The moisture sensitivity standard goes Pb-free: the pending J-STD-020D has updated guidelines for handling Pb-free parts, and no more "Tp.".

Print

Title Annotation: *New Standards*
Author: *Martell, Steve*
Date: *Jan 1, 2007*
Words: *1360*
Publication: *Circuits Assembly*
ISSN: *1054-0407*

After a great deal of behind-the-scenes research and debate, the IPC and JEDEC are nearing final approval of their joint standard J-STD-020 revision D, which sets definitions and classifications for moisture and reflow sensitivity of plastic-encapsulated ICs. There is no earthshaking change in the revision; although the new profile curve table (Figure 1) certainly represents a major shift. Overall, it is a carefully crafted document that has the potential to clarify transactions between component manufacturers that test components to meet levels defined in the document, and component users, who rely heavily on the assigned levels to ensure damage-free parts handling.

Technically, the biggest change in the new document is the more complete and precise guidelines for handling IC packages intended for Pb-free processing. The previous version gave some guidelines for components whose encapsulant, lead frame finish, and other features were designed for Pb-free processing; however, J-STD-020D spells out the differences, depending in part on the different rates at which conventional molding compounds and Pb-free molding compounds absorb water (Table 1).

Much of the empirical research that went into setting up the new standard was carried out at Intel, IBM, Philips, Agere and other major semiconductor manufacturers. Researchers needed to know not only the temperature at which a given part suffered damage, but also what type of damage it was (e.g., light delaminations along lead fingers? or a whopping popcorn crack?).

Thousands of parts were subjected to tests and then imaged acoustically to visualize the damage response. This research was carried out at numerous sites around the globe. Japan's JEITA, a counterpart to IPC and JEDEC, took part in reviewing the revised standard. The standard is being accepted and adopted worldwide.

As in the past, the standard includes soak requirements for the various moisture sensitivity levels (MSL). For a Level 3 part, for example, the soak requirement is 192 hrs. (plus 5 hrs., minus 0 hrs.) at 60% relative humidity at a temperature of 30[degrees]C. For most levels (though not for levels 1, 2 and 6) there is also an accelerated equivalent soak time--or, more precisely, two equivalent soak times: one for conventional parts and one for molding compounds typically associated with Pb-free parts. The reason for two equivalent soak times is that conventional parts absorb moisture somewhat more rapidly than Pb-free parts. So a conventional non-leaded Level 3 part would require 192 hrs. at 30[degrees]C and 60% RH under the standard soak requirement, but would have an accelerated equivalent soak time of 40 hrs. at 60[degrees]C and 60% RH. A Pb-free part classified as Level 3 would need a slightly longer accelerated equivalent soak time: 52 hrs. at 60[degrees]C/60% RH. The extra 12 hrs. account for the slower humidity uptake of the molding compound of the Pb-free part, but both the conventional and Pb-free accelerated regimes cut the required time from about eight days to about two.

One of the most significant technical differences in the new standard is the elimination of temperature tolerances in the definitions of the various MSLs. Previous versions of the standard required component manufacturers to guarantee that a component would survive, say, at 260[degrees]C +0/-5, effectively meaning a range from 255[degrees]C to 260[degrees]C. The result was that manufacturers could test parts at any temperature within that range, but the same rules were not always clear to assemblers using the parts.

The revised standard gives a fixed number for manufacturers to adhere to, and for assemblers to depend on. If a part's classification temperature is 260[degrees]C, it must be guaranteed to survive reflow up to but not exceeding that temperature. Manufacturers, of course, to play it safe, are likely to build components that will pass tests above the classification temperature. By doing so, they are likely to make them more robust and reduce the frequency of problems both for themselves and assemblers.

[FIGURE 1 OMITTED]

Closely connected to the classification temperature issue is the clarification of the classification reflow profile, which is now a single-line profile and specifies how the time (Tp) within 5[degrees]C of the classification is measured. The previous profile permitted too wide a preheat range for devices under test, which meant that whether a device passed the classification test might depend on whether the upper or lower preheat tolerances were adhered to.

The second change is abolition of the term "Tp," which referred to the peak package body temperature. This is probably the most subtle, yet most important change in the standard. Prior to the revision, the time within 5[degrees]C was based on the actual peak temperature achieved during the classification reflow profile. This approach had three problems:

1) Tp could not actually be measured until after the reflow profile had reached peak temperature.

2) Most reflow ovens were capable of automatically measuring a time above a specific temperature, but not capable of automatically measuring the time 5[degrees]C below the actual peak temperature.

3) It did not reflect actual concerns addressed in the standard, since the actual peak temperature may never reach the classification temperature or even be within 5[degrees]C of it.

The new version of the profile uses instead the term Tc (classification temperature), and limits the time a part can be exposed to the temperature range from (Tc - 5[degrees]C) to Tc (two tables in the standard give the classification temperatures), which is the exact region that manufacturers of the devices are concerned about. If the assembler's profile never reaches (Tc - 5[degrees]C), then Tp = 0 (zero) sec.

The revised standard also clarifies the testing of parts such as BGAs, sometimes tested in a dead bug orientation (upside down) because testing them in the orientation in which they will be surface-mounted will flatten the solder balls. The problem is that the test orientation may result in a different heat pattern--and a different damage response--than would occur when the BGA is actually surface-mounted. The revision requires the damage response to be similar for both orientations; otherwise, the profile will need to be modified to match the damage response.

One gray area for assemblers has been the use of non Pb-free components in Pb-free assembly processes. The new rules clarify this by requiring non Pb-free components used in Pb-free assembly adhere to the same temperature classifications and profiles as Pb-free parts.

Tom Adams is a consultant: teadams@earthlink.net. Steve Martell is manager of technical support services, Sonoscan (sconoscan.com) and chairman of the IPC Plastic Chip Carrier Group.

Table 1. Classification Profiles for SnPb and Pb-Free Parts

Profile Feature SnPb Eutectic Assembly

Average ramp rate ([Ts.sub.max] to Tp) 3[degrees]C/sec. Max.
Preheat
Temperature min. ([Ts.sub.min]) 100[degrees]C
Temperature max. ([Ts.sub.max]) 150[degrees]C
Time ([Ts.sub.min] to [Ts.sub.max]) (ts) 60-120 sec.
Time maintainted above:
Temperature ([T.sub.L]) 183[degrees]C
Time ([t.sub.L]) 60-150 sec.
Peak package body temperature (Tp) (1) See classification temp
(Table 4-12)
Time (tp) (3) within 5[degrees]C of the 20** sec.
specified classification temperature (Tc)
Average ramp-down rate (Tp to [Ts.sub.max]) 6[degrees]C/sec. max.
Time 25[degrees]C to peak temperature 6 min. max.

Profile Feature Pb-Free Assembly

Average ramp rate ([Ts.sub.max] to Tp) 3[degrees]C/sec. Max.
Preheat
Temperature min. ([Ts.sub.min]) 150[degrees]C
Temperature max. ([Ts.sub.max]) 200[degrees]C
Time ([Ts.sub.min] to [Ts.sub.max]) (ts) 60-120 sec.
Time maintainted above:
Temperature ([T.sub.L]) 217[degrees]C
Time ([t.sub.L]) 60-150 sec.
Peak package body temperature (Tp) (1) See classification temp
(Table 4-2 (2))
Time (tp) (3) within 5[degrees]C of the 30 (3) sec.
specified classification temperature (Tc)
Average ramp-down rate (Tp to [Ts.sub.max]) 6[degrees]C/sec. max.
Time 25[degrees]C to peak temperature 8 min. max.

(1) Tolerance for peak profile temperature (Tp) is defined as a supplier minimum and a user maximum.
(2) J-STD-020D. (3) Tolerance for tp is defined as a supplier minimum and a user maximum.