AN2036
APPLICATION NOTE

Solderability Tests

Lead-free devices, from STMicroelectronics, are warranted to pass the solderability tests, and to form a reliable solder joint with the base material of the circuit board, using Leaded (Sn-Pb) solder or Lead-free (Sn-Ag-Cu) solder. This document describes the context of this assertion.

ST Lead-free devices conform to the ECOPACK® 7191395 specification from ST. This, in turn, complies with the European directive on Restrictions on Hazardous Substances (RoHS) 2002/95/EU, and with the IPC/JEDEC 020 standard for resistance to soldering heat and soldering process.

These devices have to be solderable with both Leaded materials and processes, and with Lead-free materials and processes. With a composition close to the ternary eutectic composition (Table 1.), the Tin-Silver-Copper (Sn-Ag-Cu) alloy is considered as the standard lead-free material. Only Tin-Bismuth coated devices are not tested in Tin-Lead solder. This is because the Tin-Bismuth coating is not recommended for mixing with Tin-Lead solder, for board mounting, due to a reliability risk on the solder joints.

Table 1. Solder Composition for Solderability Tests

Solder	Composition	Range (% weight)
Lead-free	Tin	94.6 to 96.6
	Silver	3.0 to 4.3
	Copper	0.4 to 1.1
SnPb	Tin	60 to 64
	Lead	36 to 40

There are two kinds of tests that are applied to evaluate such ability of a surface to be wetted:

- Dip and Look
- Wetting Balance

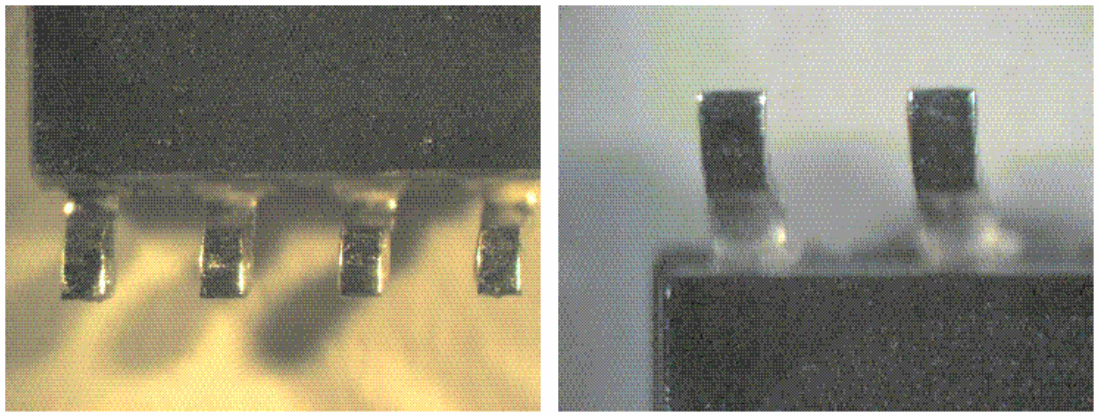
Both tests are well known, and applied, worldwide. However, different methods are often used (such as MIL standard 883-2003, JEDEC J-STD-002, JESD22-B102 and IEC 60749-21). The ones chosen by ST are intended to cover the ones that are in most widespread use by our customers.

In these tests, the packages are “aged”, in order to test the solderability under the worst conditions and to warrant at least 2 years of storage with no significant degradation of solderability.

DIP AND LOOK TEST

After appropriate ageing, the connections are dipped inside a non-activated flux, then into molten solder. Then, after cooling and optional cleaning in alcohol, the connections are inspected to verify the critical area (the one that is to be soldered to the board) of the connection surfaces is covered by fresh solder (Figure 1.). The test is considered passed if 95% of the surface is covered with fresh solder.

Figure 1. Terminals after Dip and Look Test



The mechanism for forming the solder joint depends on the coating and solder compositions as well as on the test conditions (as listed in Table 2.).

Table 2. Test Conditions

<table>
<tr><td rowspan="11">Surface Mount Devices</td><td colspan="3">– 8 hours steam ageing or ageing in humidity chamber at 85°C and 85%rH (Humidity chamber used for pre-plated components)
– Dry ageing at 150°C: 8 hours for NiPdAu Pre-plated units and 16 hours for solder coated units (Ageing is non cumulative = to be done on different samples)</td></tr>
<tr><td rowspan="4">Lead-free Solder</td><td colspan="2">Sn-Ag-Cu melted at 245°C</td></tr>
<tr><td>Flux dipping</td><td>5 to 10 seconds</td></tr>
<tr><td rowspan="2">Solder dipping</td><td>5 seconds ±0.5s for Tin based connection coatings</td></tr>
<tr><td>10 seconds ±0.5 s for Pre-plated NiPd(Au) connections</td></tr>
<tr><td rowspan="4">Leaded Solder</td><td colspan="2">Sn-Pb melted at 220°C</td></tr>
<tr><td>Flux dipping</td><td>5 to 10 seconds</td></tr>
<tr><td rowspan="2">Solder dipping</td><td>5 seconds ±0.5s for Tin based connection coatings</td></tr>
<tr><td>10 seconds ±0.5s for Pre-plated NiPd(Au) connections</td></tr>
<tr><td rowspan="3">Solder Wave Resistance to Dissolution</td><td colspan="2">Device that can be soldered by wave soldering Sn-Pb or Sn-Ag-Cu melted at 260°C</td></tr>
<tr><td>Flux dipping</td><td>5 to 10 seconds</td></tr>
<tr><td>Solder dipping</td><td>10 seconds ±0.5s</td></tr>
<tr><td rowspan="7">Insertion Packages or Through Hole Devices</td><td colspan="3">8 hours steam ageing or ageing in humidity chamber at 85°C and 85%rH</td></tr>
<tr><td rowspan="3">Lead-free Solder</td><td colspan="2">Sn-Ag-Cu melted at 245°C</td></tr>
<tr><td>Flux dipping</td><td>5 to 10 seconds</td></tr>
<tr><td>Solder dipping</td><td>5 seconds ±1s</td></tr>
<tr><td rowspan="3">Leaded Solder</td><td colspan="2">Sn-Pb melted at 245°C</td></tr>
<tr><td>Flux dipping</td><td>5 to 10 seconds</td></tr>
<tr><td>Solder dipping</td><td>5 seconds ±1s</td></tr>
</table>

Note: Non activated flux to be 25% by weight of colophany diluted in isopropanol as per IPC J-STD004.

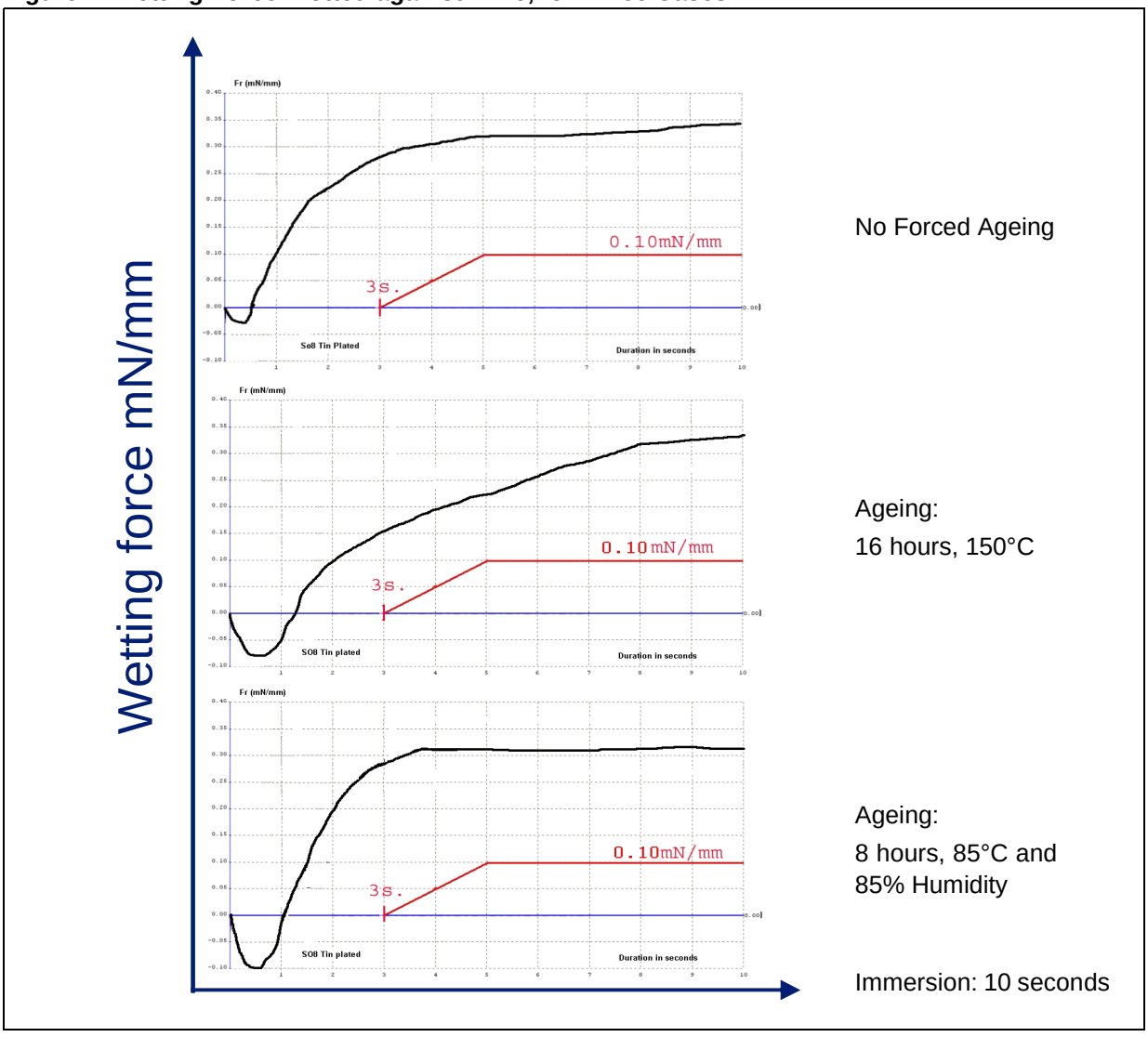
WETTING BALANCE TEST

Connections are dipped inside a non-activated flux. Then the package is loaded on the wetting balance arm, and the connections are dipped into a molten solder. The force exerted on the balance arm is plotted as a function of time.

This test cannot be applied for all the packages. It can, though, be adjusted to fit special cases.

Typical forces versus time curves are shown in Figure 2.

Figure 2. Wetting Force Plotted against Time, for Three Cases



The shape of the curves can be explained as follows:

– At the beginning, the buoyancy forces (due to the interfacial tension) are predominant, and so the wetting force is negative.

– Gradually, the solder begins to wet the terminals, and the wetting force increases with time, overcoming the buoyancy force.

– Eventually, it reaches a flat (plateau) zone.

When the measured wetting force is zero, the two forces are balanced. This point is called the “zero cross time” (t_0), and indicates the transition from no-wetting (overall force less than zero) to wetting (overall force greater than zero).

Note: No aging is applied, before the wetting balance test, during process control of production. Aging is applied for data collection purpose only.

Criteria: the test is considered as passed if:

– The wetting force reaches 0.1mN/mm within 5 seconds of immersion
– The zero cross time (t0) is less than 3 seconds.

Note: these criteria are applied for small-signal devices. Power devices can require different criteria to take into account the thermal mass of their connections.

Table 3. Tests Conditions

Solder		
Sn-Ag-Cu melted at 245°C (±5°C)	Flux dipping	5 to 10 seconds
	Solder dipping	10 seconds
Sn-Pb melted at 235°C (±5°C)	Flux dipping	5 to 10 seconds
	Solder dipping	10 seconds

Note:

– The wetting force, as measured by the balance, is divided by the total perimeter of the connections at initial immersion.
– In the case of leads that are connected to a thermal mass, such as to a dissipater, the test must be redefined to include preheating.

CONCLUSIONS

Through two standard tests (“Dip and Look” and “Wetting Balance”), ST Lead-free devices are warranted to pass solderability tests using Sn-Pb solder or Sn-Ag-Cu solder, and so to meet all the requirements for electronics soldering. In fact the solderability tests provide customers with an additional warranty that the components can be soldered without affecting the common reliability performance.

REVISION HISTORY

Table 4. Document Revision History

Date	Version	Revision Details
08-Nov-2004	1.0	First Issue