirements or not



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# What is Going to Happen Moving Forwards?

- UL shall actively communicate this message to all relevant parties
  - PCB Manufacturers
  - Material Manufacturers
  - Recognized PCB Assemblers
  - OEMs with UL Listed products
- UL shall try and have UL 796 updated, so the standardised profiles are clear for everyone
  - Although this is not required for manufacturers to start requesting to use these soldering profiles
  - If you feel it is useful to have the standardised profiles in the UL standards reach out to the Standards Technical Panel (STP) members





# What is Going to Happen Moving Forwards?

## UL Follow Up Services (FUS)

- They must ask to see evidence of the soldering profiles used for the PCBA
- They will confirm that the soldering processes the PCB have been exposed to do not exceed the Recognized solder limits and invalidate the Recognition
- 2018
  - If soldering profiles show the soldering processes exceeded the maximum solder limit temperature a Variation Notice will be raised
  - If the soldering profiles show the soldering processes exceeded the maximum solder limit time the inspector will inspect the surface of the board, if no visual damage no Variation Notice will be raised BUT the OEM / Assembler will be informed that they MUST resolve this matter such that both the Solder Limit time and temperature are in compliance
- 2019 onwards
  - Any time a Recognized PCB is being exposed to soldering processes exceeding the Recognized Solder Limits a Variation Notice will be raised



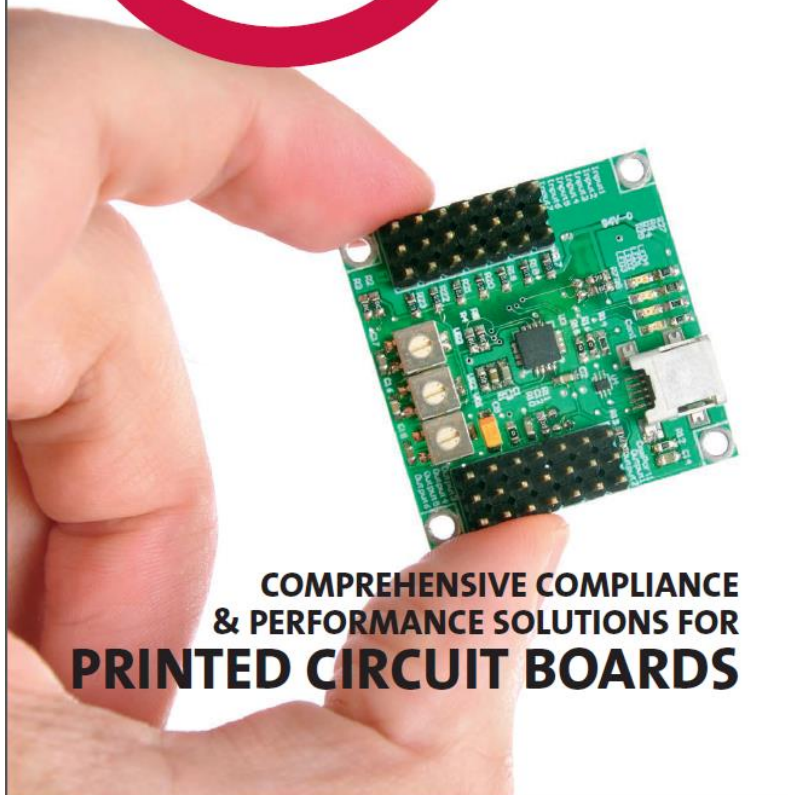
## Summary:

- Solder Limits represent the soldering processes the PCB will be exposed to during assembly
- The traditional solder float conditions do NOT represent the current SMT soldering processes
- Industry knows that PCBs can pass tests using the solder float test that cannot pass when SMT soldering processes are used, so using inaccurate Solder Limits for SAFETY testing is not acceptable
- UL will be offering standardised soldering profiles for Solder Limits to try and make their implementation easier for the industry
- Recognized PCBs need to start being evaluated using appropriate solder limits otherwise the OEM / Assembler will encounter problems
- When you are ready to improve your Solder Limits contact UL for assistance – do it before your customer contacts you!





**THANK YOU**



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& PERFORMANCE SOLUTIONS FOR  
PRINTED CIRCUIT BOARDS**

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