



*The Institute for
Interconnecting
and Packaging
Electronic Circuits*

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Procedures for Characterizing and Handling of Moisture/ Reflow Sensitive ICs

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and Packaging Electronic Circuits

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Users of this standard are encouraged to participate in the development of future revisions.

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Procedures for Characterizing and Handling of Moisture/Reflow Sensitive ICs

1.0 FOREWORD

The advent of surface mount integrated circuits (ICs) has introduced a new class of quality and reliability concerns regarding package cracks and delamination. This document defines standardized levels of performance, provides a classification procedure, offers an introduction to the failure modes, provides some history of the extent of problems, and offers methods of handling to avoid these problems.

Moisture from atmospheric humidity enters permeable materials by diffusion. Assembly processes which are used to attach surface mount ICs to printed circuit boards (PCBs) expose the entire package body to soldering temperatures. During reflow, delamination of critical surfaces within the package and cracking can result from rapid moisture expansion and materials mismatches. This damage can result in circuit failure, which could be immediate (yield) or could occur over time (reliability).

There is no "one-to-one" correlation between delamination and future electronic component failure or performance. There have been component failures traced to delamination at various sites. Some of the failures are caused by faulty technique used to remove components from the printed wiring board.

The solder reflow processes of concern are convection, convection/IR, infrared (IR) or vapor phase (VPR). The use of assembly processes which immerse the component body in molten solder is of concern but is not currently within the scope of this document.

1.1 Purpose The objective of this document is to provide IC manufacturers and users with standardized sensitivity classifications and handling procedures to avoid IC damage. This is not meant to replace reliability qualification methods.

1.2 Scope The classification procedure applies to all integrated circuits in packages which, because of absorbed moisture, could be sensitive to damage during solder reflow. These ICs include plastic encapsulated packages and other packages made with moisture-permeable materials such as epoxies. The categories are intended to be used by IC producers to inform IC users (board assembly operations) of the level of moisture sensitivity of product devices, and by board assembly operations to ensure that

proper handling precautions are applied to moisture/reflow sensitive devices.

The testing conditions for these components has a maximum body temperature between 215-219°C. For processing of components with temperatures greater than 220°C the components manufacturer and user should work as partners to identify the appropriate floor life for that peak temperature.

2.0 APPLICABLE DOCUMENTS

The following documents of the issue currently in effect form a part of this specification to the extent specified herein.

2.1 IPC¹

IPC-TM-650 Test Methods Manual

Method 2.6.20 Assessment of Plastic Encapsulated Electronic Components for Susceptibility to Moisture/Reflow Induced Damage

Method 2.6.22 Acoustic Microscopy for Plastic Encapsulated Electronic Components

2.2 Electronic Industries Association²

EIA-583 Packaging Material Standards for Moisture Sensitive Items

EIA-541 Packaging Material Standards for ESD Sensitive Items

JESD 22-A112 Moisture-Induced Stress Sensitivity for Plastic Surface Mount Devices

JESD 22-A113 Preconditioning Procedures of Plastic Surface Mount Devices Prior to Reliability Testing

JESD 42 Requirements for Handling Electrostatic-Discharge Sensitive (ESDS) Devices

JEP113 Symbol and Labels for Moisture Sensitive Devices

2.3 Military³

MIL-P-116 Method 11 Preservations, Methods of

1. Institute for Interconnecting and Packaging Electronic Circuits, 2215 Sanders Road, Northbrook, IL 60062-6135

2. Electronic Industries Association, 2001 Eye Street, N.W., Washington, D.C. 20006

3. To obtain documents, write: Standardization Documents Order Desk, Building 4D, 700 Robbins Avenue, Philadelphia, PA 19111-5094, (215) 681-2600

MIL-B-131, Type I Military Specification, Barrier Materials, Water vapor proof, Grease proof, Flexible, Heat-sealable.

MIL-STD-1686 Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies, and Equipment (Excluding Electrically Initiated Explosive Devices)

MIL-D-3464, Type II Military Specification, Desiccant, Activated, Bagged, Packaging Use and Static Dehumidification

MIL-I-8835 Military Specification, Indicator, Humidity, Card, Chemically Impregnated

MIL-B-81705, Type I Military Specification, Barrier Materials Flexible. Electrostatic-free Heat sealable

MIL-HDBK-263 Electrostatic Discharge Control Handbook for Protection of Electrical and Electronic Parts, Assemblies and Equipment (Excluding Electrically Initiated Explosive Devices)

MIL-HDBK-773 Electrostatic Discharge Protective Packaging

2.4 Federal³

FED-STD-101 C, Test Method 3030.1 Water Vapor Permeability Test of Packaging Materials (Water Vapor Transmission Rate Test)

3.0 PACKAGE TYPES AFFECTED

The main category of package types affected is Plastic Surface Mount Components. This category includes, but is not limited to, J-bend and gull-wing leaded packages such as Plastic Leaded Chip Carriers (PLCCs), Small Outline Integrated Circuits (SOICs), Plastic Quad Flat-Packs (PQFPs), and Thin Small Outline Packages (TSOPs); hereafter called "packages." Components which were not specifically designed for surface mount processing should not be exposed to surface mount reflow processes. If such components are exposed to reflow soldering conditions (such as modified process flows, double-sided assembly processes, or rework), it is the end-user's responsibility to characterize for moisture/reflow sensitivity.

Plastic components which are socketed and not exposed to solder reflow, rather than soldered are not at risk for cracking. Plastic packages, if they reach internal body temperatures approaching the soldering temperature, are at risk for delamination and package cracking. The higher the package body temperature, the greater the risk. Localized solder reflow processes that concentrate heat on the package leads are also safe. These processes include hot bar reflow, laser soldering, and hand soldering.

Components previously characterized by the manufacturer and

- manufactured with the same dimensions, materials and processes
- with the same or lesser degree of robustness noted on the label
- with production quality and field reliability data acceptable to the customer

need not be re-characterized.

Components classified by the manufacturer to the previous revision of this document need not be reclassified using the new criteria of this revision provided the specified floor life out of the bag does not change from the previous classification. If it is desired to upgrade the product by extending the floor life out of the bag, then the product must be reclassified in accordance with the new criteria of this document.

4.0 HANDLING PROCEDURES

4.1 Safe Allowable Moisture Content

4.1.1 Classification Exterior configuration is not the sole indicator of moisture/reflow sensitivity. The same number of days of ambient moisture can result in different amounts of moisture absorbed by the package, depending upon mold compound material and package design. Furthermore, the same amount of moisture in different packages might cause different amounts of damage. Packages with the same exterior configuration (lead count, thickness, etc.), might not have the same interior construction. Absorption rate and sensitivity may differ between packages which otherwise look identical. Therefore, the percentage weight gain moisture content is not useful for establishing moisture sensitivity classifications. Different package types/lead counts/die attach areas will have different levels of absorbed moisture before reflow damage will occur. Moisture absorption depends upon ambient temperature, partial pressure of water vapor, and time. Although the partial pressure of water vapor is reported in several ways in the literature, relative humidity is most frequently used (dew point is also reported); relative humidity will be used in this text.

The component floor life can be defined as the time period which begins after moisture-sensitive devices are removed from moisture barrier bags and controlled storage environments to the time when the devices have absorbed enough moisture to be susceptible to damage during reflow. The floor characteristics are dependent upon many factors. Therefore, this procedure establishes moisture sensitivity classification levels and provides the criteria for grouping components into these levels. Moisture sensitivity levels 2-6, as listed in Table 4-1, will be valid for floor life exposures to environments of 30°C/60% RH maximum. Ambient conditions exceeding 60% RH will require reclassification.

determine safe exposure times for these use conditions.

MET = "Manufacturer's Exposure Time," which is the compensation factor that accounts for the time after bake that the component manufacturer requires to process components prior to bag seal. It also includes the maximum time allowed at the distributor for having the bag open to split out smaller shipments.

Moisture Exposure = Preconditioning moisture soak to simulate total exposure time conditions.

Mandatory Bake = Unless otherwise specified by the manufacturer, bake units shipped in high temperature shipping media for 24 hours at 125 C. Units packed in shipping media which will not withstand these temperatures should be baked per the manufacturer's instructions.

4.1.2 Criteria for Classification Components are classified based upon exposure to the appropriate moisture level (see Table 4-1) reflow simulation, and evaluation for moisture/reflow damage. Acceptability criteria are listed in Table 4-2. The criteria are to be hierarchically applied. The acceptance criteria apply regardless of the moisture sensitivity classification level. This method of classification is described in detail in IPC-TM-650 Test Method 2.6.20, "Assessment of Plastic Surface Mount Components for Susceptibility to Moisture Induced Damage." Figure 1 shows the logic flow diagram for the implementation of these criteria. For incoming inspections on components of known moisture sensitivity classification levels the same methods and criteria can be used for acceptance. All criteria and methods must be agreed to between the board assembly site and the component manufacturer before using this criteria for incoming inspection.

There is no "one-to-one" correlation between delamination and future electronic component failure or performance. There have been component failures traced to delamination at various sites. Some of the failures are caused by faulty technique used to remove components from the printed wiring board.

Components previously characterized by the manufacturer and

- manufactured with the same dimensions, materials and processes
- with the same or lesser degree of robustness noted on the label
- with production quality and field reliability data acceptable to the customer

need not be re-characterized.

Components classified by the manufacturer to the previous revision of this document need not be reclassified using the new criteria of this revision provided the specified floor life

out of the bag does not change from the previous classification. If it is desired to upgrade the product by extending the floor life out of the bag, then the product must be reclassified in accordance with the new criteria of this document.

4.1.3 Electrostatic Discharge (ESD) Protection The relatively low humidity of the baking environment requires that ESD precautions should be observed in the handling of packages. Consult MIL-STD-1686 or JESD No. 42. If components are removed from tubes, trays, or tape and reel, use standard ESD handling procedures during and after removal. Consult the packaging materials specification before reusing packaging media such as trays.

4.2 Desiccant Pack for Shipping, Storage, and Shelf Life Extension Methods of keeping packages dry during shipping and storage have been adopted as an alternative to baking components dry just prior to mounting. These methods are variations on desiccant packaging of the component shipping containers, or "Bake and Bag." Note that desiccant packing has been implemented at most distributor sites. Therefore, if using distributors, consult with them on desiccant pack shipping of surface mount components. Table 4-3 shows the dry pack requirements for the various moisture sensitivity levels. Here, MBB refers to the Moisture Barrier Bag.⁴

For level 6, longer bake times may be required if MBB and desiccant are not used.

A desiccant "dry" pack consists of desiccant material and a Humidity Indicator Card (HIC) sealed with the components inside a Moisture Barrier Bag (MBB). A warning and information label, sufficient to ensure proper handling, should be provided on the outside surface of the bag. A representative configuration for desiccant packing of packages is shown in Figure 2. This dry pack system will define the total package shelf life. If the shelf life has been exceeded, the component must be 1) baked and used within the specified time guidelines, 2) baked and resealed with new desiccant and a new HIC, or 3) baked and stored in an environment of <20%RH e.g., a desiccant cabinet.

The floor life of in-process materials may be extended by the use of controlled environments. Packages may be stored outside the MBB indefinitely from moisture/reflow sensitivity considerations, if the ambient relative humidity is <20%. The use of desiccator cabinets with dry N₂ or dry air is suggested for such storage. If partial lots are used on the factory floor, the remaining components may be resealed in the MBB if the floor life has not expired. The amount of floor life remaining should be tracked and not exceeded during subsequent exposure.

4.2.1 Materials

4. Available from National Electronic Distributors Association, 35 East Wacker Drive, Suite 1100, Chicago, IL 60601. Tel. (312) 558-9111 Fax (312) 558-0701

Table 4-1 Classification and Floor Life of Desiccant Packed Components

LEVEL	FLOOR LIFE (OUT OF BAG) AT BOARD ASSEMBLY SITE	MOISTURE EXPOSURE	
		°C/%RH	TIME (HRS)
1	UNLIMITED at ≤85% RH	85/85	168
2	1 YEAR at ≤30°C/60% RH	85/60	168
3	1 WEEK at ≤30°C/60% RH	30/60	168 + MET
4	72 HOURS at ≤30°C/60% RH	30/60	72 + MET
5	As Specified on Label: 24 or 48 hours at ≤30°C/60% RH	30/60	time on label + MET
6	Mandatory Bake Bake before use and once baked must be reflowed within the time limit specified on the label	30/60	time on label

Note: Products previously classified to IPC-SM-786 do not require reclassification to this document unless the product's floor life is being changed.

Table 4-2

CRITERIA FOR MOISTURE SENSITIVITY CLASSIFICATION	
The general criteria defining moisture sensitivity are applied in a hierarchical manner.	
CRITERIA	
1. If the components pass electrical test, there is no visual evidence of external cracks, and there is no evidence of delamination or cracks observed by acoustic microscopy or other means, the component is considered to pass that level of moisture sensitivity.	
2. If the components pass electrical test and there is delamination on backside die paddle, heat spreader or die backside (lead on chip), but there is no evidence of cracking or other delamination, the component is considered to pass that level of moisture sensitivity.	
3. If internal cracks are observed by acoustic microscopy or other means, components will be evaluated using cross-sectioning or other method to assess crack length and depth and the cracks evaluated according to the following criteria. Failing components must be evaluated to the next level of moisture sensitivity. a. Cracks are not allowed to intersect the bond wire, ball bond, or wedge bond. b. Cracks are not allowed to extend from any lead finger to any other internal feature (lead finger, chip, die attach paddle.) c. Cracks are not allowed to extend more than two-thirds (2/3) the distance from any internal feature to the outside of the package.	
4. If acoustic microscopy scans exhibit any of the following criteria, the components shall be tested to the next level of moisture sensitivity or will require reliability assessment using the manufacturer's or in-house procedures. Reliability assessment may consist of: Stress testing, historical generic data analysis, etc. Specific methods including historical generic data should be agreed upon by the component supplier and board assembler. All failures should be analyzed to confirm the failure mechanism is associated with moisture sensitivity. If there are no reflow moisture sensitive induced failures, the component meets the tested level of moisture sensitivity. a. Measurable delamination change* on the top surface of the chip. b. Measurable delamination change* on any wire bonding surface of the leadframe/die paddle. c. Measurable delamination change* along any polymeric film bridging any metallic features which are designed to be isolated. d. Measurable delamination/cracking change* through the die attach region. e. Any surface-breaking feature delaminated over its entire length. A surface-breaking feature includes: lead fingers, tie bars, heat spreader alignment features, heat slugs, etc. *For this criteria the equipment must be capable of measuring a minimum "absolute" delamination change of 10%. The "absolute" percent (%) delamination change is calculated in relation to the total area being evaluated. The ability to see a "measurable" delamination change depends upon the amount of delamination present initially, the surface being scanned, and the equipment capability.	

4.2.1.1 Moisture Barrier Bags (MBBs) The protective moisture barrier bag should meet MIL-STD-81075, TYPE I requirements for flexibility, ESD protection, mechanical strength, and puncture resistance. The bags shall not exhibit contact corrosiveness. The bags shall be heat sealable. The Water Vapor Transmission Rate (WVTR), a measure of the permeability of the bag to moisture, shall be <0.02 gm/ 100 in² /24 hrs. at room temperature after aging. Bags may have WVTR values as low as 0.004 gm/100 in²/24 hours when measured to Federal Test Method Stan-

Table 4-3 Dry Packing Guidelines

Level	Bag	Desiccant	Warning Label
1	Not Required	None	Not Required
2-5	MBB Required	Required	Required
6	MBB Optional	Optional	Required

dard No. 101C, Method 3030.1, Paragraph 6.3, Procedure A for pouches. The storage life of bagged components will be determined by the properties of the barrier material