Application Report
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MSL Ratings and Reflow Profiles

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ABSTRACT

This application reports explains the relationship of MSL rating to the customer production floor life and surface mount reflow temperatures for TI semiconductors.

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Trademarks

1 Introduction

All TI surface mount ICs have a moisture sensitivity level and peak reflow classification. This information is displayed on http://www.ti.com (see Figure 1) and on the reel and box packing. Figure 2 shows examples of a box label.

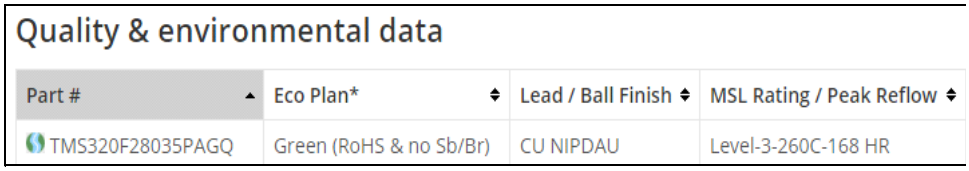

Figure 1. Example of Component MSL Rating, Peak Reflow, and Maximum Floor Life at ti.com

Figure 2. MSL 1,2,3 Rating and Peak Reflow Labeling Examples on Cardboard Box

2 Applying the Moisture Sensitivity Level (MSL)

The MSL rating of an IC determines its floor life before board mounting after the drypack packing (MSL2 and higher number ratings) has been opened. Each drypack bag includes a desiccant and a humidity control card, which should be checked immediately after opening the drypack bag for current IC package status.

IPC/JEDEC J-STD-033 is the electronics industry standard for handling, packing, shipping and use of Moisture, Reflow and Process sensitive devices. This standard includes a factory floor life table at 30°C dependant on the component MSL rating, as shown in Table 1.

Table 1. Factory Floor Life @ 30°C

MSL	Floor Life	Moisture Relative Humidity
1	Unlimited	85% RH
2	1 year	60% RH
2a	4 weeks	
3	168 hours	
4	72 hours	
5	48 hours	
5a	24 hours	
6	Bake before use and reflow within time on label	

Most semiconductor products are rated MSL3 or higher. MSL 1 is the highest rating where it is considered as being not moisture sensitive even at 85% RH and components rated MSL1 do not require dry packing.

The MSL rating is given after product qualification and determined by the materials used in its IC packaging and assembly process is based on a constant 30°C and constant relative humidity. In practice, the absorption of moisture into an IC package is proportional to temperature and relative humidity.

Therefore, floor life can generally be increased with exposure to temperatures lower than 30°C or lower humidity levels than 60% RH.

Similarly, exposing it to higher humidity conditions or higher temperatures potentially shortens the floor life.

The *Recommended Equivalent Total Floor Life* table in IPC/JEDEC J-STD-033C provides guidance on floor life for differing temperatures (20°C to 35°C) and a range of relative humidity (5% to 95%) for different package types and thicknesses.

Products that exceed their floor life can be re-worked with a bake to drive out residual moisture. The *Reference Conditions for Drying Mounted or Unmounted SMD Packages* table in IPC/JEDEC J-STD-033C provides guidance about the baking procedure and where you should take care to ensure that the plastic housing (trays, tape and reel or tubes) can withstand the temperatures being considered. Tape and Reel material should not be baked above 40°C due to risk of the packing material properties changes. A vacuum bake may be considered for IC packages without internal cavities.

For IC products with MSL Rating 2 and lower, the floor life needs to also be considered after a first reflow soldering process. Moisture from the environment where the boards are stored will ingress into the package. A bake of the assembled board may be required prior additional soldering process steps, Rework steps and other process steps with temperatures above the local water boiling point.

3 MSL Classification Peak Reflow Temperature

New non hermetic surface mount devices are classified for Moisture and Reflow temperature sensitivity according the IPC/JEDEC J-STD-020 standard revision at that time. The Peak reflow temperature is specified in dependence of package thickness and the package plastic volume. The *Pb-Free Process – Classification Temperatures (Tc)* table in the IPC/JEDEC J-STD-020 standard lists the temperatures for leadfree process, which are shown in Table 2.

Table 2. Peak Reflow Classification (Tc) Based on Package Dimensions

Package Thickness	Volume < 350 mm3	Volume 350 – 2000 mm3	Volume >2000 mm3
< 1.6 mm	260°C	260°C	260°C
1.6 mm – 2.5 mm	260°C	250°C	245°C
>2.5mm	250°C	245°C	245°C

4 MSL Classification Reflow Profile for Lead-Free Soldering

The *Classification Profile (Not to scale)* table in the IPC/JEDEC-020 shows the classification reflow profile to be used for the device MSL classification/certification by the component manufacturer with the maximum reflow temperature T_p.

Table 2 lists temperatures is the T_c (Classification temperature). For the new product classification, the T_p is higher than the T_c.

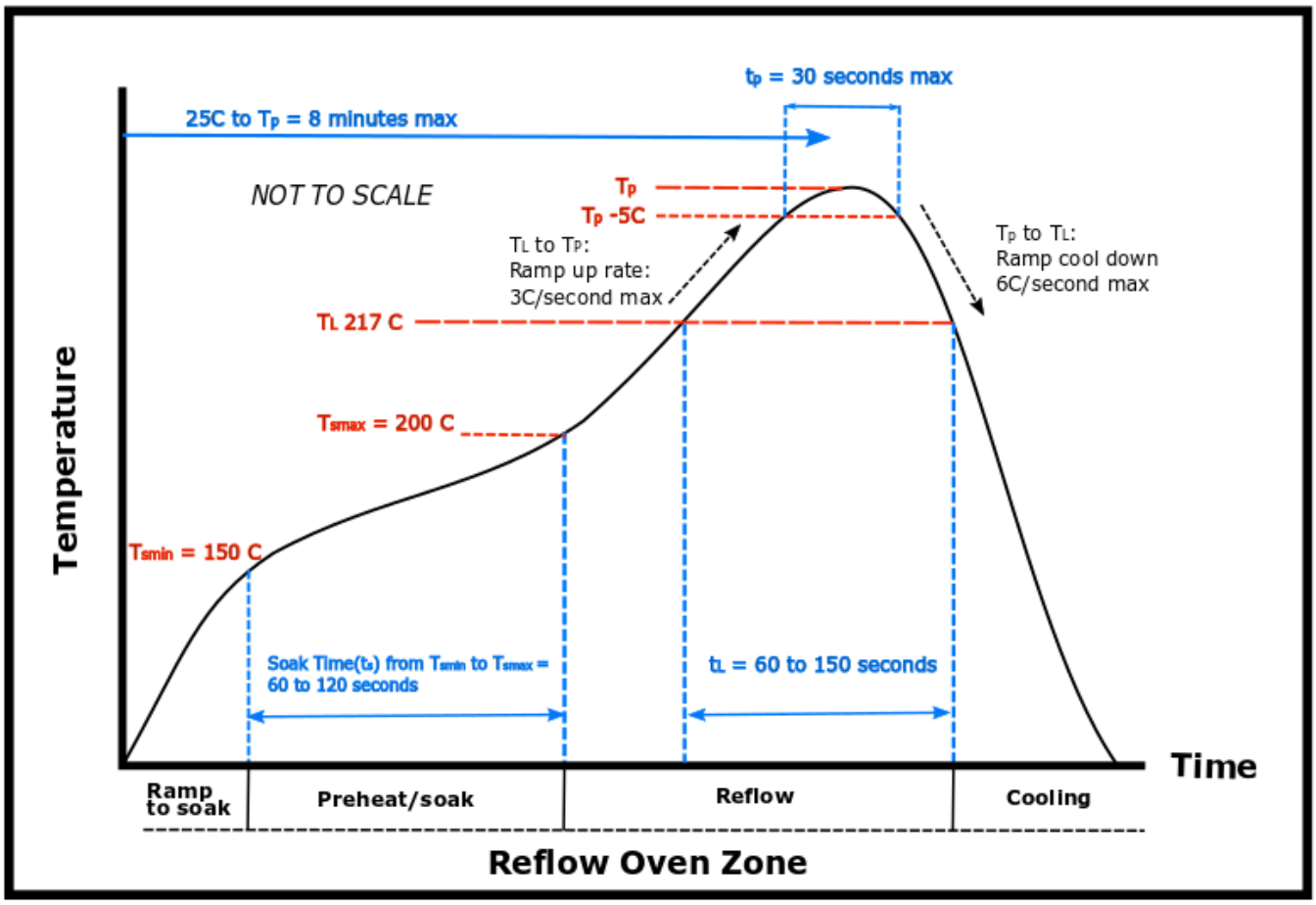

Figure 3. TI Representation of the J-STD-020 Classification Profile (not to scale)

Figure 3 illustrates the key temperature/times associated with the different Reflow oven zones. Important items defined in J-STD-020 that can impact IC reliability are:

- Soak time t_s
- Soak temperatures: min(T_{smin}) and max (T_{smax})

During the Preheat/Soak, the board and components are reaching a temperature where the flux in the solder paste is starting its activity and cleaning process of all surfaces involved into the later solder joint begins.

- Liquidous temperature (TL) for lead-free soldering - this is approximately 217°C. This varies according to the used solder alloy.
- The Peak temperature (Tp) for the reflow profile, measured at top of the package.
  - For the user (board assembly process), T_p must not exceed T_c as shown in Table 2. For the IC suppier, the Tp is ≥ Tc.
  - Time that defines the peak temperate (tp) starts/ends -5°C below T_p.
- Ramp up rate from T_L to T_P (must not exceed 3°C/second)
- Time from 25°C (room temperature) to peak temperature should not exceed 8 minutes.

- Cool down rate from TP to TL (must not exceed -6°C/second)

5 Customer Board Assembly Reflow Profile for Lead Free Soldering

As an initial starting point, the reflow profile shown in Figure 3 can be used with a typical range for the customer peak reflow temperature (T_p) of 235°C - 250°C.

For the customer production reflow soldering process, the peak reflow temperature (Tp) has to be lower than the classification reflow temperature (T_p) shown in Table 2 and Figure 3. The reflow profile and peak temperature should be in line with the solder paste manufacturerer recommendation and all used component ratings on the customer application board.

The package temperature is measured on the package top side in the package middle with a thin thermocouple glued to the package using a SMT glue that can withstand the maximum reflow temperature.

The time from 25°C to the peak temperature is sensitive for the Flux. The Flux needs to still be active when the peak temperature is reached and the solderjoint is completing. Details for the maximum process time and temperature steps should be considered from the solder paste data sheet or discussed with the solder paste supplier for optimum process conditions.

The IC packages are classified according to J-STD-020 and withstand three reflow cycles.

6 Wave Soldering

This application report primarily addresses the reflow soldering technique that can handle the finer pitch devices. Wave soldering is an older technology that is frequently used for soldering through-hole components or the larger pitch packages, such as SOT and SOIC packages, when they had been qualified for wave soldering. Wave soldering on other SMT packages is not recommended.

7 References

- **IPC/JEDEC J-STD-033C**: Joint IPC/JEDEC standard for handling, packing, shipping, and use of moisture, reflow and process sensitive devices
- **J-STD-020D.1**: Joint IPC/JEDEC standard for moisture and reflow sensitivity classification for nonhermetic solid state surface-mount devices

Both documents are available on JEDEC.ORG

Revision History

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

Changes from Original (February 2015) to A Revision	Page
• Updates were made in Section 2.	2
• Updates were made in Section 3.	3
• Updates were made in Section 4.	4
• Added new Section 5.	5
• Added new Section 6.	5

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