

Special Topics

Guidelines for the Assembly of Micronas Packages

Guidelines for the Assembly of Micronas Packages

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– HAL

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1. Introduction

Release Note: **Revision bars indicate significant changes to the previous edition.**

The Hall-effect sensor is a monolithic integrated circuit that switches in response to magnetic fields. If a magnetic field with flux lines perpendicular to the sensitive area is applied to the sensor, the biased Hall plate forces a Hall voltage proportional to this field. The Hall voltage is compared with the actual threshold level in the comparator. The temperature-dependent bias increases the supply voltage of the Hall plates and adjusts the switching points to the decreasing induction of magnets at higher temperatures. If the magnetic field exceeds the threshold levels, the open drain output switches to the appropriate state. The built-in hysteresis eliminates oscillation and provides switching behavior of output without bouncing.

Magnetic offset caused by mechanical stress is compensated for by using the “switching offset compensation technique”. Therefore, an internal oscillator provides a two phase clock. The Hall voltage is sampled at the end of the first phase. At the end of the second phase, both sampled and actual Hall voltages are averaged and compared with the actual switching point. Subsequently, the open drain output switches to the appropriate state. The time from crossing the magnetic switching level to switching of output can vary between zero and $1/f_{osc}$.

All Hall-effect sensors are equipped with an active offset compensation which minimizes the influence of mechanical stress on the magnetic characteristics. Although the magnetic characteristics are robust against external stress effects, it is important to take precautions to minimize stress from thermal or mechanical sources caused by lead forming, lead soldering and welding or overmolding during the attachment of Hall-effect sensor packages to subassemblies.

Avoiding stress during assembly will not only improve the electrical performance of the device, but will also reduce the possibility of long-term reliability problems. These guidelines provide information to minimize package stress which could compromise both the performance and reliability of Hall-effect sensor (HAL) products.

1.1. Package Stress Resulting from Assembly

Plastic package cracking is the occurrence of fractures anywhere in or on a plastic package. Over the years a vast range of mechanisms that lead to package cracking have been characterized. Mechanisms vary from one package type to another, and some may even be unique to certain package groups.

Most of the known mechanically-induced package cracks come from assembly, and specifically, lead forming operations. Worn-out forming blades and punches can result in large deflections of the leads and tie bar during processing, creating excessive stresses at the lead-to-plastic interface. Cracks occur if these stresses exceed the molding compound's fracture strength. Single-stage lead forming also creates excessive stresses at the lead-to-plastic interface.

Despite the robust design and the use of advanced materials it is hence still important to avoid any situations or conditions where the Hall sensor will be subject to forces from compression, tension, torsion, and shearing onto the package, as well as on the leads. Otherwise, this may be directly or latent hazardous to the functionality, the proper operation culminating in reliability issues.

Lead frames are prone to lead pulling, which is usually preceded by cracking at the lead-to-plastic interface. Debris underneath the package during lead forming operations can produce large bending stresses on the package, which lead to cracks if they exceed the plastic's fracture strength. Inadequate package nesting during lead forming operations can also result in similar package cracks.

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Assembly of the HAL package into a subassembly will inevitably result in a shift in the magnetic properties of the Hall-effect sensor. Micronas recommends thorough testing of a large sample size of the finished product to verify that the products meets all performance and reliability goals.

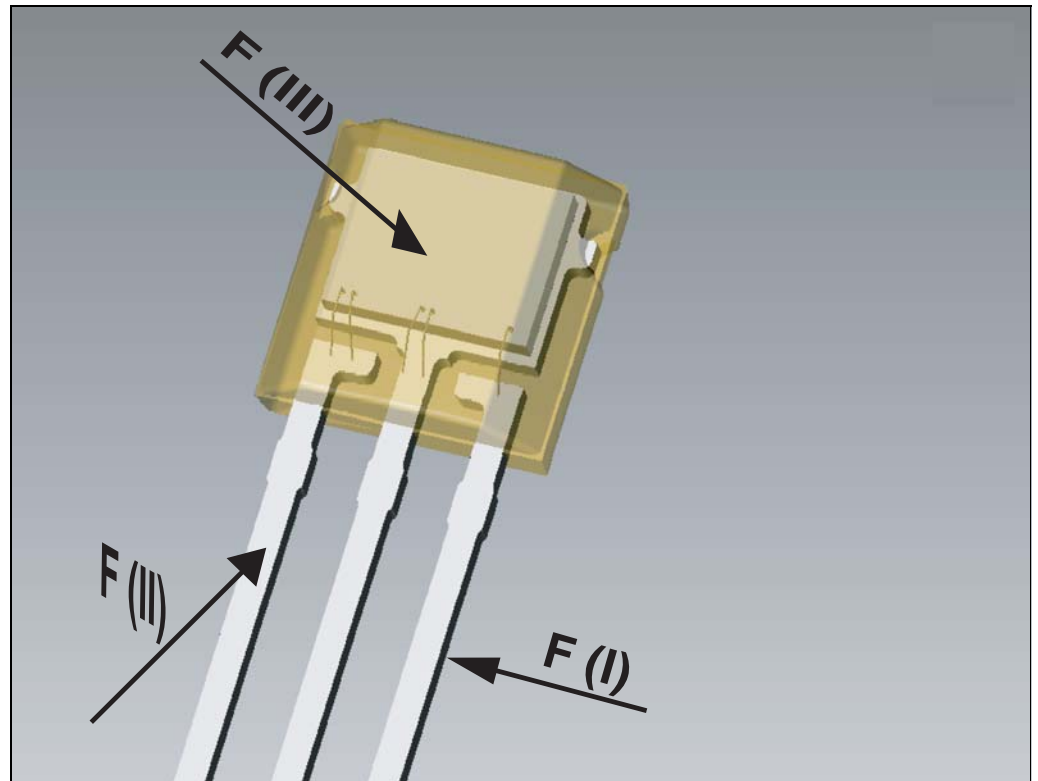


Fig. 1-1: Stress sensitive locations.

- (I) Force or bending applied to leads can damage wedge bonds and cause package cracking.
- (II) Force over wires can cause damage to wedge or ball bonds.
- (III) Force over die face can cause die cracking and parameter shift

1.2. Lead Forming

Lead forming procedures are often carried out at customer facilities as preparation of the package for subsequent assembly steps. The long package leads are imbedded in the package body to a depth of approximately 1 mm. Therefore any stress applied to the leads during lead forming operations induces a proportionally high stress in the package body which can lead to internal damage of the electrical connections or HAL device.

Micronas offers several preformed lead configurations. Consult with Micronas for the availability of preformed leads which conform to your requirements as an alternative to performing the lead forming operations.

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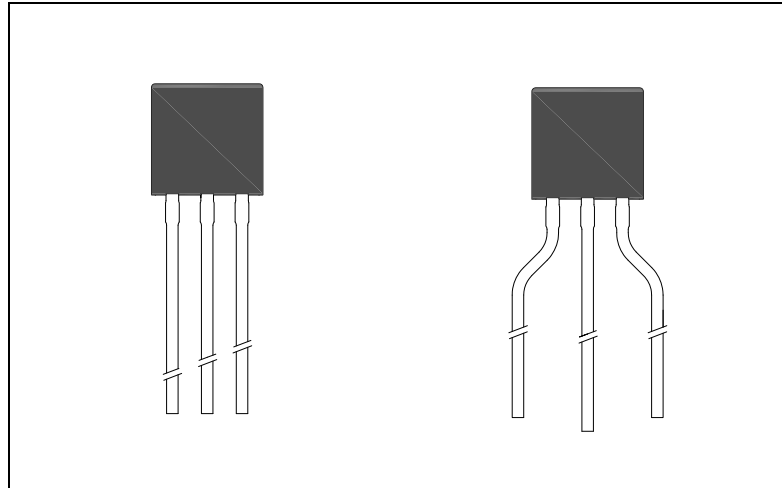


Fig. 1-2: Preformed lead configurations

The following precautions will ensure that lead forming procedures do not induce damage to the HAL device, package body or leads:

- Leads must not be formed or cut closer than 1.2 mm to the package body.
- The bend radius resulting from the lead forming operation should not extend closer than 1.2 mm to the package body.
- Leads must be adequately supported from above and below, so that the stress of the forming operation does not induce any stress in the package body.
- Any axial pulling force on the package pins is unacceptable during the lead forming operation.
- The package body must be mechanically isolated from the lead forming operation.
- Lead forming must be performed over a round anvil with a radius of at least 1 mm or 0.7 mm, according to the bending direction.

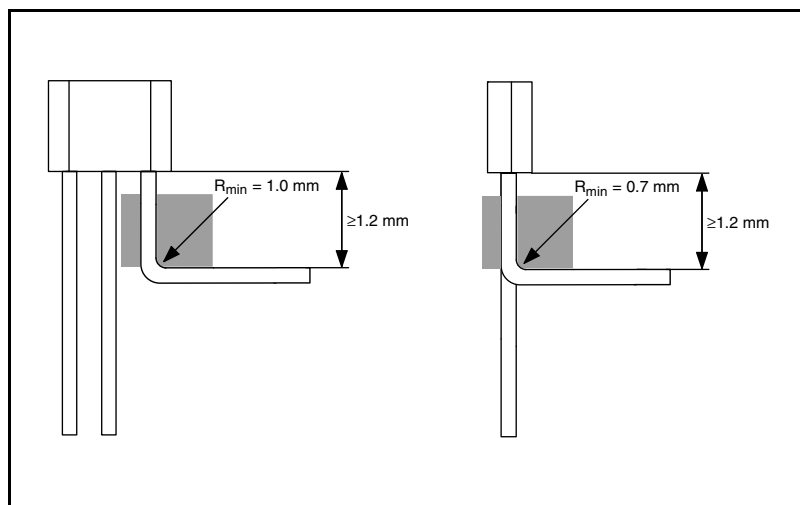


Fig. 1-3: Lead forming

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- During the bending operation, the leads should not be excessively clamped between the anvil and pusher, preferably a roller forming tool should be used.
- The clamping force should not be high enough to change the shape of the leads.
- Incidental marks on the leads caused by lead forming operations are acceptable if the penetration of the marks do not expose the leadframe base metal.
- Any marks in the leads made by clamping should have the same shape and depth on all of the leads, which is an indication of uniform clamping.

1.3. Lead Plating

All HAL packages have 100% matte tin plating (lead-free). This finish guarantees a robust solder joint when typical solder reflow profiles are used. Besides having the lowest possible environmental impact, matte tin plating is backwards compatible with tin-lead (SnPb) solders of all compositions. It can normally be processed at the same temperature used for typical SnPb solder alloys allowing the soldering of Micronas packages using an existing process, including processes which have a peak temperature below the melting point of tin (232 °C). To get reliable solder joints, it is recommended to exceed the pure tin melting of 232°C during the solder process. For lead-free solder alloys, it is recommended to exceed a temperature of 240 °C during the solder process.

Micronas lead plating has a typical thickness of 11.5 µm which is compatible with all soldering and welding processes and ensures excellent results. Typical industry standard plating thickness is higher which can lead to process problems such as splattering or the formation of solder balls.

The materials and the process used for soldering have become increasingly important due to the narrower process windows imposed by lead-free plating. 100% tin plating will wet slower than SnPb alloys and require longer preheating thereby requiring the use of fluxes which remain active for longer periods of time and maintain their properties at higher temperatures. Typically, fluxes with a higher activation level are necessary in lead-free soldering processes.

1.4. Failure Analysis

For failure analysis, the devices have to be returned as single device, stripped down from the application module. The sensor has to be free of resin, glue or other moulding material. The terminal length must be more than 2.5 mm for TO92 packages, for SMD devices it has to be the original length.

2. Shelf Life, Storage, and Transportation

2.1. Moisture-sensitive Components (MSL Classification)

For moisture-sensitive packages, it is necessary to control the moisture content of the components. Penetration of moisture into the package molding compound is generally caused by exposure to ambient air. In many cases, moisture absorption leads to moisture concentrations in the component that are high enough to damage the package during the reflow process. Thus it is necessary to dry moisture-sensitive components, seal them in a moisture-resistant bag, and only remove them immediately prior to board assembly to the PCB. The permissible time (from opening the moisture barrier bag until the final soldering process), which a component can remain outside the moisture barrier bag, is a measure of the sensitivity of the component to ambient humidity (Moisture Sensitivity Level, MSL). The most commonly applied standard IPC/JEDEC J-STD-033 defines eight different MSLs (see [Table 2-1](#)).

Please refer to the “Moisture Sensitivity Caution Label” on the packing material, which contains information about the moisture sensitivity level of our products. IPC/JEDEC-J-STD-20 specifies the maximum reflow temperature that shall not be exceeded during board assembly at the customer’s facility.

Table 2-1: Moisture Sensitivity Levels (according to IPC/JEDEC J-STD-033)

Level	Floor Life (out of bag)	
	Time	Conditions
1	Unlimited	30°C / 85% RH
2	1 year	30°C / 60% RH
2a	4 weeks	30°C / 60% RH
3	168 hours	30°C / 60% RH
4	72 hours	30°C / 60% RH
5	48 hours	30°C / 60% RH
5a	24 hours	30°C / 60% RH
6	Mandatory bake before use. After bake, must be reflowed within the time limit specified on the label.	30°C / 60% RH

2.2. Storage and Transportation conditions

Unsuitable conditions during transportation and storage of components can cause problems like poor solderability, delamination, and package cracking effects.

Due to this proper conditions for transportation and storage of components have to be ensured.

The following standards in [Table 2-2](#) should be taken into account:

Table 2-2: IEC standards

Standard	Description
IEC 60721-3-0	Classification of environmental conditions: Part 3: Classification of groups of environmental parameters and their severities; introduction
IEC 60721-3-1	Classification of environmental conditions: Part 3: Classification of groups of environmental parameters and their severities; Section 1: Storage
IEC 60721-3-2	Classification of environmental conditions: Part 3: Classification of groups of environmental parameters and their severities; Section 2: Transportation
IEC 61760-2	Surface mounting technology – Part 2: Transportation and storage conditions of surface mounting devices (SMD) - Application guide
ISO 14644-1	Clean rooms and associated controlled environments – Part 1: Classification of airborne particulates

Table 2-3: General storage conditions – overview

Product	Condition for Storing
Wafer/Die	N2 or MBB (MBB= Moisture Barrier Bag)
Component – moisture sensitive	MBB (JEDEC J-STD-033)
Component – not moisture sensitive	1K2 (IEC 60721-3-1)

2.2.1. Maximum Storage Time

Micronas guarantees 2 years of solderability for the following packages:

SOT89B-1, SOT89B-2, SOT89B-3, TO92UA-1, TO92UA-2, TO92UA-3, TO92UA-4, TO92UA-5, TO92UA-6, TO92UT-1, TO92UT-2, TO92UT-3, TO92UP-1, SOIC8-1 and SOIC8-2

The conditions to be complied with in order to ensure problem-free processing of active and passive components are described in standard IEC 61760-2.

Furthermore the ZVEI-Guideline for Long-Term Storage of Components. Subassemblies and Devices is to be taken into account.

2.2.2. Internet Links to Standards Institutes

[American National Standards Institute \(ANSI\)](#)

[Association Connecting Electronics Industries \(IPC\)](#)

3. Soldering and Welding

3.1. Basic Guidelines

When package leads are soldered or welded at customer facilities, a few basic guidelines must be observed:

- Keep the package leads as long as possible. Long leads isolate the package body from the high temperature necessary to form good solder or weld joints. Long leads are easier to form during final alignment and help isolate the package body from any stress incurred. Long leads allow for any thermal mismatch between package leads and the part to which the package is being welded.
- Stay away from the dambar cut area with soldering or welding. This dimension is about 1.2 mm on the lead starting from the package body and often referred to as “F1” in package drawings. Solderability is not guaranteed in the dambar cut area and closer to the package body.
- Maintain the lowest possible temperature and shortest process time necessary for good solder or weld joints. The temperature at the package body must not exceed 260 °C. The use of a process with a too high a temperature can damage the HAL device. On the other hand, prolonged heating due to a low temperature process can also result in heat damage.
- Minimize latent spring stress in the package leads – Due to lead forming tolerances, a certain degree of additional forming is often necessary during joining operations. If the package leads need to be deformed and then soldered or welded, this spring energy will be stored in the lead and subsequent exposure to elevated temperatures could result in movement of the leads in the package body, which could lead to electrical failures.

3.2. Lead Soldering

HAL packages (SOT89-x, SOIC8-x, TO92Ux-x, SOT23, TSSOP14) are suitable for typical soldering methods. The following guidelines on solder pastes, fluxes, contaminants to avoid and general processing equipment, conditions and parameters will help avoid damaging the package during the soldering process.

For above mentioned packages except the ones listed in [Section 2.2.1](#) solderability is guaranteed for one year from the date code on the package, provided that the product is stored at a maximum temperature of 30 °C and a maximum relative humidity of 85%. For usability of products older than one year in date code please contact Micronas. Under these conditions, no Dry Pack is required.

Micronas packages are non-hermetic and the epoxy molding compound used to form the package body can absorb moisture and other contaminants from the atmosphere. The absorbed moisture can lead to internal delamination or external package cracking when the package is exposed to elevated temperatures during soldering or welding operations, due to the pressure exerted on the package from the absorbed water when it vaporizes. Therefore, it is important that the storage requirements are fulfilled.

3.2.1. Solder Paste

Solder paste provides the metals and cleaning agents used to produce the mechanical and electrical interconnection between package leads and contact surfaces within the subassembly. The purpose of the solder paste is to provide clean and wettable surfaces to which the metal solder will adhere, thus producing a reliable electrical interconnection. The flux operates as the cleaning agent to remove potential oxides and other contaminants from both the package leads and the contact surfaces. Additionally, the flux also protects the newly cleaned metal surfaces, thereby preventing re-oxidation during the soldering process while the contact surfaces are at an elevated temperature.

3.2.2. Solder Paste Fluxes

The fluxing system is composed of a flux and binder system and can be divided into three typical categories: rosin-based (or solvent-clean); water soluble (or aqueous-clean); and no-clean. All three flux systems and flux cleaners are compatible with Micronas HAL packages with the exception of flux cleaners containing 1,1,1-trichloroethane and trichloroethylene. The solvents can lead to corrosion within the package.

Rosin-based fluxes are available in non-activated (R), mildly activated (RMA) and activated (RA) formulations. These flux types contain an activating agent which increases the wettability of the metal surfaces through the removal of surface oxides. The residue resulting from the use of rosin-based fluxes is corrosive and must be thoroughly removed from the subassembly after soldering.

The performance of the flux needs to be evaluated. A mild no-clean flux, for example, may not be acceptable under production conditions. Micronas recommends the use of halide-free water soluble fluxes because they are effective cleaners and have a very low environmental impact. No-clean fluxes have an even lower impact on the environment, but may not be effective enough under typical production conditions. No-clean fluxes should only be used when clearances within the subassembly are too small to allow the use of cleaning agents or when local environmental restrictions do not allow the use of flux removal cleansers.

3.2.3. Contaminants to Avoid

During assembly the high temperatures can have long-term effects on the reliability of the package. Leaching of contaminants through the use of water for the removal of flux can lead to the formation of corrosive compounds after the package has been assembled and put into service by the end user. Halide compounds are the largest contributor for corrosion. Any materials used in assembly containing halides must be avoided, including solder paste, fluxes and overmolding materials.

3.2.4. Lead Soldering Processes

Typical mass-production soldering is performed through either wave soldering or reflow soldering, though hand soldering may still be used for the attachment of certain components. The appropriate combination of solder, flux and process parameters must be established and qualified through experiments prior to production start.

The solder-reflow process can be used for SMD and through-hole packages. The process profiles used must be optimized to ensure that the package body is not exposed to high temperatures. This can be difficult since the maximum temperature required for a lead-free solder process is higher than the typical peak SnPb process temperature. Parts by Micronas have pure Sn plating; however, the parts can be processed by a SnPb soldering process if the condition is observed that the peak temperature exceeds 232 °C. For a pure Sn soldering process, the temperature needs to exceed 240 °C.

The wave soldering process is not recommended for SMD packages. Through-hole packages can be wave soldered. It is important that adequate spacing between the package body and the PCB board be maintained to minimize overheating of the package.

Hand soldering can be used for through-hole packages, but is not recommended for SMD packages. For hand soldering a self-regulating soldering iron should be utilized with a maximum temperature of 380 °C (for 4 s – 5 s; tested according to EIAJ ED-4701/300). If necessary, shielding should be used to avoid overheating the package body. Hot air gun type soldering equipment should never be used for manual soldering. This equipment generates excess volumes of hot air which can flow uncontrolled over the PCB resulting in damaged solder joints on the adjacent components near the package being soldered.

3.2.4.1. Reflow Profile

Table 3–4: SnPb eutectic process – classification temperatures (T_c)

Package Thickness	Volume mm ³ <350	Volume mm ³ ≥350
<2.5 mm	235 °C	220 °C
≥2.5 mm	220 °C	220 °C

Table 4-2 Pb-Free Process - Classification Temperatures (T_c)

Package Thickness	Volume mm ³ <350	Volume mm ³ 350 - 2000	Volume mm ³ >2000
<1.6 mm	260 °C	260 °C	260 °C
1.6 mm - 2.5 mm	260 °C	250 °C	245 °C
>2.5 mm	250 °C	245 °C	245 °C

Note 1: At the discretion of the device manufacturer, but not the board assembler/user, the maximum peak package body temperature (T_p) can exceed the values specified in Tables 4-1 or 4-2. The use of a higher T_p does not change the classification temperature (T_c).

Note 2: Package volume excludes external terminals (e.g., balls, bumps, lands, leads) and/or nonintegral heat sinks.

Note 3: The maximum component temperature reached during reflow depends on package thickness and volume. The use of convection reflow processes reduces the thermal gradients between packages. However, thermal gradients due to differences in thermal mass of SMD packages may still exist.

Note 4: Moisture sensitivity levels of components intended for use in a Pb-free assembly process **shall** be evaluated using the Pb-free classification temperatures and profiles defined in Tables 4.2 and 5-2, whether or not Pb-free.

Note 5: SMD packages classified to a given moisture sensitivity level by using Procedures or Criteria defined within any previous version of J-STD-020, JESD22-A112 (rescinded), IPC-SM-786 (rescinded) do not need to be reclassified to the current revision unless a change in classification level or a higher peak classification temperature is desired.

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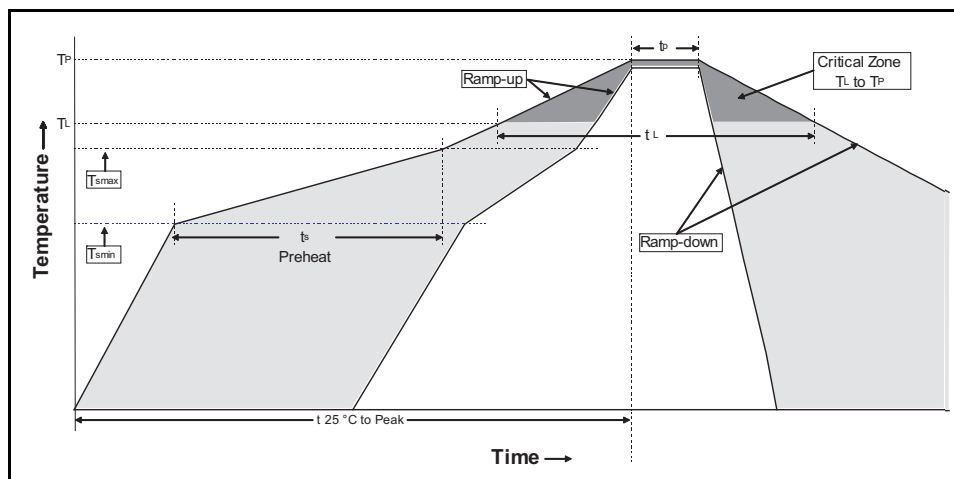


Fig. 3–4: Reflow profile for TO and SOT packages

Profile Feature	Sn-Pb Eutectic Assembly	Pb-Free Assembly
Preheat / Soak		
Temperature Min (T_{smin})	100 °C	150 °C
Temperature Max (T_{smax})	150 °C	200 °C
Time (t_s) from (T_{smin} to T_{smax})	60-120 seconds	60-120 seconds
Ramp-up rate (T_L to T_P)	3 °C/second max.	3 °C/second max.
Liquidous temperature (T_L)	183 °C	217 °C
Time (t_L) maintained above T_L	60-150 seconds	60-150 seconds
Peak package body temperature (T_P)	235 °C	260 °C
Time (t_P) within 5 °C of the specified classification temperature (T_C)	20 seconds	30 seconds
Ramp-down rate (T_P to T_L)	6 °C/second max.	6 °C/second max.
Time 25 °C to peak temperature	6 minutes max.	8 minutes max.

Note: This reflow profile is based on J-STD-020D and is valid for TO and SOT package only. The customer is responsible to check all of the possible component, board assembly and product design combinations for the different applications.

This standard cannot address all of the possible component, board assembly and product design combinations. However, the standard does provide a test method and criteria for commonly used technologies. Where uncommon or specialized components or technologies are necessary, the development should include customer/manufacturer involvement and the criteria should include an agreed definition of product acceptance.

3.3. Lead Welding

The HAL package leads are compatible with resistance and laser beam welding. The success of any welding process is dependent upon process parameters, process conditions and the material to which the package is to be joined. Micronas does not give any implied or express warranty as to the ability to weld Micronas packages and can not provide specific welding processes for its products.

Micronas recommends the following welding processes if the package is to be welded to a subassembly: resistance welding or laser welding.

Welding of copper terminals should be performed with the longest possible lead length which helps maintain a lower overall package body temperature. The lowest temperature consistent with a stable welding process should be used. The welding process temperature needs to be established through experiments to ensure that the leads can be welded to the subassembly without undo high temperature, resulting in spattering and solder ball formation. Shielding of surrounding area may be necessary to avoid potential problems such as the bridging of nearby contacts and traces.

3.3.1. Resistance Welding

There are three basic types of resistance welding process: solid state or cold welding; fusion welding; and reflow braze welding. Micronas packages are most suitable for the fusion welding process.

In a fusion welding process, either similar or dissimilar materials are heated above their melting points so that the two materials flow together forming an alloy nugget with a larger grain structure than the original materials. Typically a high welding energy for either short or long weld times is used, depending upon material properties. To avoid damaging the package, a short weld time is preferred. The joined materials exhibit good tensile, peel and shear strengths.

Since resistance welding requires high temperatures, a certain volume of material at or near the weld joint will be altered. This area is known as heat affected zone (HAZ). The properties of the material in the HAZ undergo a change which may not be beneficial to the welded joint. The welding process should be developed to minimize the size of the HAZ.

3.3.1.1. Resistance Welding Process Development

The metallurgy of the materials to be welded determines the type of electrode and the welding process parameters to be applied. When developing a new welding process, there are two general categories of metals to consider: conductive (e.g. Al, Cu, Ag, Au); and resistive (e.g. steel, Ni, Ti, W, Mo). Electrically conductive metals have a higher thermal conductivity and are softer. Electrically resistive metals produce higher heat during welding and produce better welds.

These two categories also apply to the material used for the electrodes. Therefore, conductive electrodes should be used to weld resistive parts and resistive electrodes should be used to weld conductive parts. From this it follows that when welding dissimilar materials, the anode and cathode electrodes must also be of dissimilar materials.

The parameters which have the strongest influence on the resistance welding process are as follows: welding current strength; welding on-time; secondary voltage; welding force; and electrode material and shape.

The correct settings are highly dependent upon the materials and shapes to which the package leads are to be joined. Additional variations in the materials which can have an affect on the welding parameters are: degree of surface oxidation; material age; or fluctuations in the composition of the alloys.

The best approach for the establishment of process parameters is to start with the shortest welding on-time and lowest secondary voltage and then gradually increasing the current strength while maintaining a high force. Should the required results with maximum current strength not be achieved, the secondary voltage should be increased and the welding trials repeated starting with the lowest current strength.

If the required results are still not reached, the welding on-time should be increased. Again, welding trials are made while gradually increasing the current strength and secondary voltage as described above. A gradual reduction in the welding force may be needed to reach the required results, because a lower welding force results in an increase in the intensity of the welding. When changing the welding force, always verify that no splashing occurs.

The crystal structure of the weld is highly dependent upon the rate of cooling directly after completion of the welding process. Generally, the faster the cooling, the finer the crystal structure, and therefore the stronger the weld. Since the small package pins can not quickly remove the heat, the heat should be conducted away from the welded joint through the electrodes. Therefore it is advisable to hold the electrodes in the closed position for a short period after the welding on-time has elapsed. This parameter is usually known as welding hold time.

As assistance to the process development, the following comments regarding process parameters should be considered:

Welding on-time

The welding on-time is set short for joining materials with good thermal conducting properties (e.g. Cu, Ag, Al); materials with poor thermal conducting properties (e.g. St, W, Mo) require longer on-time.

Secondary voltage

A higher secondary voltage results in a higher welding strength. Increasing the secondary voltage also increases the current density, and if too high, the surfaces of the joining parts or the electrodes can become burned which leads to splashing, scorch marks or pores. These effects can be minimized by reducing the secondary voltage or increasing the welding force.

Welding force

The welding force to be applied depends on the materials to be joined. A higher welding force is used for materials with high electrical resistance in order to reduce the contact resistance at the joining interface. A lower force is used for materials with low electrical resistance and in this case, the increased contact resistance promotes rapid heating. A welding force which is set too low results in metal splashing due to arcing between the materials to be joined.

Electrode material

The electrode material has a major influence on both the quality and the uniformity of the welds under production conditions. A mechanically stable electrode with low deformation under load is important in reaching a stable production welding process. Dissimilar workpiece and electrode material combinations provide the best welding since these combinations result in a higher resistance. Electrodes made from conductive material are used to weld electrically resistive materials (e.g. stainless steel, nickel) and electrodes made from non-conductive are used to weld electrically conductive materials (e.g. Cu, Au).

Electrode shape

The shape of the electrode has a large influence on thermal dissipation. A large contact area between the electrodes and the materials to be joined improves heat conduction and thereby increasing the weld strength and reducing surface deformation and discoloration. On the other hand, a small contact area can be beneficial when joining materials with low electrical resistance, enabling fusion temperature with low current.

3.3.1.2. Resistance Welding with Projections

Differences in part thickness, geometry and materials result in unbalanced thermal loading which can lead to splattering, weak welds and inconsistent weld quality. Projections, small raised areas which have been stamped into one of the parts to be joined, create a uniform weld heat balance between the two joining parts. Projections can take on many forms, but there are two shapes which are often used when welding package pins to a leadframe or substrate:

Elongated spherical projection – This type of projection is used for welding package leads to leadframes or substrates which are made of thermally conductive material such as copper and brass. This shape increases the localized welding heat and allows for a wide tolerance in the lead placement.

Elongated flat projection – This type of projection is a variation of the elongated spherical projection, whereby the top area has a wide and flat surface. The flat surface creates a weld heat balance when the package pins are being welded to thermally resistive materials. This shape also allows for a wide tolerance in the lead placement.

Projections improve the welding process primarily in two ways. Firstly, the projection results in the highest resistance occurring at the joining point between the two parts, point R_7 in the following diagram:

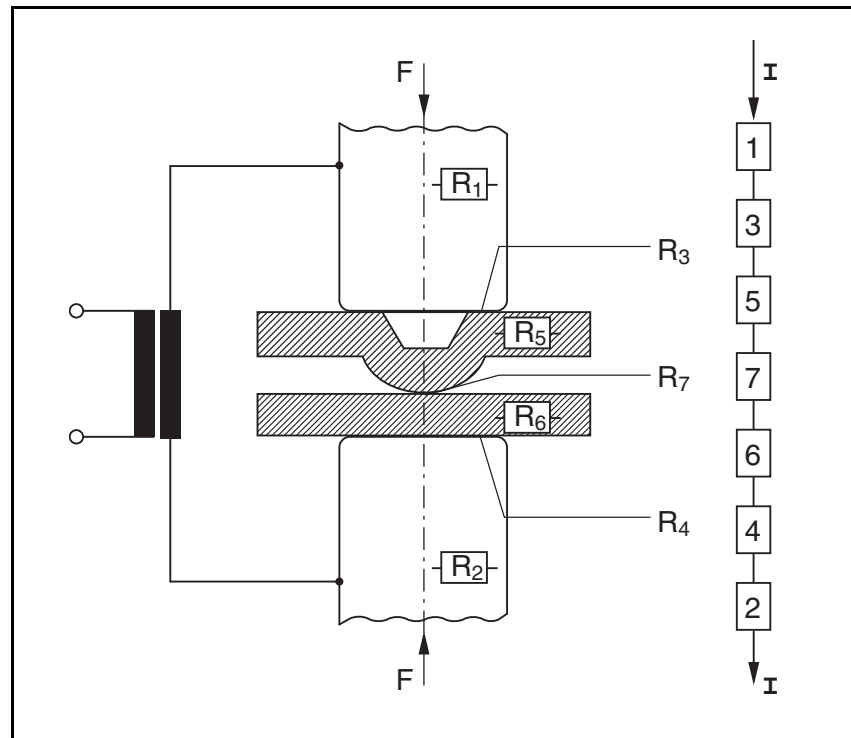


Fig. 3–5: Resistance welding

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Secondly, the projection confines the weld current to a small area thereby producing a localized, consistent weld heat allowing the use of lower weld current settings. The use of projections enables the application of simple flat electrodes which are less expensive than complex shapes and easy to maintain. Furthermore, the life of the electrodes is extended because the lower current settings result in electrodes which run cooler in production.

Regarding the design of projections, during formation of the projections the base material dimensions should not be significantly changed or distorted. Furthermore, the projections must be adequately rigid in order to avoid collapse during the welding process. Most production problems stem from improper projection geometry or placement. Avoid designing projections which are too small or too large and avoid placing projections too closely together.

Typical results achieved using a projection welding process with tests conducted by Micronas:

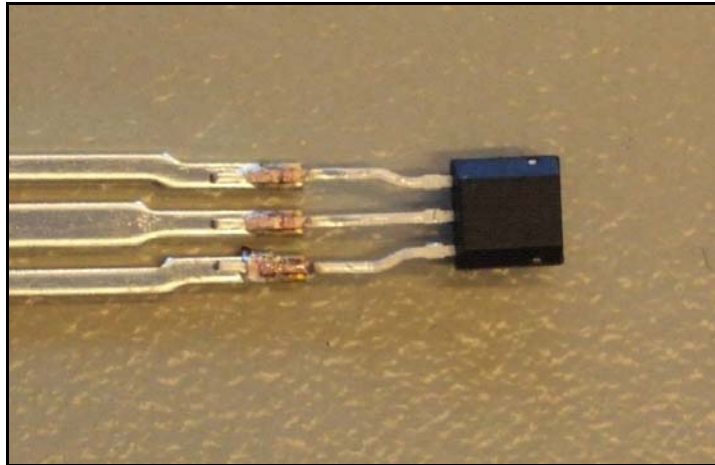


Fig. 3–6: Projection-welded HAL device

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3.3.1.3. Resistance Welding Trouble Shooting

To assist in solving typical problems associated with resistance welding, the following table should be consulted:

Problem	Solution
Electrode sticking	Use electrode with higher conductivity Clean joining surfaces and electrode surfaces Increase welding force
Incomplete welding	Increase welding current or on-time Decrease welding force Improve thermal balance Improve alignment between mating parts Clean joining surfaces
Surface melting	Decrease welding current or on-time Increase welding force Use cooled electrodes
Weld cracking	Increase welding hold time or force Decrease welding on-time
Weld porosity	Clean joining surfaces Increase welding force Decrease welding current
Surface marring	Decrease welding force, time or current Increase electrode tip size Use softer electrode
Metal splattering	Clean joining surfaces Increase welding force Decrease welding on-time or current

3.3.1.4. Resistance Welding Process Definition and Monitoring

The welding process must be clearly defined, documented and verified. The following steps outline the usual steps required to reach these goals.

- Weld process parameter optimization – Typically through the use of DOE method
- Parameters typically used to define weld quality – Peel strength, tensile or shear strength; allowable part deformation; nugget diameter; nugget penetration; optical requirements.
- Correlation of weld quality and weld monitor – Typically through the measurement of one or more of the parameters listed above and the definition of acceptable target values to be reached.
- Establishment of process limits
- Documentation of welding program and monitor
- Regular auditing of welding program and monitor
- Establishment of regular equipment inspection and maintenance

3.4. Laser Beam Welding (LBW)

LBM is a welding technique using a laser beam as a concentrated heat source, producing small, deep welds at a high throughput. The spot size of the laser should be small. The depth of penetration is proportional to the amount of power used, but is also dependent on the location of the focal point. Penetration is maximized when the focal point is slightly below the surface of the workpiece. Advantages of LBW are narrow welds, little or no distortion of the workpiece, minimal HAZ and exceptional metallurgical quality in the weld nugget.

Typically a pulsed solid state laser beam is used to weld thin materials. Nd: YAG¹⁾ lasers are often used in this application.

As stated, heat is generated by the conversion of light energy. All metals reflect light to some degree, with gold and silver high on the list and carbon steel low on the list. Gold, silver, copper, and aluminium are therefore difficult to weld requiring intense energy usually available from high energy peaking pulses or resorting to light absorbing coatings such as graphite on the weld joint surfaces to reduce their reflectivity. The 1.06 micron wavelength of the Nd:YAG laser is more readily absorbed than the longer 10.6 micron wavelength of the CO₂ lasers, therefore, in this respect more suited for welding highly reflective materials. However, though metallic reflectivity is a factor, once melted, the reflectivity essentially disappears at the Curie temperature. Therefore most metals are readily welded. The intense energy of the beam quickly melts the surface, from which thermal conductance progresses to achieve penetration.

Tests have been conducted by Micronas to show the weldability of HAL packages to both brass and copper leadframes using LBW. Good results were achieved using the following equipment:

- Laser source: Single-mode fiber laser
- Beam spot diameter: 20 µm
- Laser power: 200 W
- Feed speed: 800 mm/s
- Beam focal length: 80 mm
- Shielding gas: Argon

The technique utilized was circular welding with a path diameter of 30 µm and 9 revolutions for each welded pin. For good reproducibility, it was important to ensure that there was no gap between package leads and leadframe.

Using this equipment and technique, a welded depth of 100~200 µm was reached, with a joint diameter of about 200 µm. No defects such as pores or holes were observed. The following pictures show typical results.

1) neodymium-doped yttrium aluminum garnet; Nd:Y₃Al₅O₁₂

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Fig. 3-7: Side view, brass leadframe

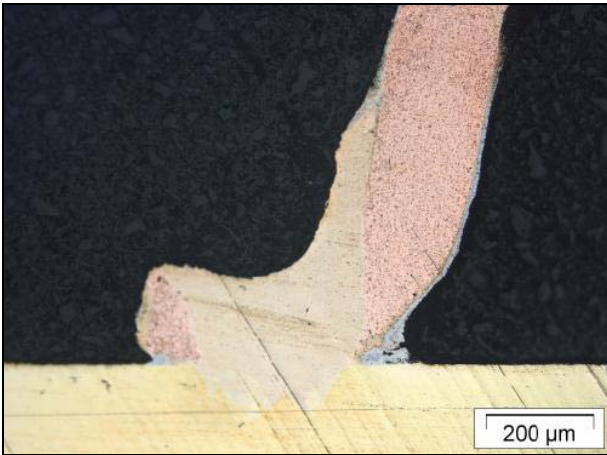


Fig. 3-8: Cross section, brass leadframe



Fig. 3-9: Side view, copper leadframe

4. Attachment of the HAL Package to Subassemblies

Most processes used for the attachment of the package body to subassemblies, including gluing, conformal coatings, potting or overmolding, induce additional stress to the package which can result in changes to the electrical characteristics of the HAL sensor.

The involved grouting materials usually cannot guarantee a complete hermetical sealing due to their chemical and intrinsic properties on the one hand and due to processing-related bubbles, pores, and inclusions on the other hand. This necessitates the use of ion-free grouting materials, as well as a strictly zero-porosity-processing of the materials.

Micronas does not give any implied or express warranty as to the ability to the use of adhesive on the package body to attach the sensor to the subassembly, the use of conformal coatings, the ultrasonic welding of the package body or the use of an overmolding process.

The best method for attachment of the package is through the use of an extra housing into which the HAL sensor is fitted. The housing can then be attached to the subassemblies using any of the above mentioned attachment processes.

When designing the housing, the following points should be considered:

- The slip-fit housing should be specially designed for the package which can be placed into the housing without excessive force; avoid press-fit tolerances in the housing design which can cause stress in the package and lead to parameter shift of the HAL device. For the time during insertion it is also necessary to ensure an adequate fixing of the HAL sensor in such a way that only a minimum of forces are transferred to the device itself.
- In case of unfavorable conditions, Hall sensors, which are not form-fit to a slip-fit housing or to other encasements, may be damaged by mechanical influence or vibration.
- Special attention should be paid to Mold-Flash when designing slip-fit housing. Mold-Flash is very thin remains of the molding material at the gate or the venting of the mold tool. When touching, it breaks from the package, but in certain cases it may affect the assembly, depending on the design of the slip-fit housing. The following drawing gives an example for the TO92 package.

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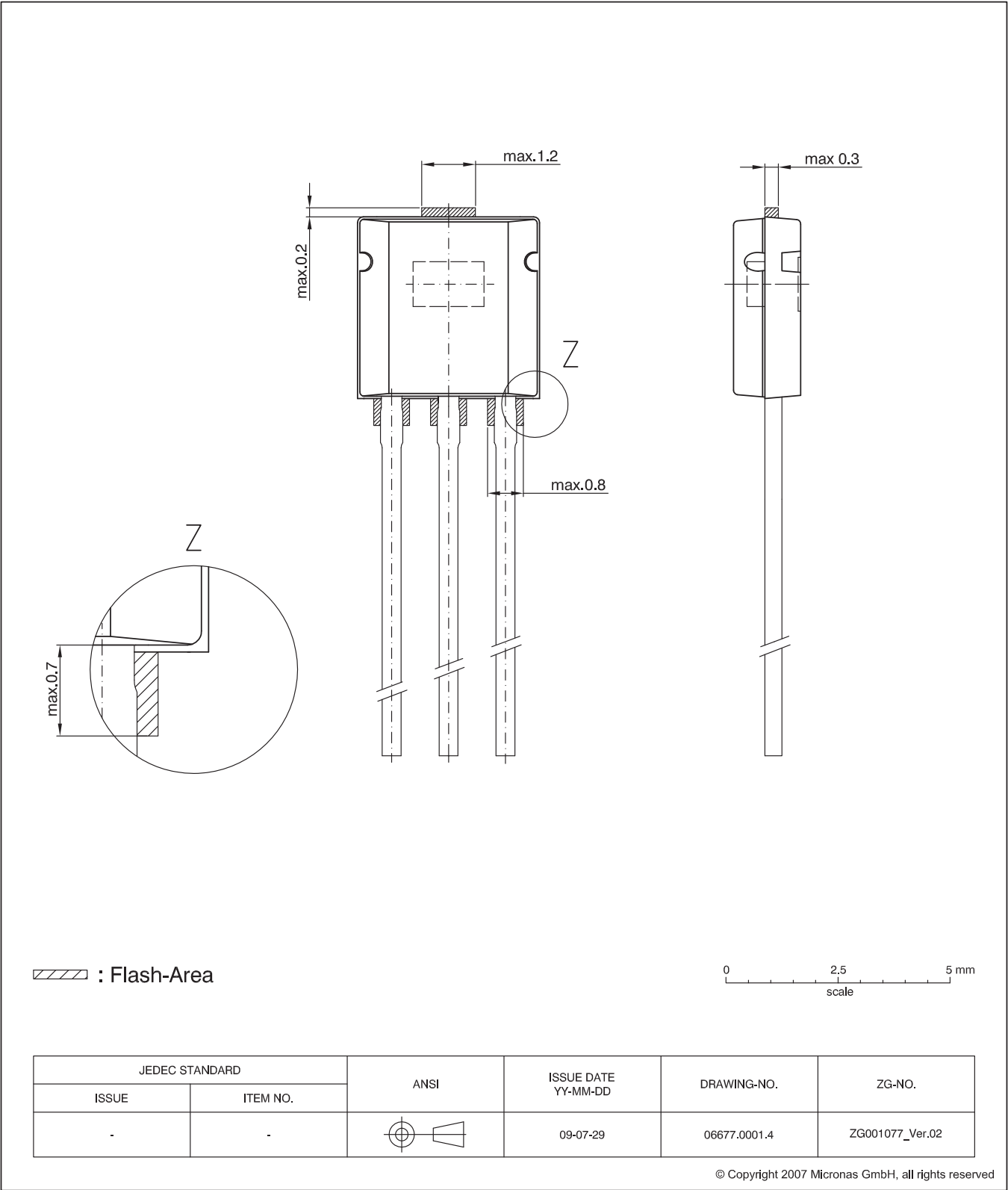


Fig. 4-10: Mold-Flash for TO92 packages

5. Standards and Supporting Documentation

For information concerning Moisture Sensitivity Level (MSL) classification and the associated package handling techniques, the documents offered from the International Electrotechnical Commission (IEC), Japan Electronics and Information Technology Industries Association (JEITA), Association Connecting Electronics Industries (IPC) or Joint Electron Device Engineering Council (JEDEC) can be very useful. Additionally, information concerning optimum soldering processes can also be obtained from these organizations.

The evaluation of solder joints formed with 100% tin solder requires additional know-how when compared to the evaluation of SnPb solder joints. The following standards should be consulted.

IPC-A-610, *Acceptability of Electronic Assemblies* is the most widely used standard published by the IPC. With multiple language versions, it has an international reputation as the source for end product acceptance criteria for consumer and high reliability printed wiring assemblies.

IPC/EIA J-STD-001 *Requirements for Soldered Electrical and Electronic Assemblies* has emerged as the preeminent authority for electronics assembly manufacturing. The standard describes materials, methods and verification criteria for producing high quality soldered interconnections. The standard emphasizes process control and sets industry-consensus requirements for a broad range of electronic products.

JEDEC J-STD-002, *Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires* describes a test method which provides optional conditions for pre-conditioning and soldering for the purpose of assessing the solderability of device package terminations.

5.1. Protection against Electrostatic Damage

IEC 61340-5-1, Protection of electronic devices from electrostatic phenomena - General Requirements describes the a system for protection of electronic components against electrostatic phenomena

IEC/TR 61340-5-2, Protection of electronic devices from electrostatic phenomena - User guide describes the application and quality control.

6. Document History

1. Guidelines for the Assembly of HAL Packages, Nov. 26, 2009; GL000017_001EN.
First release of the document.
2. Guidelines for the Assembly of Micronas Packages, March 1, 2010;
GL000017_002EN. Second release of the document.
Major changes:
 - Section 1.2 “Lead forming”: details changed
 - Section 1.4 “Failure Analysis” added
 - Section 2.1 “Basic Guidelines” changed
 - Fig. 2–9: “Side view, copper leadframe” changed
3. Guidelines for the Assembly of HAL Packages, July 24, 2012; GL000017_003EN.
Third release of the document.
Major changes:
 - Section 1.1 “Package Stress Resulting from Assembly”: text added
 - Section 3 “Attachment of the HAL Package to Subassemblies”: text added
4. Guidelines for the Assembly of Micronas Packages, April 30, 2015;
GL000017_004EN. Fourth release of the document.
Major changes:
 - Section 2: “Shelf Life, Storage, and Transportation” added