

LED Mounting Techniques

Light Emitting Diode

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LED Mounting Techniques

1. Introduction

When assembling LED-installed lighting fixtures, the mounting techniques are the critical considerations as well as the LED characteristics. However good the LEDs' characteristics may be, improper mounting method/conditions might significantly affect their characteristics, sometimes resulting in catastrophic failure.

This document expounds considerations in the LED mounting techniques by providing the precautions in each stage: "Solder Paste Printing," "LED Placement," and "Reflow Soldering."

2. Solder Paste Printing

This section expounds considerations in the solder paste printing. Solder paste is applied to the land on the printed circuit board.

The PCB design and the solder mask design determine the LED performance after the reflow soldering; therefore, customers should determine the optimal designs for the solder pad and the solder mask during this stage.

2-1. Design of Solder Pad and Stencil

Nichia demonstrates the solder paste printing for each model and determines the designs of the solder pad and the stencil to recommend to customers. The designs are described in the "SOLDERING," in our specifications. For reference, the following figures show the recommended designs for the solder pad and the stencil for NFSW757D.

- Recommended Soldering Pad Pattern

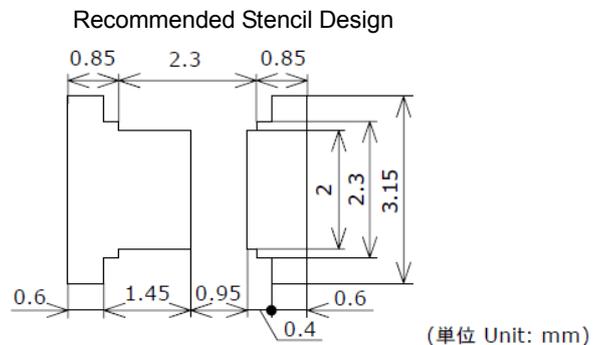
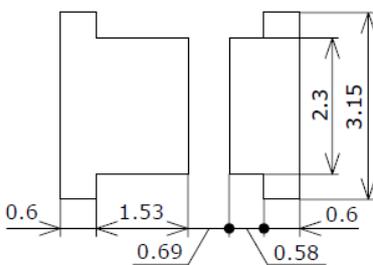


Figure 1

Recommended Designs of Soldering Pad and Stencil (NFSW757D)

2-2. Arrangement of Stencil Apertures

In case customers cannot perform the solder paste print in accordance with our recommendation, depending on their mounting techniques, they should arrange the stencil apertures to ensure that the solder paste can be appropriately applied to the solder pad (cf. Figures 2 and 3: Page 3). The following example shows the modified stencil aperture design to prevent the parts from lifting.

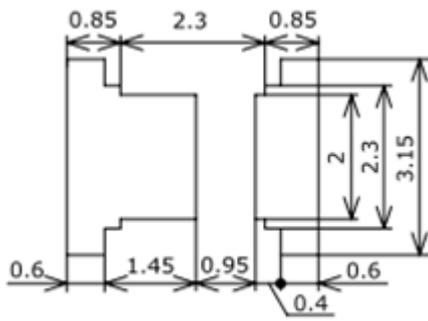


Figure 2
Recommended Stencil Design

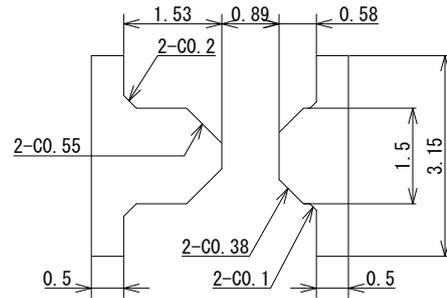
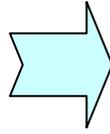


Figure 3
Modified Stencil Aperture Design
(As Countermeasure against Parts Lifting)

2-3. Application of Solder Paste

Solder paste printing requires the accurate position/amount/shape of solder paste. Customers should appropriately prepare solder paste and set the printing conditions.

Solder Paste

Solder paste removed from the refrigerator must be stirred before use. While stored in the refrigerator, the solder particles are isolated from the flux; therefore, the solder paste cannot be homogeneously applied to PCBs without being stirred. Care should be taken not to stir the solder paste for too long a time; otherwise, the flux will deteriorate. Also, be sure to remove the solder paste from the container after exposing it to room temperature to avoid condensation and moisture absorption.

Squeegee and Printing Conditions

There are various kinds of squeegees; metallic, plastic, urethane, etc. Metallic squeegees are hard and are easy to homogeneously smear the paste with; however, they are easily damaged, resulting in a short lifetime. On the contrary, urethane squeegees last longer because of their soft property; however, they tend to fold/bend above larger apertures, resulting in insufficient amount of solder there. Plastic squeegees have the intermediate features. Customers should select the squeegee depending on their products' application and their needs. The following table shows the typical printing conditions for each type of squeegee. Please note that the printing conditions depend on the printing machines, the length/stiffness of squeegees, etc.

Table 1 Printing Conditions of Each Type of Squeegee

SP60 by Panasonic								
Printing Conditions		Unit	Condition 1	Condition 2	Condition 3	Limit		
Filling	Filling Speed	mm/s	40			25 to 100		
	Material of Squeegee	--	Urethane	Plastic	Metal	Urethane	Plastic	Metal
	Pressure	g/mm	20	30	-	15 to 25	-	20 to 40
	Squeegee Angle	°	60			Fixed		
	Clearance	mm	0 to -0.2mm			0 to -0.5		
Board Releasing	Descending Speed Control	--	Modifiable high speed control			Fixed		
	Descending Speed	mm/s	5			1.5 to 5.0		
	Descending Stroke	mm	3			Fixed		
	Procedure Order after Printing	--	-			Fixed		
Cleaning	To and from motion (#1)	pcs.	15			5 to 10		
	Mode-Vacuum-Speed (One Side)	--	Dry-ON-60mm/s			Fixed		
	Mode-Vacuum-Speed (Reverse)	--	Dry-ON-80mm/s			Fixed		
	To and from motion (#2)	pcs.	-			15 to 30		
	1. Mode-Vacuum-Speed (One Side)	--	-			Fixed		
	1. Mode-Vacuum-Speed (Reverse)	--	-			Fixed		
	2. Mode-Vacuum-Speed (One Side)	--	-			Fixed		
	2. Mode-Vacuum-Speed (Reverse)	--	-			Fixed		
Others	Board Clamping Pressure	MPa	0.3			0.2 to 0.3		
	Temperature Regulator	°C	23			Fixed		

The following are the maintenance procedures of the printing machines.

- 1) Clearance: Set the clearance to ensure that the stencil is completely attached to the board.
- 2) Filling: Set the squeegee speed.
- 3) Board Releasing Speed: Set the descending speed of the board.
- 4) Cleaning: Clean the printing machines on a regular basis so as not to form bridges.



2-4. Inspection after Soldering Printing

To ensure that the position/amount/shape of solder paste are accurate, we recommend that customers should inspect the solder printing performance. For reference, the following table/picture shows the data/image obtained with an image recognition inspection unit for printed solders.

Protrusion	0.0	%	OK	OK-20-30
Faint Solder	109.9	%	OK	50-60-OK
Area	118.7	%	OK	70-71-OK-150-151
Volume	118.9	%	OK	70-71-OK-150-151
Average Height	126.8	μm	OK	84-85-OK-180-181
Location X	20.0	μm	OK	OK-190-200
Location Y	-2.9	μm	OK	OK-190-200
No solder	0.0	%	OK	OK-30-31

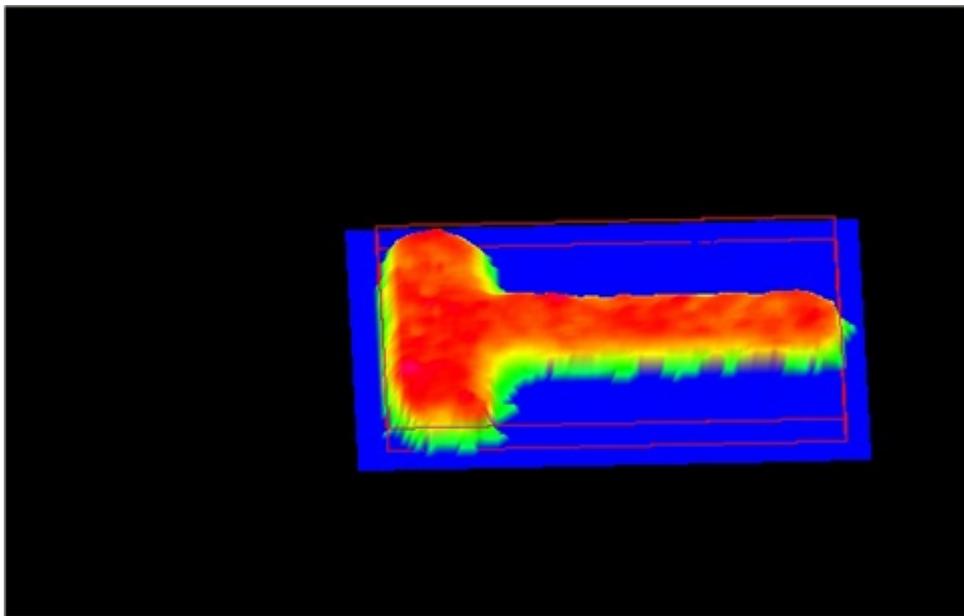


Figure 4

Image obtained with an Image Recognition Inspection Unit

3. LED Placement

This section expounds considerations while LEDs are placed on the circuit patterns after the solder paste printing. The LED placement requires the optimal shape/settings of a pick-and-place nozzle.

3-1. Shape of Pick-and-Place Nozzle

Nichia determines the optimal shape of a pick-and-place nozzle for each model through experiments. We recommend the optimal nozzle shape and size in the specifications as follows (for ref. NVSW119B). Please contact us when there is no description of the recommended nozzle in the specifications.

Recommended Conditions:

Using a nozzle designed for the LEDs is recommended (see Figure below.)

The nozzle must not have any direct contact with the encapsulating resin.

Direct contact with the encapsulating resin may result in internal disconnection causing the LED not to illuminate.

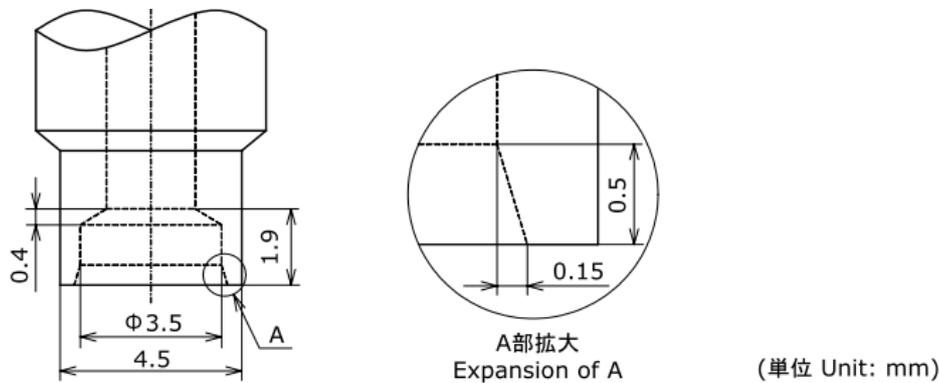


Figure 5

Recommended Nozzle for NVSW119B

3-2. LED Collecting Method

Nichia's LEDs are placed in the optimal cavities of the emboss carrier tape and they need to be collected with an optimal nozzle accordingly. There are two kinds of LED-collecting methods; insertion and hovering. The "insertion" nozzle is inserted into each cavity and vacuums each LED; on the other hand, the "hovering" nozzle vacuums LEDs above each cavity of the emboss carrier tape.

1) Insertion Type

The nozzle is inserted into each cavity and vacuums each LED, enabling stable LED-collection. Care should be taken not to insert the nozzle too deeply into the cavities; otherwise, the nozzle may damage LEDs. The inner surface of the nozzle should be finished by C-chamfering or R-chamfering, enabling each LED to be collected smoothly without being tilted.

2) Hovering Type

Nichia recommends that the hovering nozzle should be used for LEDs with lenses. The nozzle stops above each cavity and vacuums each LED.

If the "insertion" nozzle is used for LEDs with lenses, it may touch and damage the lenses depending on the LEDs' shape and the tolerance size of the LEDs and the nozzle. If you increase the clearance between the nozzle and the lens to avoid damage to the lenses, you will need a nozzle with a larger diameter, preventing the nozzle from being inserted into the cavities.

The “insertion” nozzle may touch the lenses and the pressure is applied to the lenses accordingly; on the other hand, the “hovering” nozzle may only apply vacuuming stress to the lenses. Therefore, LEDs are subject to less stress while collected with a hovering type of nozzle. Moreover, the hovering type of nozzle lasts longer because the inner wall of the nozzle can be thicker.

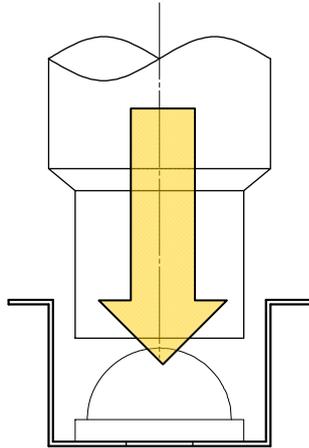


Figure 6
Insertion Type

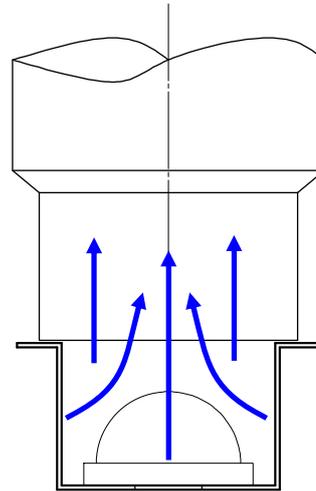


Figure 7
Hovering Type

3-3. Optimization of Vacuuming Power

The vacuuming power should be optimized to prevent collecting failures depending on the LEDs' shape/material; otherwise, LEDs may not be released from the nozzle but continue to be attached to it. The vacuuming power should be, in general, set from -40 to -80 Kpa.

3-4. Feeder

Nichia recommends that electrical feeders should be used. Air feeders generate more vibration while feeding LEDs, resulting in LED-placement failure due to the LEDs' tilt in their cavities.



Figure 8
Electric Feeder

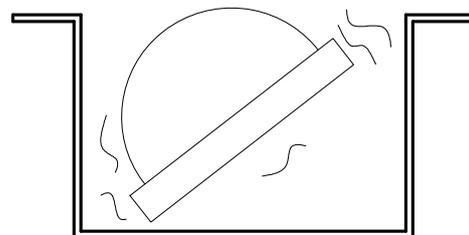


Figure 9
LED Tilt

3-5. Peeling Point of Cover Tape

LEDs may be tilted in their cavities of the emboss carrier tape depending on the LEDs' shape and the LED-placement machine. When the top cover tape is peeled far from the LED-collecting point, the LEDs tend to bounce in the space above them while vibrated, resulting in their major tilt.

Therefore, the top cover tape should be peeled just before the LED-collecting point. LEDs cannot bounce, thereby, preventing the LEDs from being tilted in the cavities.

The directions for cover tape peeling vary depending on the LED models. Please refer to the specifications of each model before use.

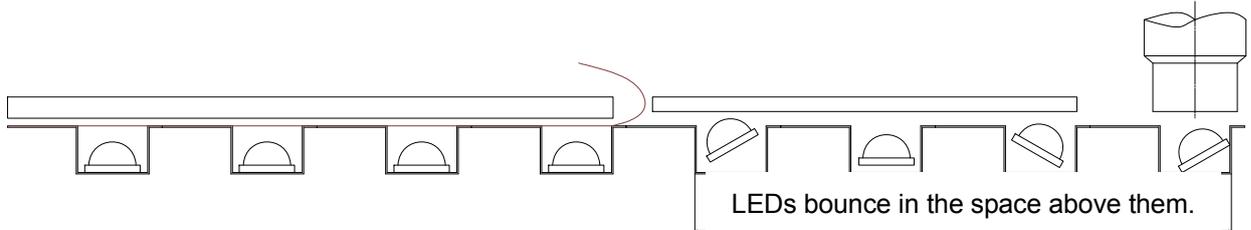


Figure 10

Incorrect Peeling Position of Cover Tape

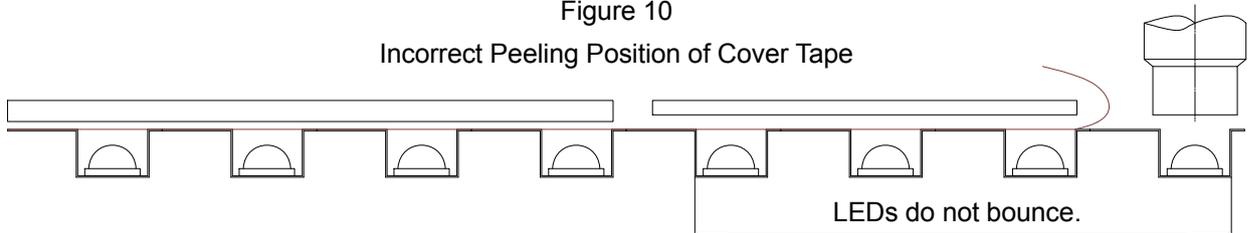


Figure 11

Correct Peeling Position of Cover Tape

3-6. Feeding Speed

The LED-feeding speed needs to be optimized depending on the LED shape. Simple square LEDs can be picked up at high speed; on the other hand, LEDs with lenses cannot be picked up at high speed.

The center of gravity of LEDs with lenses is located higher. Moreover, the lenses tend to adhere to the top cover tape. When LEDs with lenses are fed and picked up at high speed, they may be tilted in their cavities or adhere to the cover tape and fall out of their cavities.

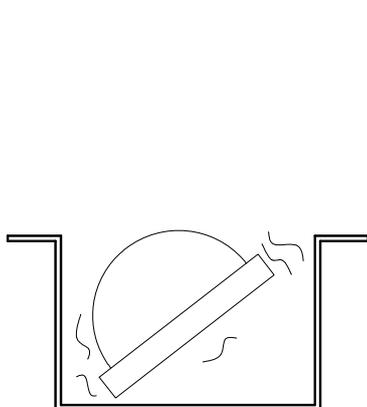


Figure 12
Tilted LED

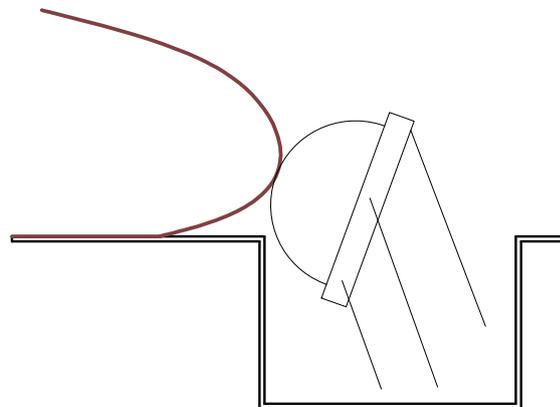


Figure 13
LED falling out of its cavity

3-7. Mounting Pressure

Customers should take care when placing LEDs on the board in the mounting pressure. Insufficient pressure will lead to the lifting of LEDs or misalignment; on the other hand, too much pressure will result in solder ball formation. The amount of stress applied to LEDs is determined by the mounting pressure and the LED-feeding speed. As the amount of stress applied to LEDs is increased, their packages are susceptible to damage accordingly. Please set the mounting pressure within approx. 3 N, in general, to prevent LED packages from being damaged.

Please avoid any stress from being applied to the lenses with the nozzle. It is highly likely that LED lenses are damaged by 3 N stress.

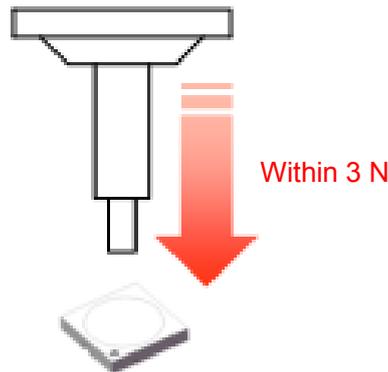


Figure 14
Mounting Pressure

4. Reflow Soldering

This section expounds considerations while LEDs are reflow-soldered. During this process, solder paste on the board melts and solder joints are formed between the LEDs and the boards in the reflow oven. The reflow ovens are separated into some areas and a specific temperature is set for each area. A good solder joint can be achieved by the temperature profile in each area.

4-1. Reflow Soldering Conditions

Nichia determines the recommended soldering conditions for each model through experiments. Please refer to the recommended conditions in the specifications (for ref. NFSW757D).

SOLDERING

- Recommended Reflow Soldering Condition(Lead-free Solder)

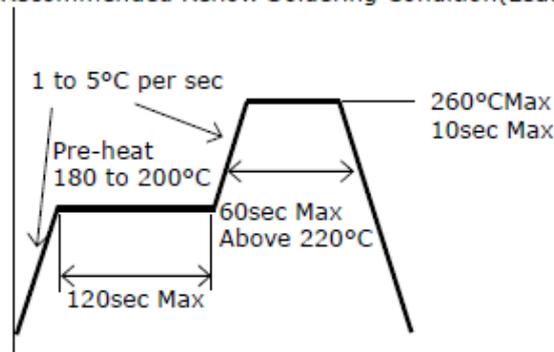


Figure 15

Recommended Reflow Soldering Conditions

4-2. Reflow Profile

The temperature profile essentially consists of the three phases: preheat, reflow, and cooling down.

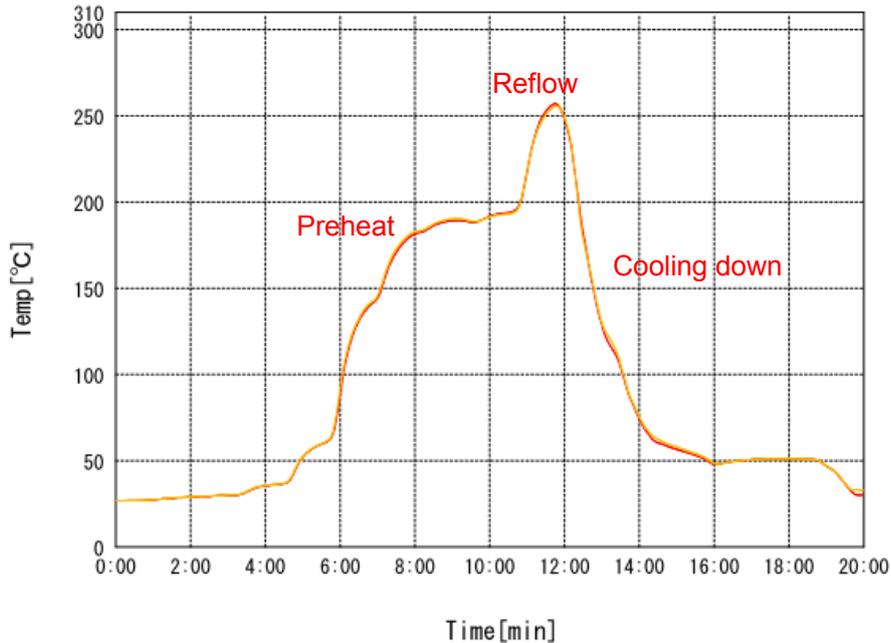
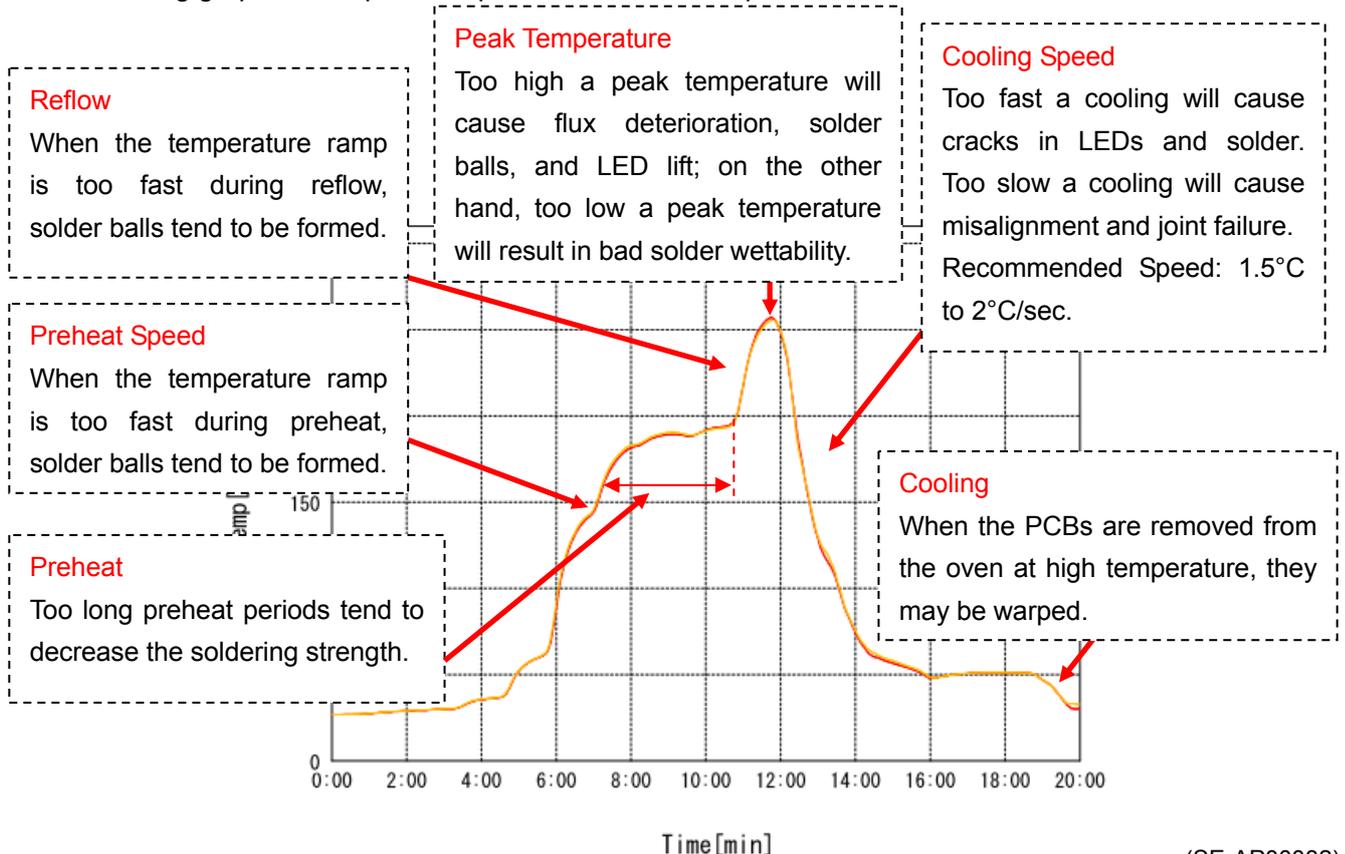


Figure 16 Reflow Profile

- Preheat: Flux contained in solder is activated and dissolves any oxide film on the board.
- Reflow: Solder is melted by heat to form the alloy.
- Cooling down: The solder joints are completed as the board is cooled down.

4-3. Temperature Zone

The following graph shows potential problems in each temperature zone.



4-4. Air Reflow and Nitrogen Reflow

Nichia recommends nitrogen reflow as follows in the specifications:

Nitrogen reflow soldering is recommended. Air reflow soldering conditions can cause optical degradation under the influence of heat and atmosphere.

Benefits of Nitrogen Reflow

The optical degradation during the reflow soldering is caused by discoloration of packaging resin. Packaging resin is susceptible to discoloration because of its property change and its oxidation under the influence of the heat during the reflow soldering. Nitrogen reflow can prevent packaging resin from discoloring resulting from oxidation; it can also prevent luminous flux decrease.

Moreover, nitrogen reflow can prevent solder paste from oxidation, contributing to the improvement of solder wettability.

Nitrogen Concentration

The nitrogen concentration needs to be increased approximately to 1,000ppm.

Comparison of Luminous Flux Decrease between Air Reflow and Nitrogen Reflow

Please refer to the following data to compare the luminous flux decrease in NS3W183 between the air reflow and the nitrogen reflow, for reference.

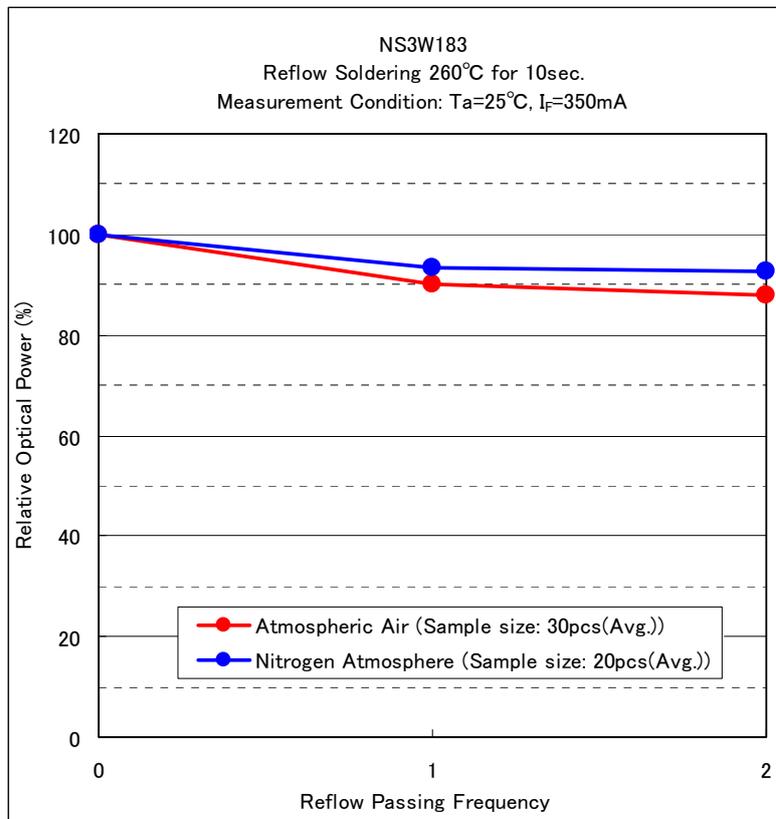


Figure 17 Luminous Flux Decrease Depending on Reflow Method

Air Reflow or Nitrogen Reflow

In some of the LED models, the luminous flux does not decrease even under the influence of air reflow soldering; for example, the luminous flux decreases only by approx. 1% in the ceramic-package LEDs after the air reflow soldering. Some of the resin-package LED models are not subject to the reflow soldering process. In those models, the nitrogen reflow is not so efficient in decreasing the luminous flux loss. Therefore, please evaluate the luminous flux decrease in LEDs by conducting air reflow soldering.

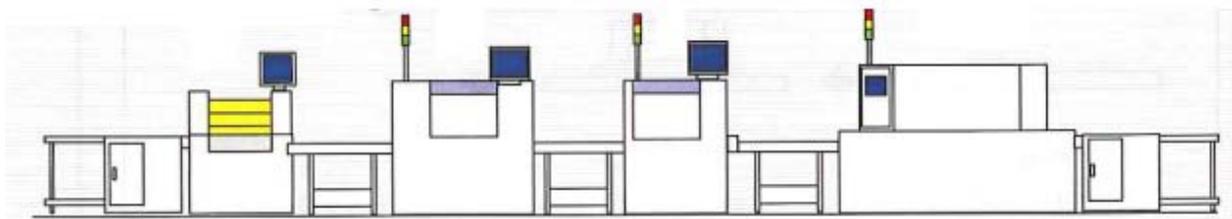
5. Verification of LED Mounting Performance

The LED mounting performance should be verified as follows before mass production:

5-1. Checking Item for LED Mounting Performance

	Checking Item	Suspected Cause of Failure
1	No crack/damage?	Too much mounting pressure
2	No emission failure?	Open circuit due to insufficient amount of solder. Short circuit due to too much amount of solder.
3	No solder balls?	Solder balls can be generated due to too much amount of solder.
4	Good solder fillet?	Insufficient amount of solder or inappropriate land shape
5	No solder bridges?	Solder bridges can be generated due to too much amount of solder.
6	No void or shrinkage?	Insufficient stir of solder paste
7	Any tilt (x,v)?	Inappropriate mounting pressure or inappropriate land shape
8	Any lift (z)?	Inappropriate mounting pressure or inappropriate land shape
9	Sufficient resistance to shearing stress?	Insufficient stir of solder paste, insufficient amount of solder, or inappropriate land shape
10	Upright tilt?	Insufficient amount of solder or inappropriate land shape

A good mounting might not be achieved even if you mount LEDs in accordance with Nichia's recommendation. The LED mounting performance varies depending on the settings of the mounting machines and the variety among the lots of solder/boards/some other parts placed on the board. Therefore, please accumulate data by fine-tuning the settings to achieve better mounting.



6. Others

This section expounds considerations in the tools or the handling of LEDs during the LED assembly processes.

6-1. Transferring Board

The circuit boards are placed on transferring boards and conveyed in a mounting machine. When the transferring boards are warped, it may result in LED mounting failure. Even when the transferring boards are not warped, they may be warped during a few dozen times of reflow soldering at the initial manufacturing stage. Therefore, we recommend examining whether the transferring boards are not warped by loading them into the reflow machines a few dozen times in advance. For reference, bakelite, glass epoxy, etc. are used for the transferring boards.

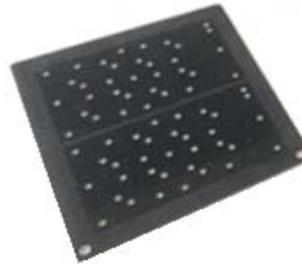


Figure 18 . Transferring Board

6-2. Handling Precautions for LED-Mounted Boards

Typical defects are wire breakage and cracks in LED packages resulting from stress applied to the LEDs. Special care should be taken while the LED-mounted boards are handled.

The following are the typical failures:

- Stress is applied to LEDs when bending or twisting stress is applied to the LED-mounted boards during the board separation process.
- Stress is applied to LEDs because the LED-mounted boards are stacked onto each other.

6-3. Lighting Inspection for LED-Mounted Boards

LEDs often turn defective from excessive current input after being mounted on the board. The excessive current is often applied to LEDs during the lighting inspections after the LED-mounting process or the assembly process.

The following are the typical factors:

- When the power supply is turned on during the lighting inspection, an excessive current is suddenly flowed into the LED.
- While the power supply is turned on, the probes touch the circuit, resulting in an excessive current flowing into the LED.
- The protection device short-circuits because of the reverse connection during the lighting inspection.

7. Request

This document does not cover all the mounting techniques. The precautions vary depending on the products and machines. We would like to collect more data concerning the mounting techniques to feed it back to our valued customers. Therefore, kindly let us know if you have any other concerns about specific mounting techniques.