

**TABLE 1.** Parameters for Pb-Free Materials

CHARACTERISTIC	TEST METHOD	COMMENTS / SUGGESTED VALUE <sup>1</sup>
Decomposition temp, Td, (5% weight loss by TGA) <sup>2,3</sup>	IPC-TM-650.2.3.40	≥335°C
Glass transition temperature (Tg), °C, by TMA <sup>4</sup>	IPC-TM-650.2.4.24c	<ul style="list-style-type: none"> <li>■ Tg &gt;140°C for all products</li> <li>■ 165°C for products with &gt;10 layers, &gt;6:1 aspect ratio, or containing BGAs</li> </ul>
In-plane coefficient of thermal expansion CTE(x-y), ppm/°C	IPC-TM-650.2.4.24c	Solder joint stress depends on peak processing temperature, component CTE
Out-of-plane coefficient of thermal expansion – CTE(z), ppm/°C, α <sub>1</sub> (above Tg) and α <sub>2</sub> (below Tg) <sup>5</sup>	IPC-TM-650.2.4.41	Via/PTH barrel and land stress depends on peak processing temperature, PTH copper ductility
<b>SECONDARY PARAMETERS</b>		
Time to delamination (T-260)	IPC-TM-650.2.4.24.1	≥30 min.
Time to delamination (T-288)	IPC-TM-650.2.4.24.1 modified per paragraph 6.1 to 288°C	≥5 min.
<b>TEST METHOD, SPECIAL</b>		
Copper ductility – PTH barrel	IPC-TM-650, 2.4.2	Depends on peak processing temperature, and PTH aspect ratio
<b>PRODUCT LEVEL VALIDATION</b>		
Solder float at 288°C (6X)	Similar to IPC-TM-650, 2.4.13 except loaded with SAC solder	First article cross-sections must pass
Conductive anodic filament testing	Preconditioning + IPC-9691, IPC-TM-650, 2.6.25	Pass

Note 1: Suggested values are highly dependent upon the product being assembled. Values suggested are based on thermally complex high layer count boards that have high material resin content, require multiple Pb-free soldering processes at or near the limits of the J-STD-020C profile requirements, and have long life requirements. Specific values will vary with the requirements of individual products.

Note 2: TGA (thermo-gravimetric analysis).

Note 3: Td, a characteristic determined by a standard test method and evaluated at 5 min., is substantially higher than delamination temperatures evaluated at 30 and 5 min. Td should be used to compare similar materials, and not used as an absolute value in isolation.

Note 4: Thermo-Mechanical Analysis (TMA) is preferred over DSC and DMA in determining Tg because total expansion from room temperature to max. processing temperature is a critical product parameter and because TMA reports the expansion of the material as a function of temperature.

Note 5: The z-axis CTEs (z-axis expansion (%)) per IPC-TM-650, 2.4.41 (50-260°C), both below and above Tg, are important to long-term reliability. Users should ensure that materials specified and associated plated-through-hole copper wall thickness and copper ductility meet reliability requirements of the products.