National Aeronautics and
Space Administration

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WORKMANSHIP STANDARD FOR SURFACE MOUNT TECHNOLOGY

NASA TECHNICAL STANDARD

PREFACE

Effective Date: 31 August 1999

This document has been issued to make available to project managers a technical standard where surface mount attachment techniques are to be used.

The document:

> Prescribes NASA's requirements, procedures, and documenting requirements for hand and machine soldering of surface mount electrical connections. These may be tailored to the program applications to obtain the most cost effective, best quality product.
>
> Describes basic considerations necessary to ensure reliable soldered surface mount connections.
>
> Establishes the responsibility for documentation of those fabrication and inspection procedures to be used for NASA work including supplier innovations, special processes, and changes in technology. For the purpose of this document the term supplier is defined as in-house NASA, NASA contractors, and subtier contractors.

Procuring NASA Enterprise Programs or Centers shall review this document for applicability to NASA contracts as well as for applicability to its internal activities.

Questions concerning the application of this publication to specific procurements or requests should be referred to the NASA Enterprise Program or Center.

Comments and suggestions for improving this publication may be submitted using the form "NASA Standard Improvement Proposal." A copy of this form is included at the end of the document.

Other processes such as conformal coating or cabling and harnessing not covered by this document may be required to fabricate hardware involving surface mounted devices. The design, materials, and processes not covered shall be defined in engineering documentation.

This Standard cancels NASA Assurance Standard 5300.4(3M), Workmanship Standard for Surface Mount Technology.

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NASA TECHNICAL STANDARDS FOR FLIGHT HARDWARE WORKMANSHIP

NASA Technical Standards can be found on the World Wide Web at URL address http://www.hq.nasa.gov:80/office/codeq/doctree/qdoc.pdf.

Title	Number
Workmanship Standard for Staking and Conformal Coating of Printed Wiring Boards and Electronic Assemblies	NASA-STD-8739.1
Workmanship Standard for Surface Mount Technology	NASA-STD-8739.2
Soldered Electrical Connections	NASA-STD-8739.3
Crimping, Interconnecting Cables, Harnesses, and Wiring	NASA-STD-8739.4
Fiber Optic Terminations, Cable Assemblies, and Installation	NASA-STD-8739.5
Standard for Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices)	NASA-STD-8739.7

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CHAPTER 1 - SCOPE

1.1 Scope

This Standard prescribes NASA's requirements, procedures, and documenting requirements for hand and machine soldering of surface mount electrical connections. The requirements established in this publication shall be utilized for the development of project-related processes. These may be tailored to the program applications to obtain the most cost effective, best quality product.

1.2 Purpose

This publication sets forth soldering requirements for reliable Surface Mount Technology (SMT).

1.3 Applicability

This publication is applicable to NASA Centers and programs utilizing SMT for flight hardware, mission critical ground support equipment, and elements thereof, and where invoked contractually.

1.4 Special Requirements

Special requirements may exist that are not covered by or are not in conformance with the requirements of this publication. Engineering documentation shall contain the detail for such requirements, including modifications to existing hardware, and they shall take precedence over appropriate portions of this publication when they have been approved in writing by the procuring NASA Center.

1.5 Approval of Departures from this Standard

1. Departures from this publication require written approval from the cognizant NASA contracting officer. The supplier is responsible for assuring that any departures from this publication are evaluated by, coordinated with, and submitted to the procuring NASA Center for approval prior to use or implementation.

2. For in-house NASA projects, this publication requires written approval by the in-house NASA project management to deviate from the provisions herein.

CHAPTER 2 - APPLICABLE DOCUMENTS

2.1 Specifications

Copies of the following applicable specifications required in connection with a specific procurement may be obtained from the procuring NASA Center or as directed by the contracting officer.

Unless otherwise specified, the issue in effect on the date of invitation for bids or request for proposal shall apply.

FEDERAL SPECIFICATIONS:

O-E-760	Ethyl Alcohol (Ethanol) Denatured Alcohol; Proprietary Solvents and Special Industrial Solvents
O-M-232	Methyl Alcohol
IT-I-735	Isopropyl Alcohol

MILITARY SPECIFICATIONS:

MIL-C-85447	Cleaning Compounds, Electrical and Electronic Components
MIL-STD-202	Test Methods for Electronic and Electrical Component Parts

NASA SPECIFICATIONS:

NASA-STD-8739.7	Requirements for Electrostatic Discharge Control (Excluding Electrically Initiated Explosive Devices)
NHB 1700.l (V1-B)	NASA Safety Policy and Requirements Document

INDUSTRY SPECIFICATIONS:

ANSI/NCSL Z540-1-1994	General Requirements for Calibration Laboratories and Measuring and Test Equipment
ANSI/J-STD-004	Requirements for Soldering Fluxes
ANSI/J-STD-005	Requirements for Soldering Paste
ANSI/J-STD-006	Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solders for Electronic Soldering Applications

2.2 Other Documents

Other documents containing relevant information include:

Industrial Ventilation Manual of Recommended Practices
Published by American Conference of Governmental Industrial Hygienists
6500 Gel, Bldg. D-5, Cincinnati, Ohio 45211.

Occupational Safety and Health Administration, 29 Code of Federal Regulations (CFR).

ASTM-D-1007, Butyl Alcohol, Secondary

MIL-F-14256, Flux, Soldering, Liquid (Rosin Base) (for reference only document was cancelled June 15, 1995)

CHAPTER 3 - DEFINITIONS AND ACRONYMS

3.1 Terms and Definitions

Adhesive. Materials used to hold parts in place during wave or reflow soldering, which may become a permanent part of the PWA, or be subsequently removed.

Blister. Raised areas on the surface of the laminate caused by the pressure of volatile substances entrapped within the laminate.

Blow Hole. A cavity in the solder surface whose opening has an irregular and jagged form, without a smooth surface.

Castellation. Metalized features that are recessed on the edges of a chip carrier, which are used to interconnect conducting surfaces or planes within the chip carrier or on the chip carrier.

Certification. The act of verifying and documenting that personnel have completed required training and have demonstrated specified proficiency and have met other specified requirements.

Chip Carrier. A low-profile four-sided (rectangular) part package, whose semiconductor chip cavity or mounting area is a large fraction of the package size.

Class 100,000. A clean room in which the particulate count does not exceed a total of 3500 particles per liter (100,000 particles per cubic foot) of a size 0.5 micron and larger, or 25 particles per liter (700 particles per cubic foot) of a size 5.0 microns and larger.

Clean Room. A clean room is an enclosed area employing control over the particulate matter in the air with temperature, humidity, and pressure controls, as required.

Cold Solder Connection. A solder connection exhibiting poor wetting and grayish, porous appearance due to insufficient heat, inadequate cleaning before soldering, or excessive impurities in the solder.

Contaminant. An impurity or foreign substance present in a material that affects one or more properties of the material. A contaminant may be either ionic or nonionic. An ionic or polar compound forms free ions when dissolved in water, making the water a more conductive path. A nonionic substance does not form free ions, nor increase the water’s conductivity. Ionic contaminants are usually processing residue such as flux activators, finger prints, and etching or plating salts.

Delamination. A separation between plies within a base material, or any planar separation within a multilayer PWB.

Dewetting. The condition in a soldered area in which the liquid solder has not adhered intimately, but has receded, characterized by an abrupt boundary between solder and conductor, or solder and terminal/termination area leaving irregularly shaped mounds of solder separated by areas covered with a thin solder film.

Disturbed Solder Joint. Unsatisfactory connection resulting from relative motion between the conductor and termination during solidification of the solder.

Dross. Oxide and other contaminants that form on the surface of molten solder.

Electrode Down Force. The force that the electrodes exert on the materials being joined.

Emulsion. A material that is built up on a printing screen to block portions of the screen. The open portions define the pattern for depositing solder paste on a PWB.

Examination. A verification of a set of requirements during the manufacturing process that may or may not be considered mandatory by the procuring installation. If an examination is considered mandatory by the procuring installation, then the examination will result in a sign-off of a certain operation by quality assurance personnel.

Excess Solder. Unsatisfactory condition wherein the solder obscures the configuration of the connection or the solder fillet exhibits a convex appearance.

Flux. A chemically-active compound which, when heated, removes minor surface oxidation, minimizes oxidation of the basis metal, and promotes the formation of an intermetallic layer between solder and basis metal.

Gull Wing Lead (Package). A surface mount part lead that flares outward from the part body.

I or Butt Lead (Package). An SMD lead, which is formed such that the end of the lead contacts the PWB land pattern.

Ionic Contaminants. Process residues such as flux activators, finger prints, etching and plating salts, etc., that exist as ions that when dissolved, increase electrical conductivity.

J-Lead (Package). An SMD lead, which is formed into a J pattern folding under the part body.

Land (Footprint). A portion of a conductive pattern usually, but not exclusively, used for connection or attachment, or both, of parts.

Land Pattern. A combination of lands intended for the mounting, interconnection, and testing of a particular part.

Lateral Edge. The two longest sides of a rectangular shaped conductive area or land.

Leaching. The dissolution of a metal coating, such as silver and gold, into liquid solder. Nickel barrier underplating is used to prevent leaching.

Leaded Chip Carrier (LCC). A chip carrier whose external connections consist of leads around and down the sides of the package.

Leadless Chip Carrier (LLCC). A chip carrier whose external connections consist of metalized terminations.

Measling. Discrete white spots below the surface of the base material, usually caused by moisture, pressure, and/or thermally induced stress.

Nonwetting. A condition whereby a surface has contacted molten solder, but the solder has not adhered to all of the surface; basis metal remains exposed.

Off Contact. Printing with a snap off. Squeegee deflects screen to PWB.

On Contact. Printing with the stencil directly in contact to the PWB throughout the printing process.

Pinhole. A solder connection with a small hole penetrating from the surface of the solder to a void of indeterminate size within the solder connection.

Pit. A relatively small recess in the solder surface, the bottom of which is visible from all angles of vision.

Planarity. The relationship between part plane and substrate plane.

Printed Wiring Assembly (PWA). The PWA consists of the PWB, parts, and associated hardware and materials.

Printed Wiring Board (PWB). A pattern of conductors printed (screened) onto the surface of an insulating base to provide interconnection for parts.

Registration. The degree to which the position of a land pattern, or portion of a land pattern with its intended position, conforms with that of any other conductive pattern on a PWB. (Parts on primary side should not conflict with parts on the secondary side or the internal layer of a multilayer PWB.)

Repair. Operations performed on a nonconforming article to place it in usable condition. Repair is distinguished from rework in that alternate processes rather than reprocessing are employed.

Resin. A fusible flammable natural organic substance used in flux. Soluble in solvents, but not water.

Rework. The reprocessing of articles or material that will make it conform to drawings, specifications, and contract.

Rosin. A synthetic resin.

Rosin Solder Joint. Unsatisfactory connection that has entrapped rosin flux. This entrapment is usually due to insufficient heat or insufficient time at soldering temperature, or both, not enabling the rosin to rise to the surface of the solder. This results in insufficient bonding and/or high electrical resistance.

Saponifiers. Chemicals, added to water, which convert rosin/resin flux residues into water soluble soaps.

Screen Mesh. A structure of woven fibers which supports the emulsion, but does not block the solder paste when used to selectively screen print solder paste onto a PWB.

Slump Test. A test performed on solder paste to measure the distance the solder metal in the solder paste spreads after printing, during the drying, and before the reflow process.

Snap Off Distance. The distance between the surface of a PWB and the screen when they are mounted in a screen printer. After the squeegee deflects the screen to the PWB and passes over it depositing the solder paste, the screen must snap off to the original position.

Solder Balls. Very small balls of solder that separate from the main body of solder, which forms the joint and remain adhered to the base laminates. Primarily caused by oxides in the solder paste that inhibit solder fusion during reflow.

Solder Paste, Dispensing Grade. Solder paste contained in a syringe type applicator.

Solder, Fractured. A joint showing evidence of cracking.

Solder, Fillet. A blended or meniscoid (rounded) configuration of solder around a part or wire lead and land.

Solder, Insufficient. Unsatisfactory connection where the solder fillet is short or otherwise incomplete.

Solder, Overheated. An unsatisfactory solder joint, characterized by a rough solder surface.

Solder Paste. A homogeneous combination of minute spherical solder particles, flux, solvent, and a gelling suspension agent, which is used in the surface mount reflow soldering process. Solder paste can be deposited onto a PWB via screen or stencil or via manual or automated dispensing systems.

Solder, Porous. Solder having a grainy or gritty surface.

Solder Slivers. Portions of tin-lead (solder) plating overhang on conductor edges partially or completely detached.

Solder Spike/Peak. A cone shaped peak or sharp point of solder usually formed by the premature cooling and solidification of solder on removal of the heat source.

Solder, Wave. A method of soldering complete PWA's where the PWB, with parts mounted, is passed through one or more waves of molten solder, which is continuously moving to maintain fresh solder in contact with the PWB.

Solder Webbing. A continuous film or curtain of solder parallel to, but not necessarily adhering to, a surface or between separate sections or circuitry that should be free of solder.

Solderability. The property of a surface that allows it to be wetted by molten solder.

Soldering Infrared Reflow. A reflow soldering furnace using infrared heating as the primary source of heat transfer in an oven environment.

Soldering, Reflow. A process of joining metallic surfaces (without the melting of basis metals) through the mass heating of the entire PWA. This mass heating process causes preplaced solder paste to melt in predefined metalized areas. Soldering is accomplished in an upright position.

Squeegee. A blade used in screen printing to wipe across the screen to force the solder paste through the screen mesh or stencil onto the foot print.

Stencil. A metal mask used in place of a screen. These are normally used for thicker paste deposits or paste with different characteristics, as there is no snap off. They do not deflect or seal.

Supplier. In-house NASA, NASA contractors, and subtier contractors.

Surface Mounting. A method of assembling PWB's (or hybrid circuits) where parts are mounted onto, rather than into, the substrate. Surface mount attachment can be achieved either through reflow soldering (where the part is soldered upright) or through dual wave soldering, where the parts are initially attached with epoxy and soldered upside down. This term also refers to the electrical and mechanical connection of a part to the surface of a conductive pattern that does not utilize part lead holes.

Tack Test. A test performed on solder paste to determine the surface tension holding force.

Tilt. When a part is mounted at an angle relative to the PWB surface.

Tinning. The coating of a surface with a uniform layer of solder.

Viscosity. The property of a fluid that enables it to develop and maintain an amount of shearing stress dependent upon the velocity of the flow, and then to offer continued resistance to flow.

Visual Examination. The qualificative observation of physical characteristics, utilizing the unaided eye or within stipulated levels of magnification.

Void. A total absence of material.

Wetting. Flow and adhesion of a liquid to a solid surface, characterized by smooth, even edges, and a low dihedral angle.

Wetting, Negative. When measured from the vertical plane, the solder fillet forms a negative angle.

Wetting, Positive. When measured from the vertical plane, the solder fillet forms a positive angle.

White Room. An environment that is equal to or better than a class 100,000 clean room, which however, does not require certification records or additional record keeping.

Wicking. A flow of molten solder, flux, or cleaning solution by capillary action.

Working Life. The period of time during which a material, such as solder paste, remains usable.

3.2 Acronyms

CFR	Code of Federal Regulations
DIP	Dual-In-Line Package
ESD	Electrostatic Discharge
GSFC	Goddard Space Flight Center
JPL	Jet Propulsion Laboratory
LCC	Leaded Chip Carrier
LLCC	Leadless Chip Carrier
MELF	Metal Electrode Face
MSDS	Material Safety Data Sheets
NIST	National Institute of Standards and Technology
OSHA	Occupational Safety and Health Administration
PLCC	Plastic Leaded Chip Carrier
PWA	Printed Wiring Assembly
PWB	Printed Wiring Board
SMD	Surface Mount Device
SMT	Surface Mount Technology
SOIC	Small Outline Integrated Circuit (Gull-Wing Lead)

SOLIC Small Outline Large Integrated Circuit (Gull-Wing Lead Wide Body)

SOJ SOIC Package with J-Leads

SOT Small Outline Transistor/Diode/LED

CHAPTER 4 - GENERAL

4.1 General

1. **Implementation.** NASA quality assurance personnel will advise and assist suppliers, NASA personnel, and delegated agencies in the proper and effective implementation of the provisions of this publication. Effective implementation includes establishing a system that will identify each inspection point and provide records.

2. **Changes in Requirements.** When related requirements or changes in requirements are specified, NASA quality assurance personnel will assure that the Government agency delegated to inspect at the supplier's site of fabrication has received full instruction so that the work will be inspected to actual contract requirements.

3. **Nonstandard Processes, Materials, or Parts.** When the supplier intends to use processes, materials, or parts not covered by this publication, the supplier shall document the details of fabrication and inspection, including acceptance and rejection criteria, and shall provide appropriate test data. Such documentation shall be approved by the procuring NASA Center prior to use.

4.2 Surface Mount Soldering Programs

1. NASA quality assurance personnel will advise and assist contractors, suppliers, NASA personnel, and delegated agencies in the proper and effective implementation of the provisions of this publication.

2. When related requirements, or changes in the requirements, are specified, NASA quality assurance personnel will ensure that the Government agency delegated to inspect at the supplier's site of fabrication has received full instructions so that the work will be inspected to the actual contract requirements.

3. Unless parts are manufactured specifically to comply with contracts or subcontracts citing this publication, internal connections of parts are not subject to the requirements of this publication. The supplier shall assure that parts have suitable internal solder connections that will not unsolder or deteriorate when tinning is performed or external connections are made.

4. Use of leadless chip carrier (LLCC), I-lead, J-lead, and L-lead configurations in critical applications shall require prior approval of the procuring NASA Center. I-lead configurations are not recommended.

4.3 Documentation

1. The supplier shall document the methods and procedures proposed to incorporate the requirements of this publication into the design, fabrication, and inspection of surface mount solder connections involved in the contract or purchase order.

2. Documents required herein, except as specified by paragraph 4.1-3, shall be submitted to the procuring NASA Center or its designated representative as required by the contract or purchase order. Applicable supplier surface mount soldering program documents, or portions thereof, accepted on other NASA contracts shall be included to avoid duplication of effort.

4.4 Rework

1. Rework is permissible unless excluded by other provisions of the contract. All rework shall meet the requirements of this publication and approved engineering documentation.

2. **Repair is not rework.** Repairs shall be made only in compliance with applicable contractual requirements and after authorization for each incident by the procuring NASA Center. Repairs shall be accomplished using documented methods previously approved in writing by the procuring NASA Center. For in-house NASA projects, repairs shall be authorized, in writing, for each incident by the appropriate Project Office and Quality Management.

CHAPTER 5 - TRAINING AND CERTIFICATION PROGRAM

5.1 General

1. The supplier is responsible for maintaining a documented training program that meets the requirements of this Standard.

2. The supplier shall assure that the personnel are familiar with the requirements of this Standard, SMT reflow soldering techniques, and other pertinent requirements of the contract. The supplier shall implement a training program that provides the necessary training of soldering and inspection personnel in parts mounting and connection requirements, soldering techniques, and use of equipment and procedures pertinent to their responsibilities in performance of the contract requirements. The supplier is responsible for certifying and maintaining the certification of each individual who solders, inspects, or instructs. Operators, inspectors, and instructors shall be qualified to fulfill all requirements of this Standard involved in their assigned tasks.

3. Certification of each individual who solders, operates the SMT reflow equipment, witnesses processes, or inspects soldering shall fulfill all requirements of this Standard pertaining to the types of connections involved in their assigned work. Demonstration of proficiency and understanding of the requirements is a requisite for certification and recertification. Evidence of certification status shall be maintained in the work area.

5.2 Vision Requirements

1. The supplier is responsible for ensuring that all personnel who perform soldering or inspect soldered connections meet the following vision test requirements as a prerequisite to training, certification, and recertification. The vision requirements may be met with corrected vision (personal eyeglasses). The vision tests shall be administered by a qualified examiner, accepted by the procuring supplier, using standard instruments and techniques. Results of the visual examinations shall be maintained and available for review.

2. The following are minimum vision requirements:

   a. **Far Vision.** Snellen Chart 20/50.

   b. **Near Vision.** Jaeger 1 at 355.6 mm (14 inches) or reduced Snellen 20/20, or equivalent.

   c. **Color Vision.** Ability to distinguish red, green, blue, and yellow colors as prescribed in Dvorine Charts, Ishihara Plates, or AO-HRR Tests.

NOTE: ***A PRACTICAL TEST, USING COLOR CODED WIRES AND/OR COLOR CODED ELECTRICAL PARTS, AS APPLICABLE, IS ACCEPTABLE FOR COLOR VISION TESTING.***

5.3 Certification Levels

1. Level A NASA instructors are certified by the NASA Training and Certification Board. Level A NASA instructors have the authority to train Level B instructors, operators, and inspectors. Upon successful course completion, a certificate shall be issued.

2. Certification of Level B instructors shall be provided by the supplier based on successful completion of the training provided by a Level A NASA instructor. Level B instructors are authorized to train operators and inspectors employed at their organization and by their subtier contractors.

3. Certification of inspectors shall be provided by the supplier based on successful completion of the training provided by a Level A NASA instructor or Level B supplier instructor. An inspector is trained and certified to inspect for conformance with the requirements of this Standard.

4. Certification of operators shall be provided by the supplier based on successful completion of the training provided by a Level A NASA instructor or Level B supplier instructor. An operator is trained and certified to fabricate solder connections in conformance with the requirements of this Standard. When operators are certified to perform limited operations or processes, it shall be stated on the certification card.

5.4 Training Program Requirements

1. The supplier is responsible for training and certification of operators and inspectors in the SMT soldering processes and associated processing equipment.

2. The supplier training program documentation shall be submitted to the procuring NASA Center as directed by the contract. A NASA Generic Surface Mount Technology Training Plan from the NASA Training Centers is available for use as a guideline.

3. The training program shall:

   a. Identify the criteria for qualification and certification of Level B instructors, operators, and inspectors.

   b. Document the methods and procedures proposed to fulfill the requirements of this Standard.

   c. Utilize visual standards consisting of satisfactory work samples or visual aids that clearly illustrate the quality characteristics of soldered connections applicable to the contract.

   d. Utilize applicable illustrations in this Standard, supplemented as necessary, for visual standards. Standards of unacceptable conditions may also be used for clarification or comparison.

e. Make applicable standards readily available.

5.5 Documentation

1. The supplier training program documentation shall describe the training and certification program proposed to satisfy the requirements herein for the types of solder connections to be made. This documentation shall include the following, as applicable:

   a. Qualifications of instructors.

   b. Procedures for training, including who will be trained and for what purpose, (e.g., operator, inspector).

   c. Lesson plan(s) and/or student standard.

   d. Hours of instruction.

   e. Procedures for certification and recertification.

   f. Procedures for recording training, recertification, and method of identifying/recalling trained personnel.

   g. Certification criteria.

2. Records of training and certification shall become part of the supplier's quality data and shall be retained for a minimum of 5 years, or as specified in the contact.

3. Evidence of certification status, including limitations, shall be available in the work area.

5.6 Maintenance of Certification Status

1. Maintenance of certification for instructors, operators, and inspectors requires continuous proficiency.

2. Recertification of Level B instructors shall include the successful completion of retraining provided by a Level A NASA instructor. Recertification of operators and inspectors shall include successful completion of retraining provided by a Level A NASA instructor or a Level B supplier instructor.

3. Recertification shall be required when:

   a. Proficiency requirements herein are not met.

      (1) Instructors - proficiency unacceptable.

      (2) Operators - unsatisfactory quality of articles fabricated.

(3) Inspectors - unsatisfactory quality of inspection.

(4) Quality/quantitative data demonstrates a need for recertification.

b. New soldering or inspection techniques have been approved that require different skills.

c. Work period interruption of greater than 6 months occurs.

d. Two years has elapsed since last certification.

4. Certification shall be revoked when:

a. Certificate holder fails recertification.

b. Certificate holder fails to meet visual acuity requirements of paragraph 5.2.

c. Termination of employment.

d. Supplier training program fails to meet requirements set forth herein or set forth otherwise in the contract.

5.7 Training Resources

1. The training received at the NASA Training Centers will be based on the basic principles of surface mount technology. The training will not address specific brands of equipment.

2. Training of Level B instructors is available at either the Goddard Space Flight Center (GSFC) or the Jet Propulsion Laboratory (JPL). The NASA Generic Surface Mount Technology Training Plan will be supplied to instructors at the time of course completion.

a. GSFC
Training Center
Code 300.1
Greenbelt, MD 20771
(301) 731-8632
FAX (301) 731-8628

b. JPL
Training Center
MS83-204
4800 Oak Grove Drive
Pasadena, CA 91109
(818) 354-6730
FAX (818) 393-0090

3. Suppliers may train operator or inspector personnel in-house for certification or recertification utilizing certified Level B instructors and approved soldering programs, or arrange for this training at one of the NASA conducted schools.

4. A fee is required. Contact either training center for information.

CHAPTER 6 - FACILITIES, EQUIPMENT, AND MATERIALS

6.1 Facility Cleanliness

The work area shall be maintained in a clean and orderly condition. Smoking, eating, and drinking at the individual work station in the work area shall not be permitted. Nonessential tools and materials are not permitted at the work station. Personnel access to the work area shall be 1imited to direct performance, monitoring, and support personnel. As a minimum, facilities utilized for soldering operations, inspection, storage, and tests specified herein shall be established and maintained in accordance with the following.

6.2 Environmental Conditions

1. Unless classified as a class 100,000 clean room or white room, the area in which SMT processing is to be carried out shall be maintained in a neat orderly fashion with no loose material (dirt, dust, solder particles, oils, clipped wires, facial or body makeup) or other environmental conditions that could lead to contamination of the work piece.

2. Outside and recirculated air shall be filtered to remove dust particles. Filters shall be inspected to applicable standards monthly and changed as required. Handling and disposal of filters shall be in accordance with Federal, State, and local laws and regulations.

3. The temperature and humidity shall be monitored in the processing area. They shall be maintained within the limits defined as the comfort zone in Figure 6-1 (30 percent - 60 percent humidity, 65° - 85° F temperature). Temperature and humidity variations shall be maintained within process parameters.

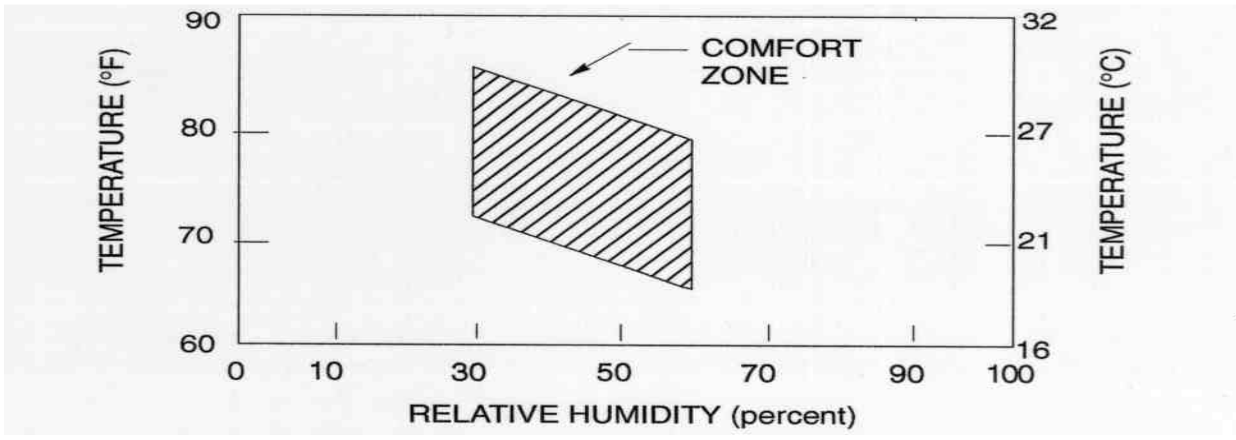


FIGURE 6-1. Comfort Zone Chart Temperature Requirements

4. Parts, materials, and equipment being processed that require more stringent control of environmental conditions than those stated above shall have those requirements and controls identified and specified in the engineering documentation.

5. Areas used for cleaning parts, and areas where toxic or volatile vapors are generated, shall have a ventilation system for removing air contaminants. The ventilation system shall comply with the recommendations and guidelines of the Occupational Safety and Health Administration (OSHA) requirements 29 CFR Part 1910.

6.3 Lighting Requirements

Illumination of the working surfaces shall have a minimum light intensity of 1076 Lm/m^2 (100 foot candles) on the surface being soldered or inspected. Supplemental lighting may be used to achieve the required lighting levels.

6.4 Tool and Equipment Control

The supplier shall:

1. Select tools and equipment used in soldering and in work preparation areas appropriate to their intended function.

2. Clean and properly maintain equipment and tools.

3. Document or reference, in the supplier's soldering program, detailed operating procedures and maintenance schedules for tools and equipment requiring calibration, functional testing, or setup.

4. Maintain records of tool and equipment calibration and verification. Calibration shall be traceable to the National Institute of Standards and Technology (NIST) in compliance with the requirements of ANSI/NCSL Z540-1-1994.

5. Prohibit unauthorized, defective, or uncalibrated tools in the work area.

6.5 Electrostatic Discharge Requirements

Electrostatic discharge (ESD) requirements shall be in accordance with NASA-STD-8739.7.

6.6 Soldering Equipment

Reflow soldering machines, soldering irons, and associated process equipment such as cleaning systems, cleanliness test equipment, preheaters, fluxers, and solder pots shall be of a type that do not expose the parts or printed wiring assemblies (PWAs) to electrical energy that would damage or degrade the items being soldered or cleaned. The soldering equipment shall not impart damage of a mechanical nature to the part body or leads. There shall be no vibration or excessive movement exhibited by the equipment which would cause discrepant solder connections or part misalignment. The equipment shall not produce electromagnetic pulses or

radiation that would damage or degrade the PWA's or part. Preheat time shall be less than the activity lifetime of the flux.

Equipment shall be appropriately stored and adequately protected when not in use. It shall be verified or recalibrated at established intervals to assure compliance and precision.

A program shall be established to assure continuing process capability. Special controls shall be developed for equipment characteristics that control the key product requirements such as soldering temperatures, contamination levels of cleaning systems, and solder paste-dispensing.

6.7 Heat Sources

1. **General.** Each supplier shall:

    a. Select tools and equipment that provide a means of applying and controlling the amount of heat to the metals to be joined which is compatible with their size, shape, and thermal conductivity. The equipment must be able to maintain the soldering temperature at the connection throughout the soldering operation.

    b. Control the cleanliness of the heat source to ensure uniform heat transfer and to prevent contamination of the solder connection.

    c. Prohibit the use of soldering guns.

CAUTION: ***HEAT SHALL NOT BE APPLIED TO A SOLDERED CONNECTION OR ADJACENT AREAS IN SUFFICIENT INTENSITY TO DEGRADE THE CONNECTION OR DAMAGE ADJACENT PARTS OR AREAS.***

2. **Conductive-Type Irons.** Soldering irons shall be of the temperature controlled type; controllable within ± 5.5°C (±10°F) of the preselected idling temperature.

    a. Soldering irons (single element, tweezers, or clamps) shall be electrically earth grounded. Prior to and periodically during use, the tip shall be checked for:

        (1) Proper insertion.

        (2) Tight attachment.

        (3) Cleanliness.

        (4) No oxidation scale between tip and heat element.

        (5) Continuously tinned surface on the tip working surface to ensure proper heat transfer and to prevent transfer of impurities.

        (6) Proper tip size relative to work involved.

        (7) Ground continuity.

(8) Pits

b. Soldering irons shall be of a type that do not produce levels of electromagnetic, electrostatic, electrical, or other forms of energy detrimental to the parts being soldered. The iron shall be a type that incorporates protective parts to limit potential differences between ground and tip to 2 mV or less.

3. **Noncontact Heat Sources.** When heat is applied by a suitable grounded jet of hot gasses, vapor phase, or by radiant energy beams, the supplier shall set up, operate, and maintain the equipment using established, documented procedures, which are subject to review by the procuring NASA Center.

4. **Supplemental Heat Sources.** When supplemental heat is applied by hot gasses, radiant energy, or any other source for aiding the hand and wave soldering process, the equipment shall be set up, operated, and maintained by personnel using established and documented procedures, which are subject to review by the procuring NASA Center. If required for ESD prevention, air ionizers shall be used.

5. **Solder Pots.** Solder pots shall be capable of maintaining the solder temperature at ± 5.5°C (±10°F) of the preselected temperature. Solder pots shall be grounded.

a. Tinning solder pots shall be analyzed on an established schedule, based on usage, to ensure that they meet the requirements of Table 6-1, and that the total of gold plus copper does not exceed 0.3 percent. Records of the analysis shall be kept. The solder pot may be replaced on an established schedule, based on usage, in lieu of analysis. When the solder produces a dull, frosty, or granular appearance on the work, the pot shall be immediately removed from use.

b. Solder pots used for tinning operations should be maintained at required temperatures and monitored, as a minimum, before and after each tinning operation or 8 hour period of pot operation.

6.8 Thermal Shunts

Thermal shunts (also called heat sinks or heat dissipater clamps) shall be used to absorb heat from part leads where necessary to protect parts and insulating materials from damage during tinning and soldering operations. Care shall be taken in the selection, application, and removal of thermal shunts to avoid damage to conductors, parts, insulation, or associated solder connections.

TABLE 6-1. Solder Contaminant Levels

Maximum Allowable Percent by Weight of Contaminant

Contaminant	Percent Allowed
Copper (Cu)	0.25
Gold (Au)	0.20
Cadmium (Cd).	0.005
Zinc (Zn)	0.005
Aluminum (A1)	0.006
Antimony (Sb)	0.5
Iron (Fe)	0.02
Arsenic (As)	0.03
Bismuth (Bi)	0.25
Silver (Ag)	0.10
Nickel (Ni)	0.01
Gold & Copper.	0.30

6.9 Inspection Aids

Inspection shall be performed using aids conforming to the following:

1. Microscopes equipped with video cameras, monitors, and still photographic capabilities are permissible.

2. Microscopes equipped with refractor boxes, oblique illumination, or other 45° angle viewing aids are permissible.

3. Inspection light sources shall provide shadowless illumination.

4. For inspection of solder connections, magnification aids that permit simultaneous viewing with both eyes are preferred, but not required.

5. Utilize only glass optical elements.

6. The use of nondestructive inspection methods, e.g., x-ray, laser, and automated inspection systems are permissible; however, the process shall be fully documented and shall not damage parts.

6.10 In-Process Storage and Handling

1. The supplier is responsible for the development and implementation of requirements and procedures necessary to prevent damage and to control conditions that could degrade the reliability of parts and deliverable items. Containers shall be compatible with materials stored therein.

2. When handling of bare metal surfaces, which are to be soldered, is unavoidable, clean lint free gloves or antistatic finger cots shall be used. If metal surfaces are handled with a bare hand, or otherwise become contaminated, they shall be immediately cleaned using an approved solvent (see paragraph 6.14).

3. Shunts, such as bars, clips, or conductive covering, shall be used to protect an electrostatic discharge sensitive item which is not being tested or worked on.

6.11 Materials Selection

The supplier shall ensure that materials selected to be soldered will readily accept solder. All gold plating shall be removed by tinning prior to use in accordance with paragraph 7.2. All materials to be soldered shall be verified as solderable prior to use. All materials shall meet program and contractual outgassing and offgassing requirements.

WARNING: ***ALL WASTE AND HAZARDOUS WASTE RESULTING FROM THESE PROCESSES SHALL BE DISPOSED OF IN ACCORDANCE WITH FEDERAL, STATE, AND LOCAL LAWS.***

6.12 Solder

1. Solder shall conform to ANSI/J-STD-005, ANSI/J-STD-006, or equivalent. For general applications, hand soldered connections shall be made with flux cored wire solder (see paragraph 6.13). Solid solders (e.g., bar, ingot, etc.) may be used for solder pots and baths. Composition shall be Sn60 or Sn63. The composition of solder used for wave soldering shall be Sn60 or Sn63.

2. Solder paste shall be Sn63/Pb37, Sn60/Pb40, or Sn62/Pb36/Ag2 composition. Solder paste shall be compatible with base metal and shall meet the following requirements:

    a. Specify flux used in solder paste or cream in accordance with paragraph 6.13.

    b. Metal percentage and viscosity shall be selected to meet the process parameters.

    c. Particle size and shape compatible with process; elliptical and spherical shaped particles are permitted provided they are uniform for effective screening or stenciling and have a length to width ratio no higher than 1.5 to 1.

    d. Solder paste purity shall be maintained at all times whether premixed or mixed in-house, by the following:

        (1) Previously opened containers of premixed or mixed in-house solder paste shall be stored in accordance with the manufacturer’s recommendations.

        (2) Once removed, paste shall not be returned to the original container. Discard unused excess paste.

(3) Solder paste containers used for repackaging bulk paste shall not introduce contaminates.

(4) All solder paste stored under refrigerated conditions shall be allowed to return to ambient temperature prior to opening the container.

(5) No solder paste, mixed in-house or premixed, shall be used if the shelf life recommended by the manufacturer has expired. Containers shall be marked with the expiration date.

(6) Solder paste that has dried out and become lumpy or crusty shall not be used.

(7) Tools that contact solder paste shall be cleaned immediately prior to use, and shall not promote intermetallic reaction, nor introduce contaminates.

(8) The lid from the solder paste container, when removed, shall not introduce contaminants when returned to the container.

6.13 Flux

1. **Types and Usage.** Process documentation shall describe the types of fluxes, where each is used, and the necessary precautions.

2. **Rosin Flux.** Rosin flux shall conform to ANSI/J-STD-004, Type L0, L1, or equivalent. Rosin flux types R or RMA in accordance with the requirements of the former military specification, MIL-F-14256 (cancelled June 15, 1995), are considered equivalent to ANSI/J-STD-004, Types L0 or L1, respectively. For all fluxing applications where adequate subsequent cleaning is not practical, only rosin flux Type L0 (Type R of MIL-F-14256) shall be used. Liquid flux used with flux-cored solder shall be chemically compatible with the solder core flux and with the materials with which it will come in contact.

3. **Variations.** The use of any other flux compositions and forms (other than those listed in 6.13-2) shall require the approval of the procuring supplier. The request for approval shall include the following information as a minimum:

   a. A complete chemical characterization of each flux.

   b. A detailed control system for procurement, receiving inspection, storage, usage, and application.

   c. Detailed flux removal, cleaning processes, monitoring requirements, cleanliness test methods, and their results.

   d. Controls to be maintained to prevent distribution or use of the flux outside the prescribed area.

4. PWA's processed utilizing this flux shall not be returned to the production or fabrication processes until all flux has been removed and PWA's meet the cleanliness requirements of Chapter 11.

6.14 Solvents

1. The solvents or aqueous cleaners used for removal of grease, oil, dirt, flux, and other debris shall be selected for their ability to remove both ionic and nonionic contamination. The solvents or cleaners used shall not degrade the materials or parts being cleaned. A list of approved solvents and cleaners is provided in Table 6-2. Mixtures of the approved solvents may be used. Solvent containers shall be properly labeled. The use of any other solvents requires the approval of the procuring supplier and shall be identified in the supplier's engineering documentation. Material Safety Data Sheets (MSDS) for solvents and cleaners shall be available for personnel review.

2. Methyl alcohol, secondary butyl alcohol, and tertiary butyl alcohol shall be used only when purchased as a constituent of an already blended solvent. Pure methyl alcohol or secondary butyl alcohol shall not be used alone as a solvent.

3. When deionized water is used, care shall be exercised to ensure that proper drying is accomplished immediately after its use.

NOTE: ***CLEANERS AND SOLVENTS SHALL NOT BE USED IN ANY MANNER THAT WILL CARRY TO OR DEPOSIT RESIDUE ON ELECTRICAL CONTACT SURFACES SUCH AS THOSE IN SWITCHES, POTENTIOMETERS, OR CONNECTORS.***

4. Water-based saponifier and detergent systems shall require the approval of the procuring supplier.

5. Solvent and cleaning systems have the potential of removing marking information from parts. Appropriate marking permanency testing shall be performed as part of the evaluation procedure for any solvent or cleaning system.

WARNING: ***SOLVENTS USED IN THE SURFACE MOUNT TECHNOLOGY MANUFACTURING PROCESS CAN BE HAZARDOUS AND VOLATILE. THESE MATERIALS SHALL BE USED IN ACCORDANCE WITH THE RECOMMENDATIONS AND GUIDELINES OF THE INDUSTRIAL VENTILATION MANUAL OF RECOMMENDED PRACTICES AND THE OCCUPATIONAL SAFETY AND HEALTH ADMINISTRATION (OSHA), 29 CFR, PART 1910. THE MATERIAL SAFETY AND DATA SHEET (MSDS) FOR EACH SOLVENT SHALL BE READILY AVAILABLE FOR ALL USERS.***

TABLE 6-2. Solvent and Cleaners

Solvent & Cleaners	Specification
Ethyl Alcohol	O-E-760, Types III, IV, or V
Isopropyl Alcohol	TT-I-735
Methyl Alcohol (See paragraph 6.14-2)	O-M-232, Grade A
Butyl Alcohol, Secondary (See paragraph 6.14-2)	ASTM-D-1007
Water	1 megohm-cm, minimum resistivity (See paragraph 6.14-3)
Detergent cleaners and saponifiers	(See paragraph 6.14-4)

6.15 Adhesives

1. Adhesives shall be readily dispensable, nonstringing, and have a reproducible dot profile after application.

2. Adhesives shall be compatible with the printed wiring board (PWB) and the part and shall not interfere or alter circuit performance.

3. Adhesives shall be noncorrosive.

4. Adhesives shall have sufficient strength or surface tension to hold parts during handling prior to cure.

5. Some adhesives can become brittle when in contact with solvents. Compatibility tests shall be performed between the adhesives and the solvents used for cleaning the assembly prior to use.

6. The adhesive material shall meet program outgassing, offgassing, and flammability requirements.

6.16 Oil Used For Wave Soldering

When oil is used to reduce surface tension and oxidation of the liquid solder, it shall be selected using the following criteria:

1. Thermal stability or low evaporation loss.

2. Long length of “use life” before a change is necessary.

3. Low weight loss.

4. High boiling point.

5. Good wetting ability.

6. Ease of removal from the assembly after soldering.

The only additives allowed in the oil are oxidation inhibitors, wetting agents, and dross scavengers (fatty acids).

6.17 Personnel Protection

Personal protective equipment shall be provided as appropriate for the work being performed. At a minimum, protective equipment shall include eye protection, gloves, and ventilation systems. Protective equipment shall comply with the requirements of Occupational Safety and Health Administration (OSHA), 29 CFR Part 1910.

CHAPTER 7 - PREPARATION FOR SOLDERING

7.1 Coplanarity

1. **Coplanarity.** Parts shall be examined 100 percent for coplanarity from the lead to the surface to which the part is to be soldered.

   a. The use of a coplanarity block, or other means of verifying planarity, is permissible provided it meets the applicable ESD requirements.

   b. Coplanarity examination equipment shall be of a type that will not damage or degrade the part or part lead.

   c. Should the part or part lead be nonplanar in excess of .0762 mm (0.003 inches) to the surface, the part shall be placed in a protective container and reworked in accordance with Chapter 13.

7.2 Part or Part Lead Tinning

1. The portion of the lead and/or part, except chip capacitors and chip resistors, that will eventually become part of the completed solder connection shall be tinned with a hot tin-lead solder alloy and shall be cleaned prior to connection.

   a. Lead forming, lead alignment, or lead cutting shall be accomplished prior to tinning for ribbon leaded parts.

   b. Gold-plating on all surfaces, which become a part of finished solder connections, shall be removed by two or more successive tinning operations (solder pot or iron), or by other processes demonstrated to have equivalent effectiveness.

2. Verify that the tinned surfaces exhibit at least 95 percent coverage.

NOTE: ***THE CONTACT TIME BETWEEN GOLD PLATINGS AND MOLTEN SOLDER SHALL BE SUFFICIENT TO REMOVE ALL GOLD FROM THE CONDUCTOR. THIN RESIDUAL BANDS OF GOLD-TIN INTERMETALLIC CAN SEVERELY EMBRITTLE CONNECTIONS.***

7.3 Solder Paste Testing

Solder paste shall be submitted to the following tests:

1. Oxidation/cohesion (solder ball). This test will be performed prior to applying the solder paste to the PWB. An acceptable result of this test is the formation of one or two bright shiny solder balls that are centrally located on the test coupon. Unacceptable results include:

   a. More than two solder balls.

b. Excessively dull or frosty appearance.

c. A halo of small particles (fines).

d. Peripheral solder balls.

2. Slump (spread). This test should be performed weekly or at some period determined by the supplier, whichever is less. The test sample should be representative of the spacing and pad sizes of the item to be fabricated.

   An unacceptable result is slumping of the solder paste to the point that it causes bridging between the deposited solder paste patterns.

3. Additional testing requirements for verification of the working life of the solder paste shall be documented by the supplier and approved by the procuring supplier.

4. The test method shall be as described in Appendix A.

7.4 PWB Preparation

1. Prior to use, the PWB shall be examined for:

   a. Oxidation.

   b. Discoloration.

   c. Damage.

   d. Contamination.

   e. Flatness.

2. The PWB's shall be cleaned and demoisturized prior to soldering. The bake-out time and temperature shall be established and defined in the supplier's process documentation. Demoisturizing shall be performed within 8 hours prior to soldering. Bakeout time and temperature, and the time in and time out of the oven or chamber shall be recorded. The PWB's may be stored for longer periods of time in a controlled, moisture-free atmosphere. Precleaned PWB's shall be placed on a holding fixture in a calibrated convection oven. The holding fixture shall provide sufficient support to the PWB during the bake cycle to prevent warping.

CHAPTER 8 - MATERIAL DEPOSITION AND PARTS PLACEMENT

8.1 General

The supplier's engineering documentation shall define the material deposition and parts placement requirements of this chapter.

8.2 Solder Deposition

1. Solder paste or cream shall be deposited on the substrate or land pattern by means of a stencil, screen, or syringe. The solder deposition process shall be consistent and repeatable. Process documentation shall define the method for solder paste/cream deposition and its accept/reject criteria.

2. The supplier shall demonstrate that the solder deposition process remains within the limits defined by this Standard and engineering documentation.

NOTE: ***FOR CONSISTENCY IN VOLUME OF SOLDER DEPOSITION, AN AUTOMATED OR SEMI-AUTOMATED SCREEN/STENCIL PRINTER IS RECOMMENDED.***

3. The supplier shall determine the working life of the solder paste and shall maintain the soldering process within these limits.

NOTE: ***THE SOLDER PASTE CONTAINER SHALL NOT BE LEFT OPEN ANY LONGER THAN NECESSARY DUE TO THE RAPID OXIDATION PROCESS OF THE SOLDER PASTE AFTER REMOVAL.***

8.3 Screen Printing

1. For a clear definition of print, the mean particle size of the solder paste shall be a maximum of 1/3 the size of the screen mesh.

2. The screen positioned above the substrate shall be in a parallel plane to the substrate.

3. The snap-off distance between the screen and the substrate shall be defined in the engineering documentation.

4. The squeegee shall be of a rubber or synthetic material that will not damage or degrade the screen.

5. The frame size of the screen shall be 2X the print area, unless otherwise defined by the engineering documentation.

6. The emulsion thickness on the wire mesh shall be defined by the engineering documentation.

7. The mesh size, mesh angle, emulsion, and paste thickness tolerance shall be determined using the screen manufacturer's instructions and shall be defined in the engineering documentation.

8.4 Stencil Printing

1. The pattern area of the stencil shall be metal foil (e.g., brass, stainless steel).

2. The open area in the stencil shall be optimized at each solder paste deposition site, such that the final solder joint, after reflow, appears as specified in Appendix B.

3. The thickness of the stencil pattern shall be design driven and specified in the engineering documentation.

4. When additional solder volume is required by design, it is permissible for the etched area in the stencil to be larger than the associated footprint.

5. When the stencil design is larger than the associated footprint, the spacing between solder deposits shall be sufficient to prevent solder bridges.

6. A method for holding the substrate in registration with the stencil shall be employed. Tolerances for the degree of accuracy required shall be part of the engineering documentation.

7. The squeegee shall be of a material that will not damage or degrade the stencil.

8. The frame size of the stencil shall be l.5X the print area unless otherwise dictated by the engineering documentation.

8.5 Syringe Dispensing

1. Dispensing grade solder paste shall be used in a preloaded cartridge for syringe dispensing.

2. Printing grade solder paste shall not be used in syringe dispensers.

3. A dispensing schedule relative to part size and interconnecting sites shall be developed and defined in the engineering documentation.

8.6 Paste Alignment and Thickness

1. Required solder paste thickness range shall be documented. Solder paste thickness shall be verified. The use of a microscope or solder paste depth gauge is permissible for solder paste thickness measurements.

2. Solder paste alignment for each PWB shall be examined for compliance to paragraph 12.6. The solder paste alignment inspection results shall be recorded.

8.7 Parts Placement and Alignment

CAUTION: ***MANY OF THE SMALL CHIP PARTS HAVE NO PART MARKINGS. CARE MUST BE EXERCISED TO AVOID MIXING OF PARTS THAT LOOK IDENTICAL, BUT HAVE DIFFERENT VALUES.***

The supplier shall develop and document parts placement and alignment requirements which meet the minimum process and quality acceptance requirements of this Standard, as well as any criteria unique to the process.

1. Equipment, tools, fixtures, and materials used to hold, position, or restrain parts shall not damage or deform the part, part leads, or the substrate. Improper or excessive tension or compression shall not be applied to the part during mounting.

2. Parts shall be placed in the solder paste within a maximum of 2 hours, and the solder paste reflowed within a maximum of 4 hours of solder paste application unless otherwise specified in the supplier's engineering documentation. Part alignment rework shall be accomplished within the specified time allotment from solder deposition to solder reflow. See paragraph 8.2-2.

3. Failure to meet the criteria in Chapter 12 shall cause the part to be realigned manually.

4. Part placement and alignment shall be examined prior to solder reflow.

   a. Marked parts shall be mounted with the markings visible.

   b. There shall be no evidence of cracks, nicks, or chip outs in the part or substrate termination area.

   c. There shall be no evidence of glass fibers or lifted circuitry.

   d. Parts shall be mounted parallel to the surface of the PWB.

   e. Unless a part is specifically designed to accept another part into its configuration, there shall be no piggy-backing or stacking of parts.

   f. Smeared solder paste bridging conductors are unacceptable.

   g. Chip parts shall be positioned as close as possible to the center and aligned with the edges of the footprint.

      (1) A chip part shall not have lateral overhang more than 25 percent of the width of the part.

      (2) The inside overhang of the chip to land pattern area shall not be more than 50 percent of the end termination width.

h. Gull wing leads shall be positioned as close as possible to the center of the footprint.

    (1) Gull wing leads shall have a maximum of 25 percent lateral overhang.

    (2) Gull wing leads shall have a maximum of 25 percent toe overhang.

i. J-leaded parts shall have a maximum of 25 percent lateral or toe overhang.

j. L-leaded parts shall have a maximum of 25 percent lateral overhang.

k. Butt or I-leads shall have a maximum of 25 percent lateral overhang.

l. Metal Electrode Face (MELF) parts shall be positioned as close as possible to the center of the footprint.

    (1) Side overhang shall not exceed 25 percent of the termination thickness.

    (2) Inside overhang shall not exceed 50 percent of the termination thickness.

m. Leadless Chip Carriers (LLCC) parts shall not overhang the land.

8.8 Part Placement In-Process Inspection

Parts placement and alignment shall be inspected using magnification of 4X to l0X prior to solder reflow and the results documented.

1. PWB substrate and parts shall not be damaged by placement of parts, or by the tools used to place the parts.

2. Parts which have had the seal broken or operational elements exposed are unacceptable.

3. Thick film chip resistors shall be positioned with the colored protective glass film in the “up” position.

4. The parts shall be positioned and aligned on locations with the orientation in accordance with the engineering documentation.

8.9 Adhesive Dispensing

Adhesives shall be deposited on the substrate by means of a stencil or syringe. The adhesive deposition process shall be consistent and repeatable. Engineering documentation shall define the method for adhesive deposition and its accept/reject criteria. Adhesives shall be cured following parts placement inspection per the manufacturer’s recommendation prior to soldering.

8.10 Adhesive Registration and Thickness

1. Required adhesive thickness range shall be documented. The adhesive thickness shall be verified. The use of a microscope is permissible for adhesive thickness measurement.

2. The adhesive dot should be centered under the body of the part equidistant between the land pattern areas.

3. The adhesive dots shall not contact solderable surfaces of land patterns, part leads, or part terminations.

8.11 Support Equipment

Placement equipment and other support equipment shall in no way create, induce, or impart harmful and damaging electrostatic charges or physical damage to the parts being positioned or otherwise dispensed.

Equipment used to deposit solder pastes and adhesive creams shall be of a screening, stenciling, or syringe dispensing type. The equipment shall be capable of applying pastes or creams of a viscosity and quantity optimum to hold the positioned part to the PWB before and during the soldering operation. The equipment shall be capable of ensuring accurate/uniform coverage. The equipment used to apply solder preforms shall be capable of ensuring accurate/uniform positioning or alignment of the preform with the land or part lead/termination as applicable.

CHAPTER 9 - SOLDERING PROCESSES

9.1 General

A soldering log shall be maintained showing pre-heat temperature, solder reflow temperature, and time in each zone for each PWA type in order to repeat previously successful runs. Computer generated profiles for each PWA type are acceptable.

When PWA's are required to be submitted to more than two mass reflows the reason for the additional processing shall be documented, and notification shall be provided to the procuring NASA Center within 24 hours.

9.2 Reflow Soldering Systems

1. **Heater Bar Reflow Soldering.** This type of reflow soldering equipment shall provide an optical feature or equivalent to ensure proper part alignment. The part lead foot shall be located within 20 percent of the nominal land foot length by this feature. Improper or excessive tension or compression shall not be applied to the part during solder solidification. In addition, these equipment shall:

    a. Maintain the part lead or shorted bar to a preselected temperature that is a minimum of 12° C (20° F) above the melting point of the solder. Maximum temperature shall not damage parts or substrate.

    b. Maintain the dwell time temperature at ± 2.5 percent of the preset value.

    c. Incorporate the power supply time at temperature control.

    d. Provide repeatable electrode down force to within 15 percent of the preset value.

2. **Condensation reflow soldering.**

    a. The preheat temperature shall be controlled to a selected PWA temperature prior to solder reflow.

    b. The solder reflow fluid shall have a minimum boiling point of 12° C (20° F) above the melting point of the solder paste/cream being used. Maximum temperature shall not damage parts or substrate.

    c. A ventilation system shall be used which conforms to the environmental conditions as described in paragraph 6.2.

3. **Convection/radiation reflow soldering**

    a. The preheat temperature shall be controlled to a selected PWA temperature prior to solder reflow. The selected temperature shall be maintained within ± 2° C (± 5° F) at the heater.

b. Solder reflow temperature shall be controlled to a preselected temperature. This temperature shall be maintained ± 6° C (± 10° F) at the PWA surface in the reflow zone during solder reflow. Maximum temperature shall not damage parts or substrate.

c. A soldering log shall be maintained showing preheat temperature and solder temperature range for each PWA type in order to repeat previously successful runs.

d. A ventilation system shall be used which conforms to the environmental conditions as described in paragraph 6.2.

4. **Hot gas/air reflow soldering**

a. The preheat temperature shall be controlled to a selected PWA temperature prior to solder reflow.

b. The soldering reflow temperature, measured on the PWA surface, shall be controlled.

c. The equipment shall prevent solder reflow, minimize thermal shock cycling, and not jeopardize the integrity of adjacent parts and PWA's during the solder reflow process.

d. A reflow soldering log shall be maintained showing preheat temperature and the reflow temperature range for each PWA type in order to repeat previously successful runs.

5. **Automated or automatic wave-soldering**

a. The preheat temperature shall be controlled to a selected PWA temperature. The selected temperature shall be maintained within ± 2°C (± 5° F).

b. The conveyor speed shall be controlled to a preselected rate and shall not vary more than 25.4 mm (1 inch) per minute.

c. Solder temperature shall be controlled so that the solder in the wave is 248.9° C (480° F) to 273.9° C (525° F).

d. The height of the solder wave shall be controlled to a constant preselected height.

e. The solder bath shall be analyzed on an established schedule, based on usage, to assure it meets the requirements of Table 6-1. Anytime the solder produces a dull, frosty, or granular appearance on the work, the bath shall be removed from use.

f. The oil shall be analyzed on an established schedule, based on usage, to determine the rate of degradation and the oil replacement period.

g. A wave soldering log shall be maintained showing preheat temperature, conveyor speed, solder temperature range, and wave height for each PWA type in order to repeat previously successful runs.

9.3 Cleaning After Soldering

After soldering, the flux dross inhibitor, solder resist, and oil shall be promptly removed in accordance with Chapter 10.

CHAPTER 10 - CLEANING OF SURFACE MOUNT PWA'S

10.1 General

1. Cleaning solvents and agents shall be of a type listed in Chapter 6.

2. PWA's to be cleaned shall be handled in a manner that will not degrade or damage the parts or PWB.

3. Parts and PWA's shall be cleaned and dried in a manner that does not damage or degrade the hardware (including Electrostatic Discharge damage).

4. Specific procedures shall be developed for drying unsealed parts that are immersed or aqueous cleaned.

5. PWA's shall be cleaned within a time frame that permits removal of contaminants.

10.2 Cleaning Systems

1. Cleaning systems and equipment used to clean solder connections of surface mounted parts and PWA's integrating surface mounted parts may be manual or automated multiple zone types. Acceptable cleaning systems include:

   a. Vapor degreasing equipment.

   b. Aqueous cleaning system.

   c. A combination of the above systems.

CAUTION: ***CONVEYORS, PALLETS, ETC., MOVING UNITS FROM ONE ZONE TO ANOTHER OR THROUGHOUT THE SYSTEM SHALL BE OF A MATERIAL AND CONFIGURATION THAT PRECLUDES CONTAMINATING, DAMAGING, OR OTHERWISE DEGRADING THE UNIT OR PARTS THEREOF.***

2. Aqueous cleaning, hi-pressure washing machine, or semiautomatic equipment shall not be used for cleaning electrical or electronic parts or PWA's, unless it has been demonstrated that the reliability of the parts or PWA's will not be degraded by the process. Use of this method of cleaning requires prior authorization from the procuring supplier.

10.3 Sonic Or Ultrasonic Cleaning

Ultrasonic cleaning shall not be used for cleaning assemblies that contain electronic parts.

10.4 Cleaning Processes

1. **Manual Cleaning.** Manual cleaning shall, as a minimum, be the three step method. The manual cleaning process shall contain the following:

   a. PWA's shall be immersed in an approved solvent bath and scrubbed with a natural bristle brush until all visible contaminants have been removed.

   b. The PWA shall be rinsed by immersion in a second, clean, approved solvent bath.

   c. Rinse the PWA, by immersion, in a third clean approved solvent bath, or by spraying/pouring the solvent from a bottle.

   d. This process shall be repeated until there is no visible evidence of flux residue or other contamination. Spray should only be used if the nozzle is properly grounded, or if it has been tested to show that the solvent is static free.

<u>NOTE</u>: ***AS SOLVENT BATHS BECOME VISIBLY CONTAMINATED, THEY SHALL BE REPLACED.***

2. **Vapor Degreasing - General Requirements:**

   a. Use of solvents other than those listed in Chapter 6 require prior approval from the procuring supplier.

   b. Do not use vapor degreasing on conformally coated PWA's.

   c. Maintain vapor degreaser as per manufacturer's recommendations.

   d. Vapor degreaser engineering documentation shall be generated by the supplier and approved by the procuring supplier.

   e. The vapor degreaser operating engineering documentation shall contain the following information as a minimum:

      (1) The rate of speed for lowering and raising the PWB in and out of the vapor zone. Speed shall be such that parts dry as they exit the vapor.

      (2) Length of time the PWB is exposed to the vapor or condensate sump.

      (3) If a spray nozzle is used, the distance from the end of the nozzle to the PWB.

      (4) Length of time the PWB is exposed to the vapor or condensate sump after spraying.

   f. Parts or PWA's shall not have contact with the boiling sump. A handling rack which will prevent part damage, assure vapor circulation around all parts and PWA surfaces, and provide for condensate drainage shall be used.

CHAPTER 11 - CLEANLINESS REQUIREMENTS

11.1 General

Cleaning requirements shall be specified in the supplier's engineering documentation.

11.2 Cleanliness Testing

1. Cleanliness testing is used to monitor the effectiveness of post-soldering PWA cleaning processes. All PWA's shall be tested prior to applying conformal coating and the results recorded.

2. Two basic test methods are recommended.

   a. Resistivity of solvent extract (paragraph 11.6).

   b. Sodium chloride (NaCl) salt equivalent ionic contamination test (paragraph 11.7).

3. Other test methods must be approved by the procuring supplier before use.

11.3 Cleanliness Testing Equipment

Equipment used for cleanliness testing shall be capable of measuring the resistivity/conductivity of a test solution (75 percent by volume isopropyl alcohol and 25 percent by volume deionized water) in which contaminants from the test specimen are solubilized. The equipment shall be calibrated to a standard solution. The span of measurement (dynamic range) of the equipment shall be a maximum 3.1 megohms per square centimeter (20 megohms per square inch) of the test specimen surface (or equivalent conductivity if referenced to micrograms sodium chloride).

11.4 Testing Frequency

1. Testing shall be performed with sufficient frequency to ensure compliance with the requirements of paragraph 11.5 test limits. At a minimum, this shall consist of once per shift, and immediately prior to changing the cleaning solvent solution.

2. It is recommended that statistical process control methods be used to control continuous solvent cleaning processes. Records of relevant readings shall be maintained for early detection of a trend towards an out of specification condition.

3. In the event that the result of a test is unacceptable, all the PWA's that were cleaned between the previous passed test and this failed test are considered unacceptable.

4. Failed PWA's shall not be recleaned until appropriate corrective actions have been performed on the cleaning system to ensure its correct operation.

11.5 Test Limits

1. **Resistivity of Solvent Extract.** The resistivity of the solvent extract shall have a final value greater than 2,000,000 ohm-cm.

2. **Sodium Chloride Salt Ionic Contamination Equivalent Test.** The final value for this test must be less than 1.55 micrograms per square centimeter (10 micrograms per square inch) of PWB surface area.

11.6 Resistivity of Solvent Extract

Solvent extract resistivity shall be measured as follows (also see Table 11-1).

1. Prepare a test solution of 75 percent by volume isopropyl alcohol and 25 percent by volume deionized water. Pass this solution through a mixed bed deionizer cartridge. After passage through the cartridge, the resistivity of the solution shall be greater than 6×10^6 ohm-cm (conductivity less than 0.166 micromhos/cm).

2. Clean a funnel, a wash bottle, and a container with a portion of this test solution. Measure out 1.55 milliliters of fresh test solution for each square centimeter (10 milliliters of fresh test solution for each square inch) of assembly area of both sides of the PWA.

3. Slowly direct the test solution in a fine stream onto both sides of the PWA until all the measured solution is used.

4. The resistivity of the solvent extract shall be determined using a resistivity meter.

11.7 Sodium Chloride Salt Equivalent Ionic Contaminant Test

Sodium chloride salt equivalent ionic contamination shall be measured as follows (also see Table 11-1):

1. The sodium chloride salt equivalent ionic contamination test must use a solution of 75 percent isopropyl alcohol and 25 percent deionized water. This solution must be verified for correct composition upon initial use and every 4 hours during a shift. The time limit may be extended when the results of data provide definite indications that such actions will not adversely affect the results of the test.

2. The equipment must be calibrated using a known amount of sodium chloride standard on the same schedule as the percentage composition verification.

3. The starting or reference purity of the solution must be greater than 20×10^6 ohm-centimeters (0.05 micromhos/centimeter) before each sample is tested.

4. Commercial equipment is available that can perform this test automatically. Such equipment is recommended for the control of continuous solvent cleaning operations. The equipment gives a direct readout in micrograms of NaCl per square centimeter (or square inch), but requires careful calibration to the flux system used for accurate results.

TABLE 11-1. Cleanliness Test Values

Test Method	Starting Resistivity	Ending Values
Solvent Extract Resistivity	$6 X 10^6$ ohm-cm	Shall be greater than $2 X 10^6$ ohm-cm
Sodium Chloride Salt Equivalent Ionic Contamination	$20 X 10^6$ ohm-cm	Shall be less than 1.55 micrograms/square centimeter (10.0 micrograms/square inch)

CHAPTER 12 - QUALITY ASSURANCE PROVISIONS

12.1 General

1. **Workmanship.** Workmanship shall be of a level of quality adequate to assure that the processed products meet the performance requirements of the engineering documentation and criteria delineated herein.

2. **Inspection.** Inspection for acceptability shall be performed on all solder connections, parts mounting, conductor routing, part condition, and PWB features to the requirements specified in this document. Parts and conductors shall not be physically disturbed to aid inspection. The visual workmanship standards for inspection are shown in Appendix B.

3. **Method of Inspection.** X-ray and/or laser inspection is permissible provided the parts have been x-ray hardened, or it has been demonstrated that the x-ray emission level is not detrimental to the part. Complete documentation of the x-ray and/or laser processes, procedures, and safety requirements are required.

4. **Quality Assurance.** The following functions shall be performed:

   a. Verify that all tests, examinations, inspections, and measurements specified by this document have been performed.

   b. Verify that all personnel who assemble or inspect hardware in accordance with this document have been trained and certified as specified in Chapter 5.

   c. Conduct in-process surveillance of all assembly operations to verify that all processes and procedures implementing the requirements of this document are current, approved, adequate, and being accurately utilized.

   d. Verify that parts and PWB's are cleaned, solderable, and undamaged prior to being assembled and soldered.

   e. Verify and monitor that the facility cleanliness, environmental conditions, and lighting requirements of Chapter 6 are being met.

12.2 Magnification Requirements

1. Magnification for the following shall be 4X to 45X:

   a. Solder paste testing.

   b. Coplanarity.

   c. Tinning.

   d. Part alignment.

2. Magnification for soldered connections shall be:

land width	land width	land width
> 0.65mm (0.025")	< 0.65mm (0.025")	< 0.39mm (0.015")
10X - 25X	10X - 40X	25X - 45X

3. Magnification requirements shall be specified in the inspection instructions.

12.3 Documentation Verification

Quality assurance personnel shall verify that all required documentation is current and approved. The documentation shall include:

1. **Records:**

   a. Results of the visual examination as per paragraph 5.2-1.

   b. Evidence of operator and inspector certification as per paragraph 5.5.

   c. Evidence of filter inspection and changes as per paragraph 6.2-2.

   d. Environmental monitoring as per paragraphs 6.2-3 and 6.2-4.

   e. Production and inspection tool calibration as per paragraph 6.4-4.

   f. Solder pot and bath analyses as per paragraph 6.7-5.

   g. Solder pot temperature monitoring as per paragraph 6.7-5.

   h. Solder paste tests as per paragraph 7.3.

   i. Solder paste thickness as per paragraph 8.6.

   j. Convection/radiation reflow soldering log as per paragraph 9.2-3c.

   k. Hot gas/air reflow soldering log as per paragraph 9.2-4d.

   l. Wave soldering log as per paragraph 9.2-5g.

   m. Readings of solvent cleaning processes as per paragraph 11.4-2.

   n. Cleanliness level results as per paragraph 11.5.

2. **Procedures:**

   a. Soldering program as per paragraph 4.3.

   b. Training and certification program as per paragraphs 5.1 and 5.4.

c. Calibration system as per paragraph 6.4-4.

d. Tooling and equipment operating procedures as per paragraph 6.4-3.

e. Non-contact heat source operation and maintenance procedures as per paragraph 6.7-3.

f. Use of supplemental heat sources as per paragraph 6.7-4.

g. X-ray and/or laser inspection procedures as per paragraph 6.9-6.

h. In-process storage and handling procedures as per paragraph 6.10-1.

i. Flux usage as per paragraph 6.13-1.

j. Solder cream deposition as per paragraph 8.2-1.

k. Cleaning procedures as per paragraph 11.1.

l. Rework procedures as per 13.1-4.

12.4 Documentation Authorization

Quality assurance personnel shall verify that the following documentation has been approved by the procuring NASA Center or supplier prior to implementation:

1. Special engineering requirements as per paragraph 1.4.

2. Special soldering processes, materials, or connections as per paragraphs 4.1-3 and 6.7-3.

3. Approval of departures from this Standard as per paragraph 1.5.

4. Repair as per paragraph 4.4-2.

5. Special fluxes, as per paragraph 6.13-3.

6. Water based saponifier and detergent as per paragraph 6.14-4.

7. Bake time for demoisturizing PWB’s as per paragraph 7.4-2.

8. Aqueous cleaning as per paragraph 10.2-2.

9. Vapor degreasing engineering documentation as per paragraph 10.4-2.

10. Special cleanliness test methods as per paragraph 11.2-3.

11. Verification tests as per paragraph 14.1.

12.5 Verification of Tools, Equipment, and Materials

1. **Tools and Equipment.** Tools and equipment shall be verified for conformance to the applicable requirements as found in paragraph 6.4.

2. **Material.** All materials shall be verified for conformance with engineering documentation and contract requirements. All materials shall conform to the requirements of 6.11 through 6.16. Material controls shall be implemented to ensure that only conforming materials are used. Materials not conforming or not required for the operations involved shall be removed from the work area or tagged nonusable.

3. **Solderability.** All material to be soldered shall be verified as solderable prior to use.

12.6 In-Process Examinations

Quality assurance personnel shall verify the following accept/reject criteria when required, unless the process has proven that greater deviations can be tolerated.

1. **Solder Paste Application**

   a. Reject Criteria

      (1) Solder paste bridging between lands.

      (2) Isolated solder paste.

      (3) Void in the solder paste.

      (4) Solder paste coverage less than specified by the engineering documentation.

      (5) Solder paste misalignment that covers more than 25 percent of the open area between lands.

      (6) Smeared solder paste bridging conductors.

2. **Part Alignment**

   a. Reject Criteria

      (1) Piggy-backed or stacked parts not included in the design per paragraph 8.7-4e.

      (2) Chip parts have lateral overhang more than 25 percent the width of the part or inside overhang more than 50 percent of the end termination width (Figure B-1).

      (3) Chip part tilting exceeds 25 percent of part thickness (Figure B-2).

(4) Gull wing leads have more than 25 percent lateral or toe overhang (Figure B-4).

(5) J-leaded parts have more than 25 percent lateral or toe overhang (Figure B-7).

(6) L-leaded parts have more than 25 percent lateral overhang (Figure B-9).

(7) I-leaded parts have more than 25 percent lateral overhang (Figure B-11).

(8) MELF parts have side overhang more than 25 percent of the termination thickness or inside overhang more than 50 percent of the termination width (Figure B-13).

(9) LLCC overhangs the land (Figure B-15).

3. **General Rejection Criteria.**

(1) Markings not visible on parts that are marked per paragraph 8.7-4a.

(2) Evidence of cracks, nicks, or chip outs in the part or substrate termination area per paragraph 8.7-4b.

(3) Evidence of glass fibers or lifted circuitry per paragraph 8.7-4c.

12.7 In-Process Inspections

1. **Accept Criteria:**

a. Thick film chip resistors positioned with the colored protective glass film in the "up" position per paragraph 8.8-3.

b. Parts positioned and aligned in accordance with the engineering documentation per paragraph 8.8-4.

2. **Reject Criteria:**

a. PWB substrate or parts damaged per paragraph 8.8-1.

b. Part seal broken or operational elements exposed per paragraph 8.8-2.

12.8 Inspection Criteria, General

1. **General Acceptance Criteria.** Acceptance criteria are described in Chapters 1 through 12, Appendix B, and the following:

a. The appearance of the solder joint surface shall be smooth, nonporous, undisturbed, and shall have a finish that may vary from satin to bright depending on the type of solder used.

b. Solder shall wet all elements of the connection. The solder shall fillet between connection elements over the complete periphery of the connection.

c. When a part has leads, the lead contour shall be visible.

d. Complete wetting.

e. Support of parts as identified in the engineering documentation.

f. Part marking visible.

g. A nonuniform flow line, where the solder adheres to the surface being covered, is acceptable, provided there is evidence of good wetting.

h. Absence of the defects as enumerated in paragraph 12.8-2.

2. **General Rejection Criteria.** The following are some characteristics of unsatisfactory conditions; any of which is cause for rejection:

a. Parts:

(1) Improper tinning of part leads.

(2) Part improperly supported or positioned (polarity, centering, planarity).

(3) Part damaged (especially cracks in ceramic parts).

(4) Cut, nicked, stretched, or scraped leads exposing base metal (except smooth impression marks resulting from bending tool holding forces).

(5) Flux residue or other contaminants.

(6) Improper positioning of leads to solder pad for lap terminations.

(7) Improper lead bending and cutting.

(8) Spliced part leads.

(9) Part leads used as terminals except when the part lead is designed as a terminal.

(10) Part lead more than 0.26mm (0.010 inch) above solder pad on lapped termination.

(11) A part obscuring the solder termination of another part, unless sequential inspection was performed.

b. Solder connections:

(1) Cold solder connection.

(2) Overheated solder connection.

(3) Fractured or disturbed solder connection.

(4) Poor wetting.

(5) Blowholes, pinholes, and voids (except pits as defined in paragraph 3.1).

(6) Insufficient solder.

(7) Splattering of flux or solder on adjacent areas.

(8) Rosin solder joint.

(9) Contamination (e.g., lint, flux, dirt).

(10) Dewetting.

(11) Non-wetting.

(12) Part body (meniscus) in solder joint.

(13) Dull or frosty appearance.

(14) Solder scratches.

(15) Solder cracks/fractures.

(16) Solder extending into the stress relief bend of any leaded part (Gull wing leaded parts such as Small Outline Transistor/Diode/LED (SOT), Small Outline Integrated Circuit (Gull-Wing Lead) (SOIC), Small Outline Large Integrated Circuit (Gull-Wing Lead Wide Body) (SOLIC), SOIC Package with J-Leads (SOJ), etc.).

(17) Porous.

(18) Solder webbing.

(19) Solder balls.

(20) Solder slivers.

(21) Whiskers/dendrite.

(22) Evidence of gold or gold/tin intermetallic formation.

c. Printed wiring board:

(1) Separation of conductor pattern from base laminate.

(2) Burns on base laminate.

(3) Discoloration that bridges uncommon conductors (e.g., measling, halo effect, overheating).

(4) Solder peaks, icicles, sharp edges, and bridging on conductor patterns.

(5) Cut, nicked, gouged, or scraped printed wiring conductor that exposes base metal (except for vertical edges).

(6) Cut, nicked, gouged, or scraped base laminate that exposes glass fibers.

(7) Delamination of the PWB base laminate.

(8) Solder mask tackiness, flaking, or separation from the base laminate or conductors.

(9) Repaired or damaged printed wiring conductor pattern.

(10) Blisters.

12.9 Inspection Criteria, Specific

1. Chip Parts

a. Accept Criteria

(1) Concave fillet on vertical terminal faces of the chip (See Figure B-3).

(2) Evidence of good wetting to the chip and the land (See Figure B-3).

b. Reject Criteria

(1) Part tilted more than 25 percent of the part thickness (See Figure B-2).

(2) Part tilt prevents the proper placement or mounting of adjacent parts (See Figure B-2).

(3) Solder fillet is less than 50 percent of the part thickness (See Figure B-3).

(4) Solder fillet exhibits a negative wetting angle (See Figure B-3).

(5) No evidence of solder flow under the ends of the chip (See Figure B-3).

(6) Leaching of the termination area.

(7) Lateral overhang exceeds 25 percent of the part width (See Figure B-1).

(8) Inside overhang exceeds 50 percent the end termination width (See Figure B-1).

2. **Leaded Parts**

a. Accept Criteria

(1) Concave solder fillet with evidence of good wetting of the lead to land (a heel fillet is mandatory) (See Figure B-6).

(2) Lead is discernible under the solder (See Figure B-6).

b. Reject Criteria

(1) Lateral overhang exceeds 25 percent of the lead width (See Figure B-4).

(2) Toe overhang exceeds 25 percent of the lead width (See Figure B-4).

(3) Foot nonplanarity exceeds .26 mm (0.010 inch) above the pad (See Figure B-5).

(4) A short or incomplete solder fillet, which does not extend to the land edges (See Figure B-6).

(5) No evidence of a heel fillet (See Figure B-6).

3. **J-Leaded Parts**

a. Accept Criteria

(1) Concave solder fillet with evidence of good wetting (a heel fillet is mandatory) (See Figure B-8).

(2) Lead is partially discernible at the inside curvature next to and under the part body (See Figure B-8).

(3) Lead is partially discernible at the heel (See Figure B-8).

b. Reject Criteria

(1) Lateral overhang exceeds 25 percent of the lead width (See Figure B-7).

(2) Toe overhang exceeds 25 percent of the lead width (See Figure B-7).

(3) Insufficient solder does not reach the start of the lead bend (See Figure B-8).

(4) Excess solder extending beyond 50 percent of the lead height (See Figure B-8).

(5) A negative wetting angle (See Figure B-8).

(6) No evidence of a heel fillet (See Figure B-8).

(7) Contour of the lead is not visible through the solder fillet (See Figure B-8).

4. **L-Leaded Part**

a. Accept Criteria

(1) Concave solder fillet with evidence of good wetting (See Figure B-10).

(2) Lead is discernible under the solder (See Figure B-10).

b. Reject Criteria

(1) Lateral overhang exceeds 25 percent of the lead termination width (See Figure B-9).

(2) No evidence of a heel fillet (See Figure B-10).

(3) Excess solder extending beyond 75 percent of the lead height (See Figure B-10).

(4) A short or incomplete solder fillet, which does not extend to the land edges (See Figure B-10).

5. **I-Leaded Parts**

a. Accept Criteria

(1) Concave solder fillet with evidence of good wetting (See Figure B-12).

(2) Lead is discernible under the solder (See Figure B-12).

b. Reject Criteria

(1) Lateral overhang exceeds 25 percent of the lead width (See Figure B-11).

(2) No evidence of a heel fillet across the entire contact area (See Figure B-12).

(3) Excess solder extending beyond 75 percent of the lead height (See Figure B-12).

(4) A short or incomplete solder fillet which does not extend to the land edges (See Figure B-12).

6. **MELF Parts**

a. Accept Criteria

(1) Concave solder fillet with evidence of good wetting (See Figure B-14).

(2) Solder exhibits a positive wetting angle (See Figure B-14).

b. Reject Criteria

(1) Lateral overhang exceeds 25 percent of the termination thickness (See Figure B-13).

(2) Solder fillet does not extend the entire contact area (See Figure B-14).

(3) Excess solder exhibiting a negative wetting angle (See Figure B-14).

(4) No evidence of solder flow under the ends of the part (See Figure B-14).

(5) Termination is not discernible (See Figure B-14).

7. **LLCC Parts**

a. Accept Criteria

(1) Complete concave solder fillet in the castellation (See Figure B-16).

(2) Visible evidence of solder reflow under the LLCC termination area (See Figure B-16).

(3) After reflow, stand-off height above the PWB substrate is not less than 0.127 mm (0.005 inch).

b. Reject Criteria

(1) Castellation overhangs the land (See Figure B-15).

(2) Insufficient solder fillet that does not extend at least 75 percent of the thickness of the castellation (See Figure B-16).

(3) Excess solder that exhibits a negative wetting angle (See Figure B-16).

(4) Poor flow or a nonwetting condition at the top of the solder joint (See Figure B-16).

CHAPTER 13 - REWORK

13.1 General

Rework shall be defined as an operation which returns a PWA/part to its original configuration. Rework shall not be considered repair.

1. There shall be no electrical or mechanical damage imparted to the part or PWA as a direct or indirect result of rework.

2. Equipment used to accomplish rework shall conform to the requirements of Chapter 6.

3. Rework of unsatisfactory solder connections shall not be performed until the discrepancies have been documented.

4. Supplier rework processes and procedures require prior approval.

5. Solder wicking braid is permissible during rework.

6. All uncoated PWA's submitted for rework shall be cleaned in accordance with Chapter 10 of this document as required. Special cleaning procedures shall be developed, documented, and approved by the procuring supplier for the cleaning of conformally coated PWA's.

13.2 Coplanarity Rework

Coplanarity rework of the part shall meet the requirements of paragraph 13.1, and the following:

1. Metallic tools such as tweezers shall not be used to rework leaded parts.

2. Preformed or molded tooling may be used as a holding fixture or coplanarity verification tool during the rework process.

3. Tools used to bend, move, or otherwise apply pressure to the part lead shall be a wooden orange stick or made of a soft or pliant material.

NOTE: ***PRESSURE AGAINST THE LEAD SHALL BE APPLIED IN A MANNER AS NOT TO IMPART STRESS TO THE AREA OF THE LEAD THAT ENTERS INTO OR IS ATTACHED TO THE BODY OF THE PART.***

4. Plastic tools may be used provided they are carbon impregnated or it has been demonstrated they are ESD safe.

5. Parts shall be cleaned following coplanarity rework.

13.3 Solder Paste and Part Alignment Rework (Pre-Reflow)

1. Solder paste and parts, which do not meet the alignment requirements of Chapter 8, shall be reworked as follows:

    a. Manually realign with the aid of an approved hand tool.

    b. The solder paste shall not be disturbed and shall not exhibit smearing or bridging after part movement.

    c. Should the solder become smeared the part and the solder paste shall be carefully removed.

    d. All visible traces of solder paste shall be removed from the affected area on the PWB and part leads with an approved solvent.

    e. If the PWB is populated with additional parts, new solder paste shall be deposited on the footprint with a solder paste syringe dispenser, and the part remounted.

    f. If the PWB is unpopulated it shall be completely cleaned of solder paste.

    g. The cleaned PWB shall be submitted to manufacturing for conformance to paragraph 7.4.

    h. The part may be re-used after the part leads are cleaned with an approved solvent.

13.4 Part Replacement and Realignment (Post-Reflow)

In addition to paragraph 13.1, part replacement shall meet the following requirements:

1. Hot air or hot gas rework stations are permissible provided it can be demonstrated the hot air or gas does not reflow the solder of the adjacent solder connections.

2. Wicking off of solder with wicking braid and a hand soldering tool is permissible for most parts. The exceptions are leadless chip carriers, ceramic capacitors, and resistors.

CAUTION: ***DUE TO THE FRAGILITY OF SURFACE MOUNT LAND PATTERNS, EXTREME CAUTION MUST BE EXERCISED IN THE WICKING OFF PROCEDURE. HEAT SHALL BE CONTROLLED 315°C ± 20°C (600°F ± 35°F). EXCESS MOVEMENT OF THE WICKING BRAID DURING HEAT APPLICATION WILL, IN MOST CASES, LOOSEN OR TOTALLY REMOVE THE FOOTPRINT.***

3. The reworked area shall be cleaned thoroughly prior to the deposition of fresh solder paste.

4. Hand soldering of parts is permissible provided all necessary precautions are observed to prevent part damage.

CHAPTER 14 - GENERAL REQUIREMENTS FOR VERIFICATION

14.1 General

When prescribed by the procuring NASA Center, verification tests shall be conducted to establish confidence in the reliability of the solder joints. A test plan shall be submitted to the procuring NASA Center or its designated representative for approval. The test plan shall detail the test environment, test duration, test PWA design, and failure criteria based on life and mission requirements.

APPENDIX A. OXIDATION/COHESION AND SLUMP TESTS

A.1 Oxidation/Cohesion Tests

A.1.1 General:

The oxidation/cohesion test is to be performed in accordance with the guidelines established in paragraph 7.3.

A.1.2 Materials and Equipment

Ceramic coupon, bare FR-4, bare G-10 (5.lcm x 5.1cm (2" x 2"))

Stencil

Squeegee

A.1.3 Procedure

1. Prepare the test coupon by thoroughly cleaning with an approved solvent.
2. Prepare the stencil by thoroughly cleaning with an approved solvent.
3. Ensure that the solder paste has had enough time to come to room temperature before opening the container.
4. Stir the paste thoroughly until there is no evidence of separation between the solder particles, solvents, and flux. Stir approximately one minute.
5. Place the stencil over the test coupon so that the pattern is centered on the coupon.
6. Using the squeegee, scoop out enough solder paste to fill the hole pattern in the stencil.
7. Holding the stencil firmly in place, draw the squeegee at a 45 degree angle across the hole pattern.
8. Discard the excess paste. DO NOT return the solder paste to the container. Clean the squeegee with an approved solvent.
9. Carefully lift the stencil from the coupon without smearing the paste. Release the coupon from the stenciling fixture.
10. Clean the stencil with an approved solvent.
11. Inspect the pattern to ensure that it is not smeared.
12. Reflow the coupon using the same profile and environment to be used for the actual hardware.

13. Inspect the reflowed solder paste pattern for compliance with the criteria in paragraph 7.3-1.

14. If the paste pattern fails to meet the criteria in paragraph 7.3, repeat the test.

15. If the second test passes, perform a third test to confirm the results. If the second test fails, stop the assembly process and determine the cause of the test failure.

A.2 Slump Test

A.2.1 General

The slump test is to be performed in accordance with the requirements established in paragraph 7.3.

A.2.2 Materials and Equipment

G10/FR4 coupon (5.lcm x 5.1cm (2” x 2”))

Squeegee

Stencil with test pattern

Solvent

Acid brush

Calibrated oven

A.2.3 Procedure

1. Prepare the test coupon by thoroughly cleaning with an approved solvent.

2. Prepare the stencil by thoroughly cleaning with an approved solvent.

3. Ensure that the solder paste has had enough time to come to room temperature before opening the container.

4. Stir the paste thoroughly until there is no evidence of separation between the solder particles, solvents, and flux. Stir approximately one minute.

5. Place the stencil over the test coupon so that the pattern is centered on the coupon.

6. Using the squeegee, scoop out enough solder paste to fill the hole pattern in the stencil.

7. Holding the stencil firmly in place, draw the squeegee at a 45 degree angle across the hole pattern.

8. Discard the excess paste. DO NOT return the solder paste to the container. Clean the squeegee with an approved solvent.

9. Carefully lift the stencil from the coupon without smearing the paste. Release the coupon from the stenciling fixture.

10. Clean the stencil with an approved solvent.

11. Inspect the pattern to ensure:

    a. A clear definition of print.

    b. That bridging has not occurred.

12. Verify that oven temperature is 80°C (176°F).

13. Place the test coupon in the oven for 30 minutes.

14. Remove the coupon and reset oven temperature to 170°C (338°F).

15. Inspect the test coupon for slumping or bridging. (If bridging has occurred, record the results and terminate the test.)

16. Verify that the oven temperature is 170°C (338°F).

17. Place the coupon in the oven for 3 minutes.

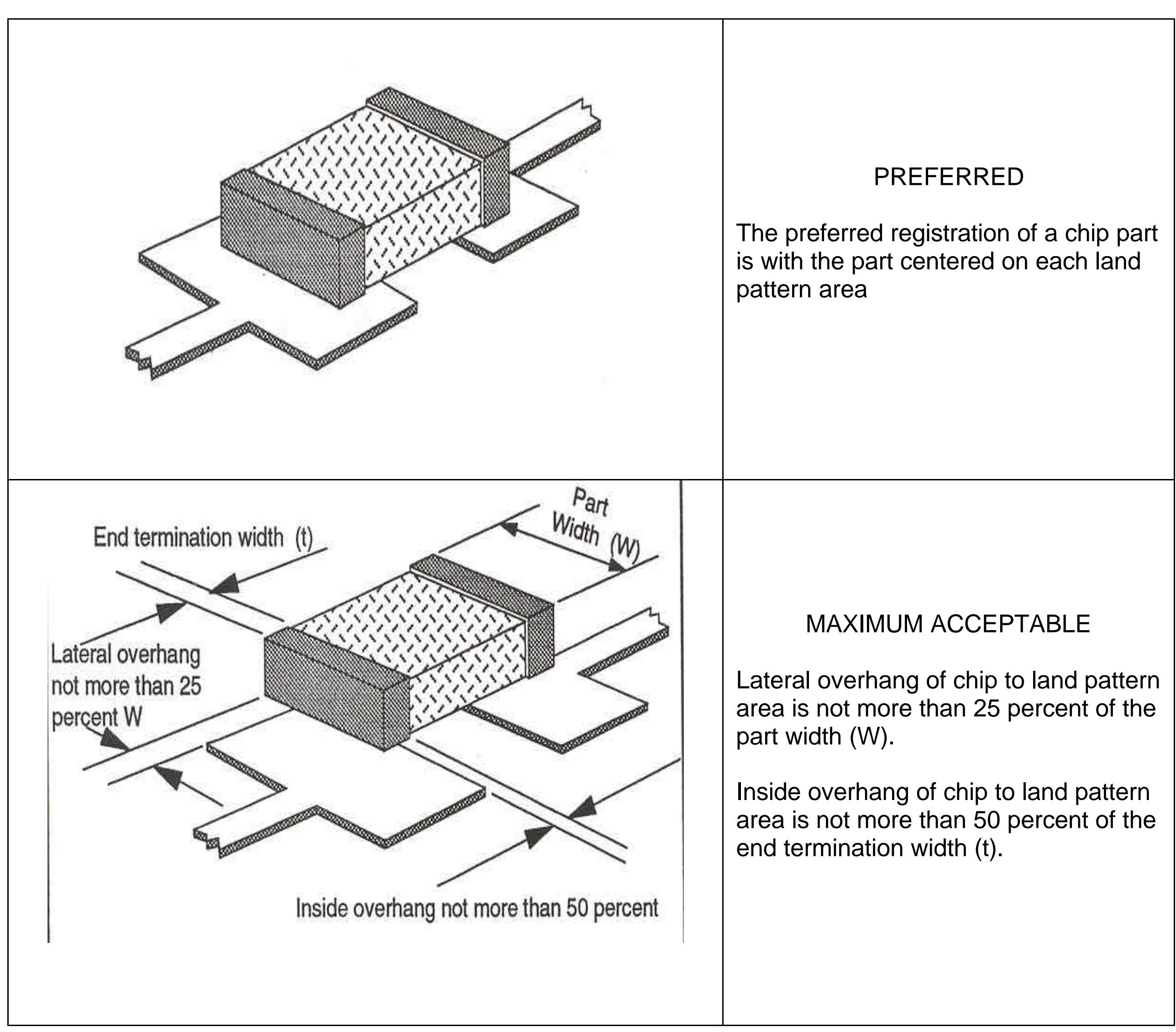
18. Remove the coupon and inspect the coupon for slumping or bridging. If bridging has occurred, record the results.

19. If the test fails at any point, thoroughly clean the coupon with an approved solvent and repeat the test. If the test fails again, record the results and disposition the solder paste. If the test passes the second test, record the results and perform the test again for verification.

20. Clean the test coupon with an approved solvent.

APPENDIX B

VISUAL WORKMANSHIP STANDARDS



PREFERRED

The preferred registration of a chip part is with the part centered on each land pattern area

MAXIMUM ACCEPTABLE

Lateral overhang of chip to land pattern area is not more than 25 percent of the part width (W).

Inside overhang of chip to land pattern area is not more than 50 percent of the end termination width (t).

FIGURE B-1. Chip Part Registration to Land

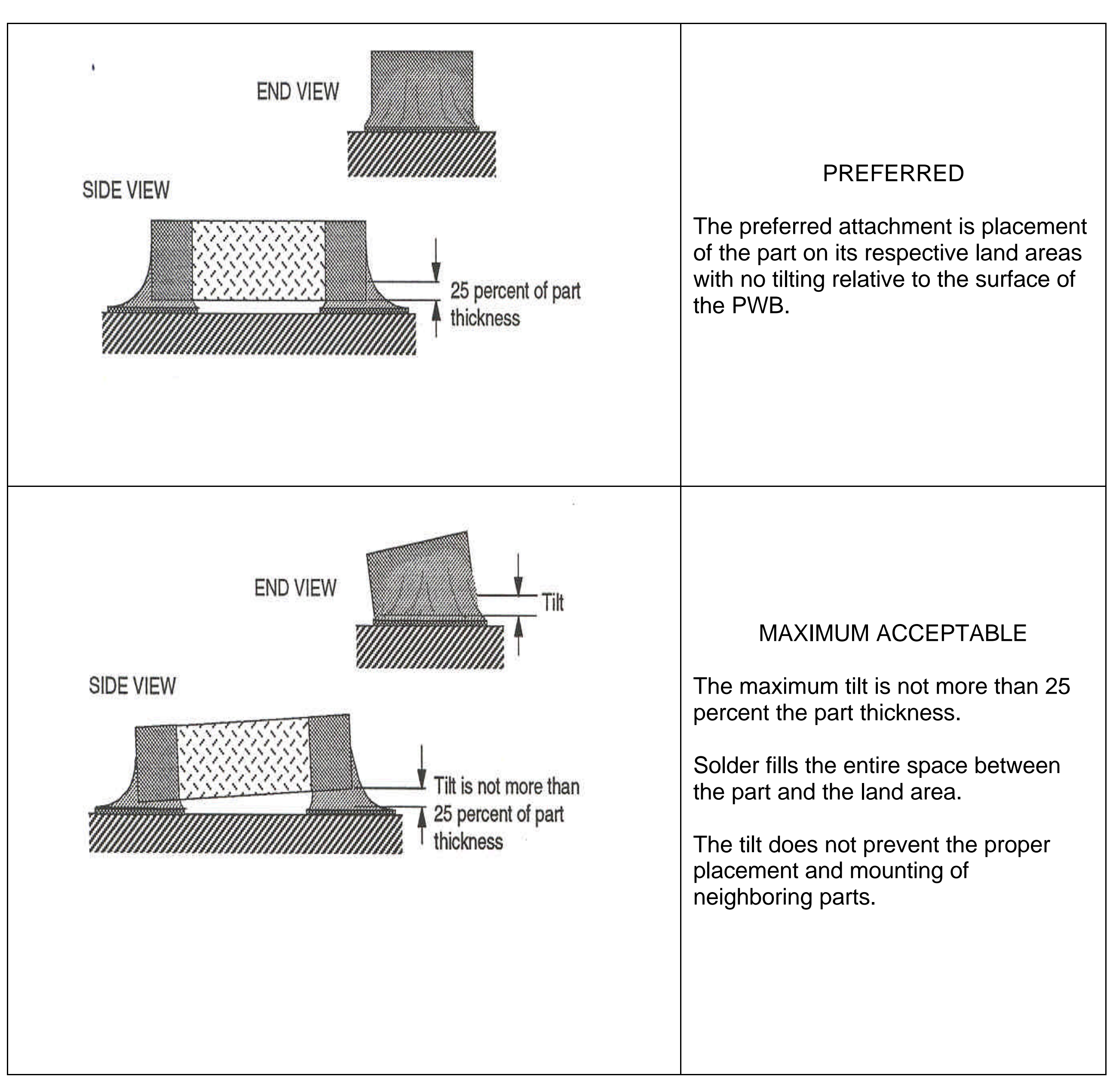
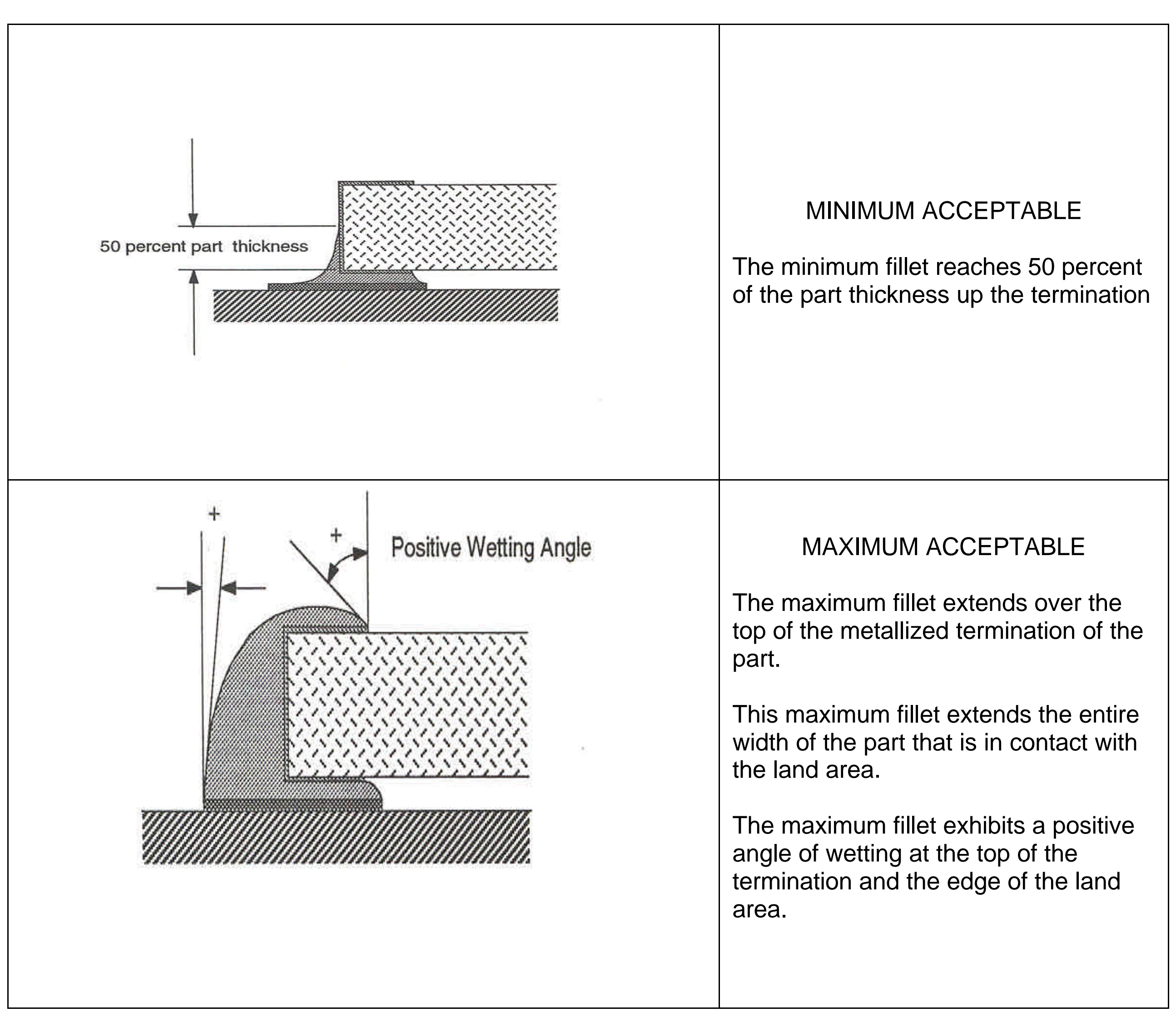
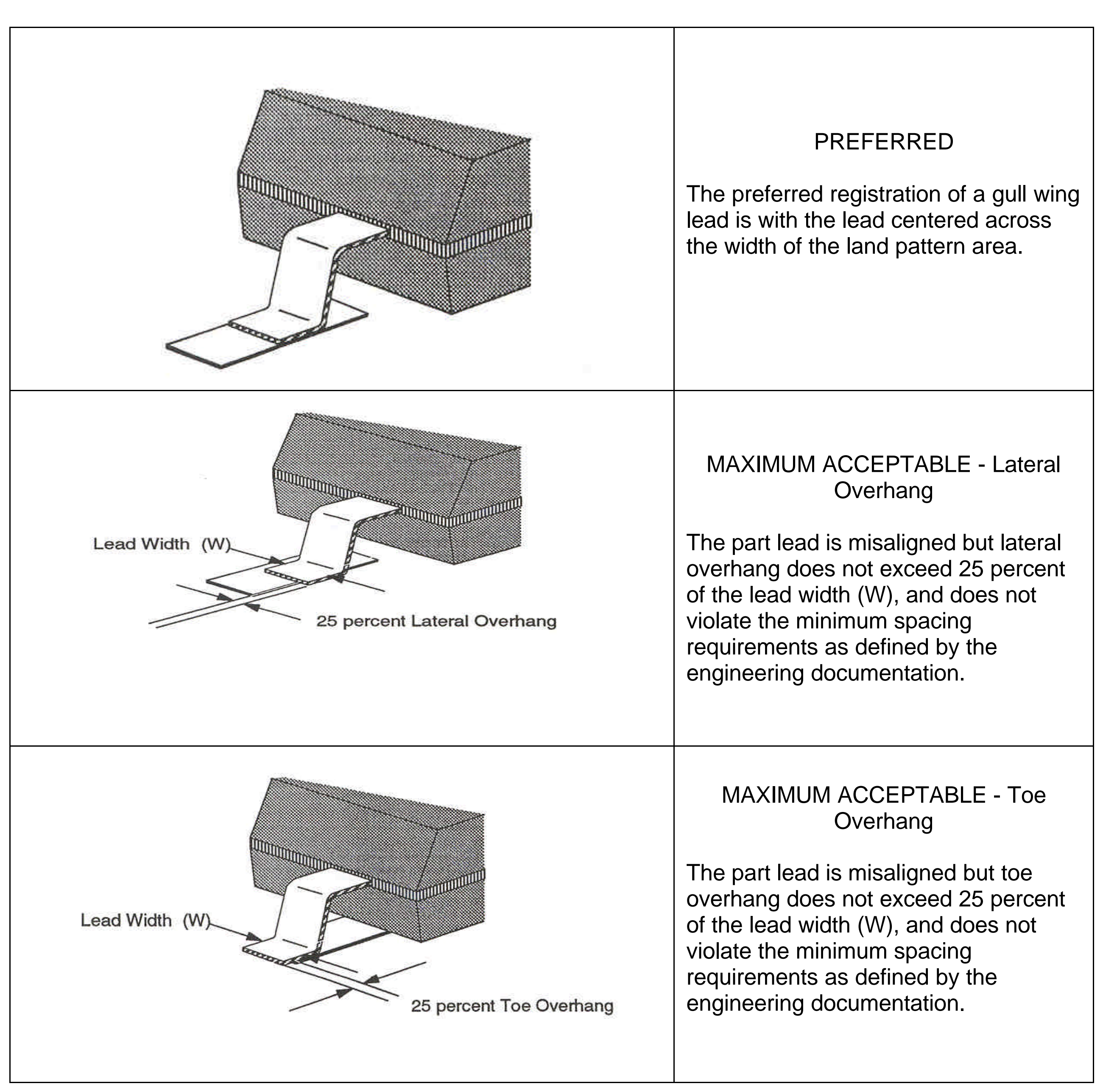


FIGURE B-2. Chip Part Tilting



	MINIMUM ACCEPTABLE The minimum fillet reaches 50 percent of the part thickness up the termination
	MAXIMUM ACCEPTABLE The maximum fillet extends over the top of the metallized termination of the part. This maximum fillet extends the entire width of the part that is in contact with the land area. The maximum fillet exhibits a positive angle of wetting at the top of the termination and the edge of the land area.

FIGURE B-3. Chip Part Solder



PREFERRED

The preferred registration of a gull wing lead is with the lead centered across the width of the land pattern area.

MAXIMUM ACCEPTABLE - Lateral Overhang

The part lead is misaligned but lateral overhang does not exceed 25 percent of the lead width (W), and does not violate the minimum spacing requirements as defined by the engineering documentation.

MAXIMUM ACCEPTABLE - Toe Overhang

The part lead is misaligned but toe overhang does not exceed 25 percent of the lead width (W), and does not violate the minimum spacing requirements as defined by the engineering documentation.

FIGURE B-4. Gull Wing Lead Registration to Land

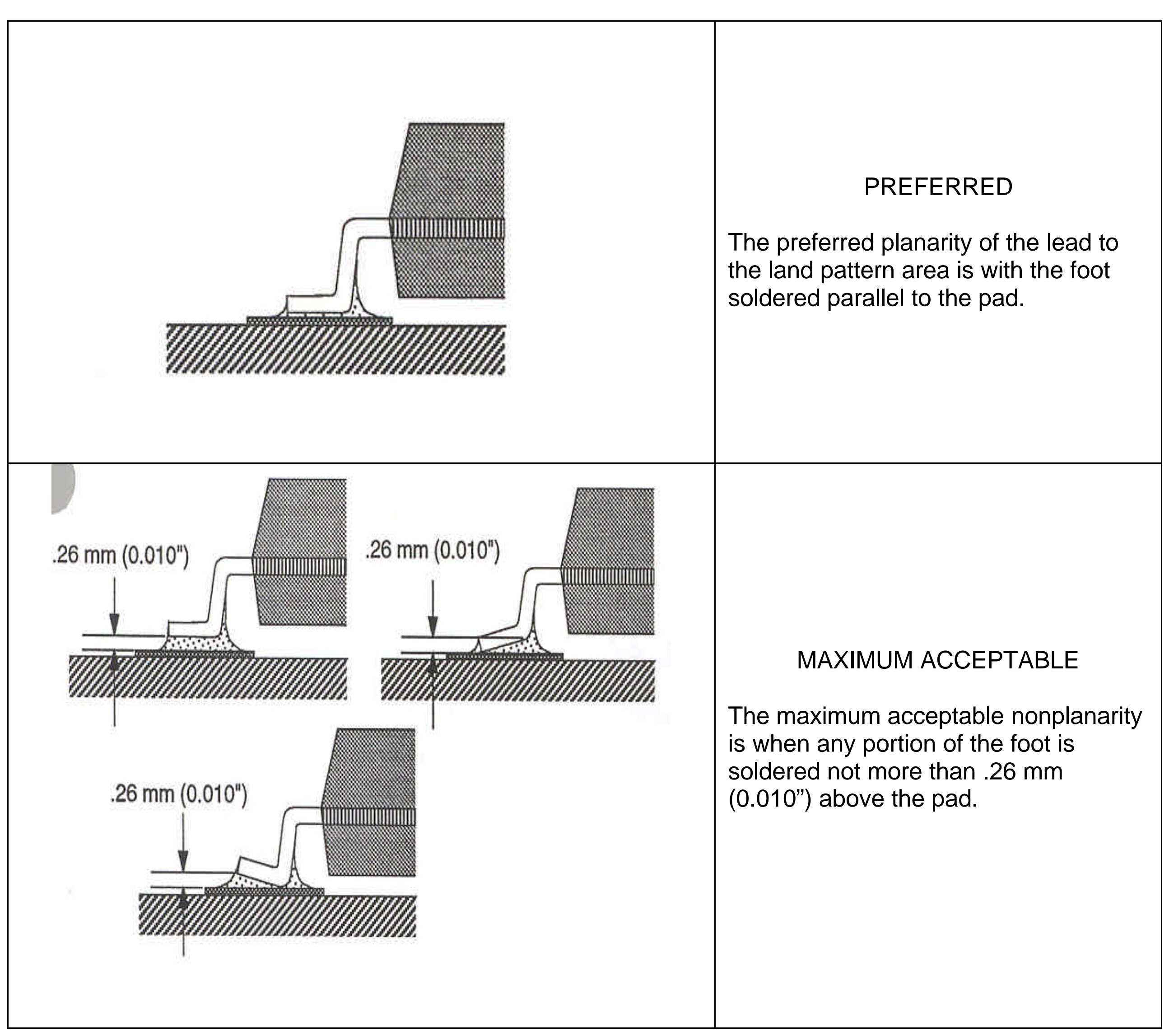
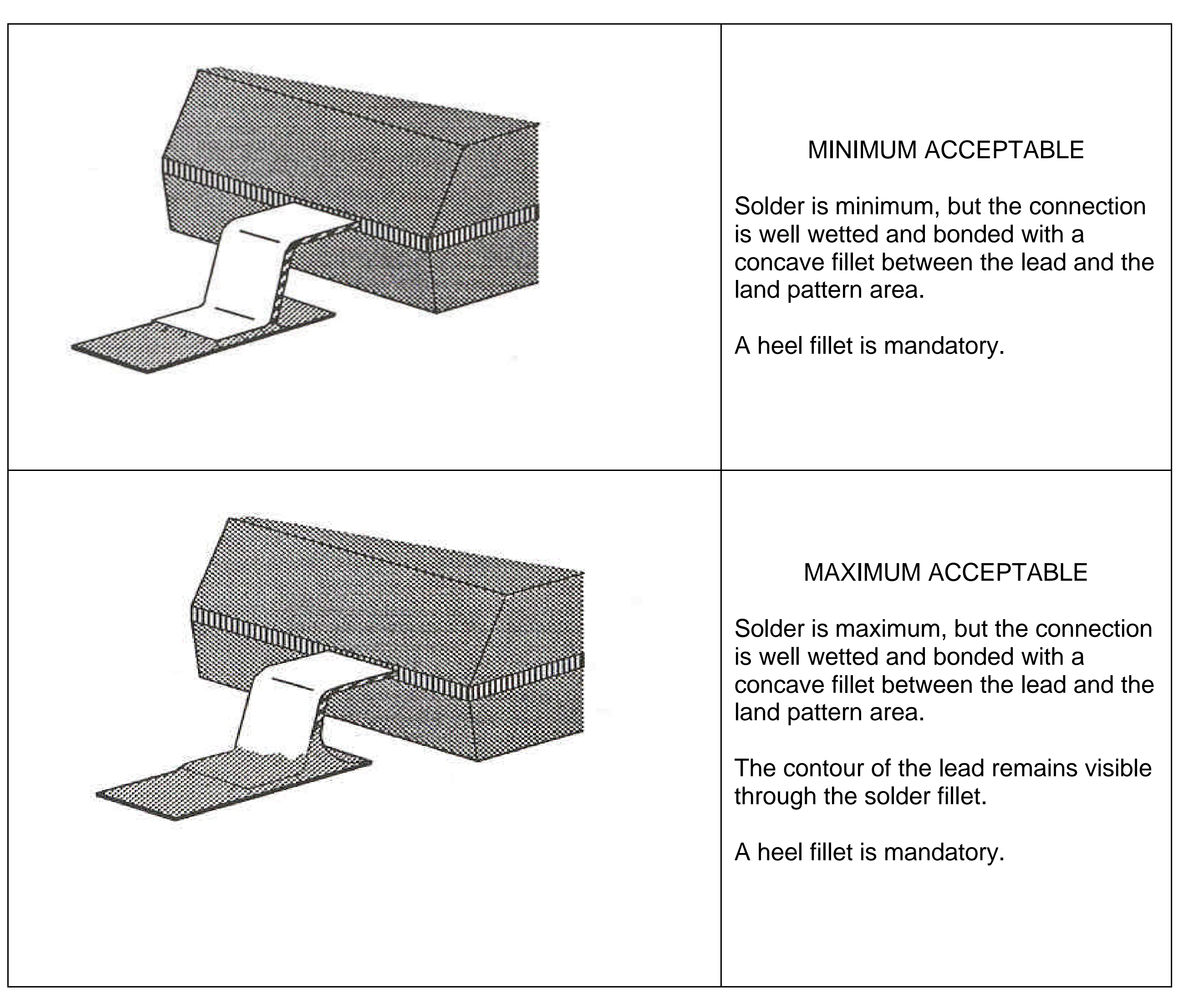


FIGURE B-5. Gull Wing Lead Planarity to Pad



MINIMUM ACCEPTABLE

Solder is minimum, but the connection is well wetted and bonded with a concave fillet between the lead and the land pattern area.

A heel fillet is mandatory.

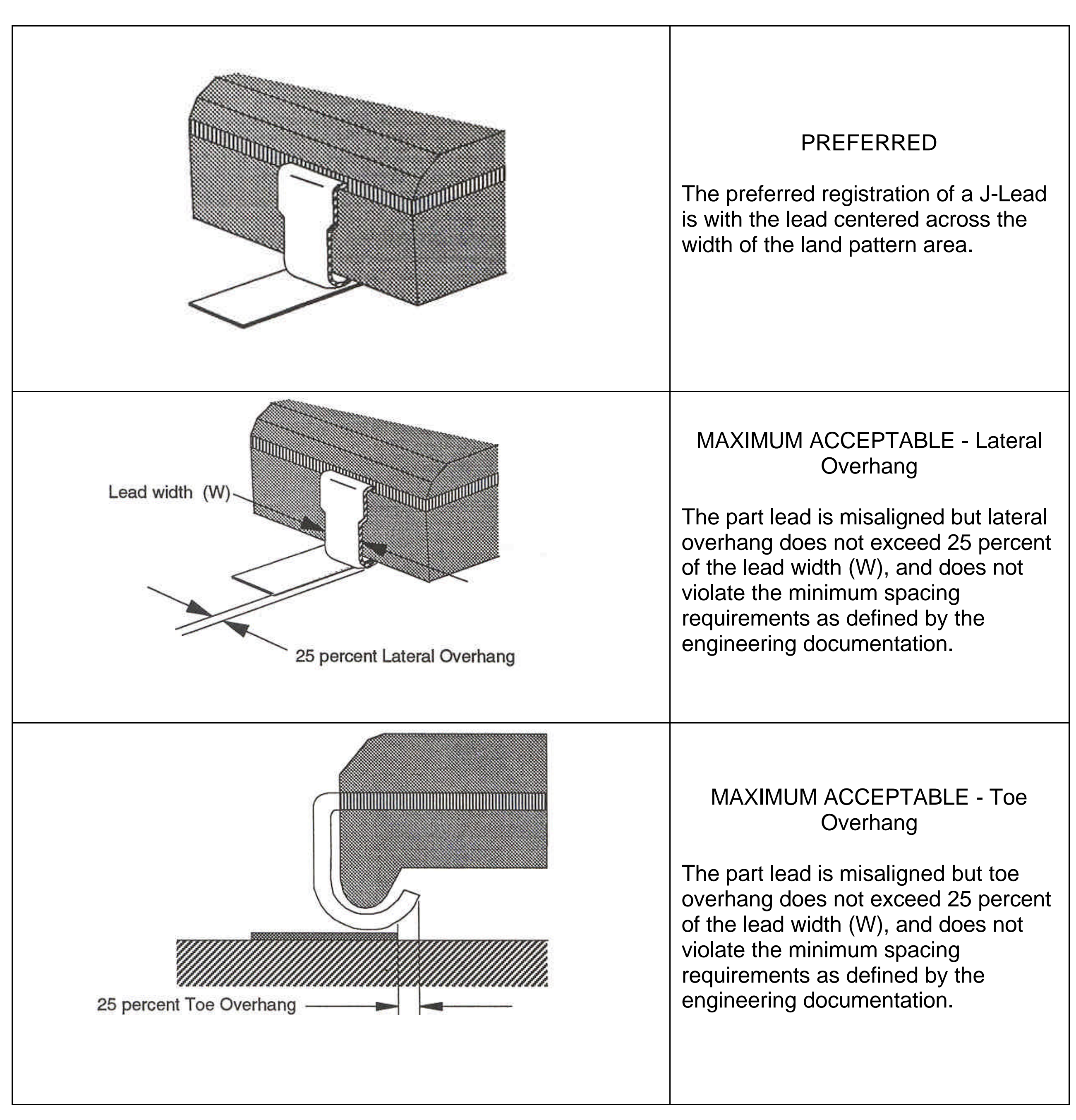
MAXIMUM ACCEPTABLE

Solder is maximum, but the connection is well wetted and bonded with a concave fillet between the lead and the land pattern area.

The contour of the lead remains visible through the solder fillet.

A heel fillet is mandatory.

FIGURE B-6. Gull Wing Lead Solder



PREFERRED

The preferred registration of a J-Lead is with the lead centered across the width of the land pattern area.

MAXIMUM ACCEPTABLE - Lateral Overhang

The part lead is misaligned but lateral overhang does not exceed 25 percent of the lead width (W), and does not violate the minimum spacing requirements as defined by the engineering documentation.

MAXIMUM ACCEPTABLE - Toe Overhang

The part lead is misaligned but toe overhang does not exceed 25 percent of the lead width (W), and does not violate the minimum spacing requirements as defined by the engineering documentation.

FIGURE B-7. J-Lead Registration to Land

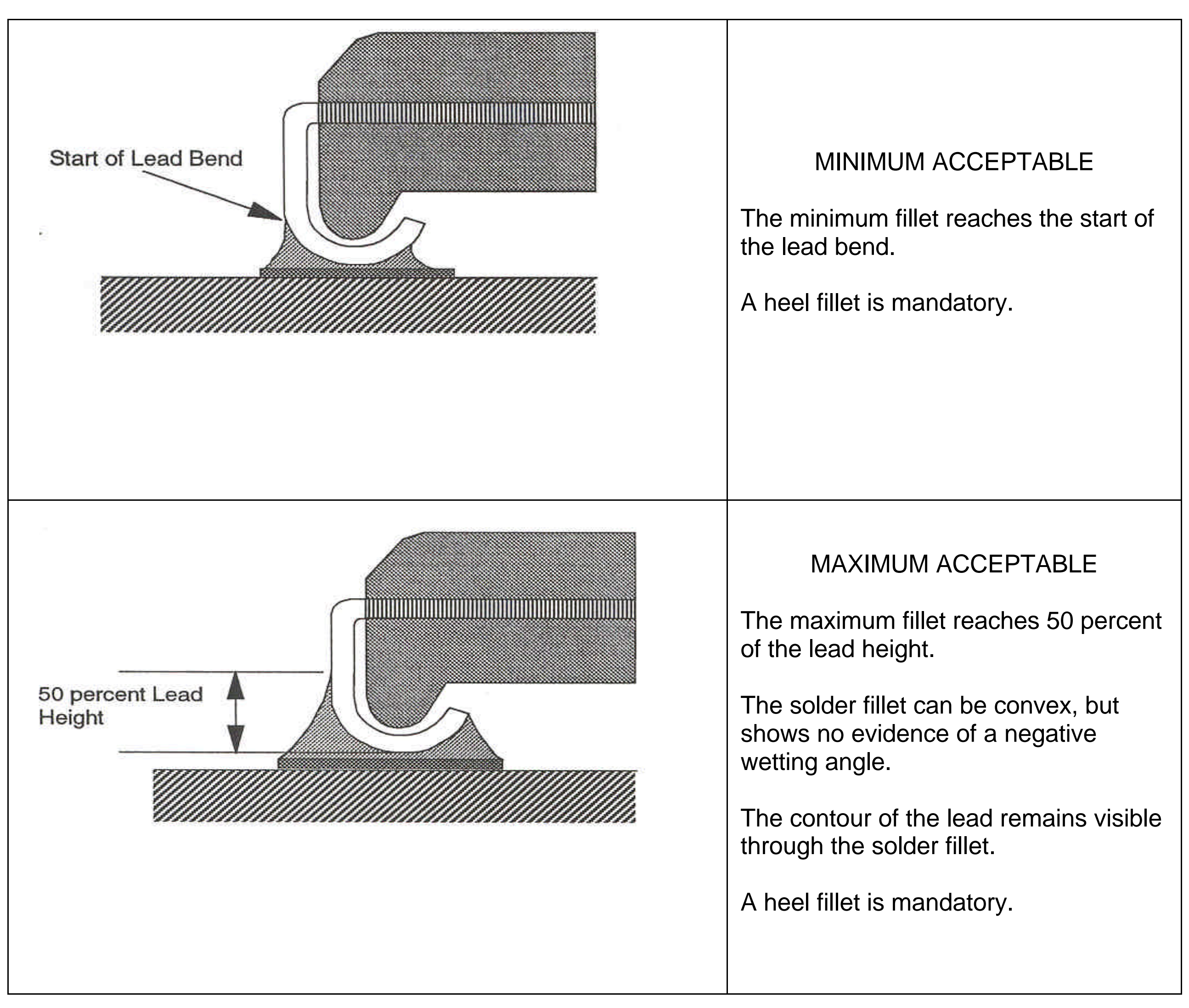
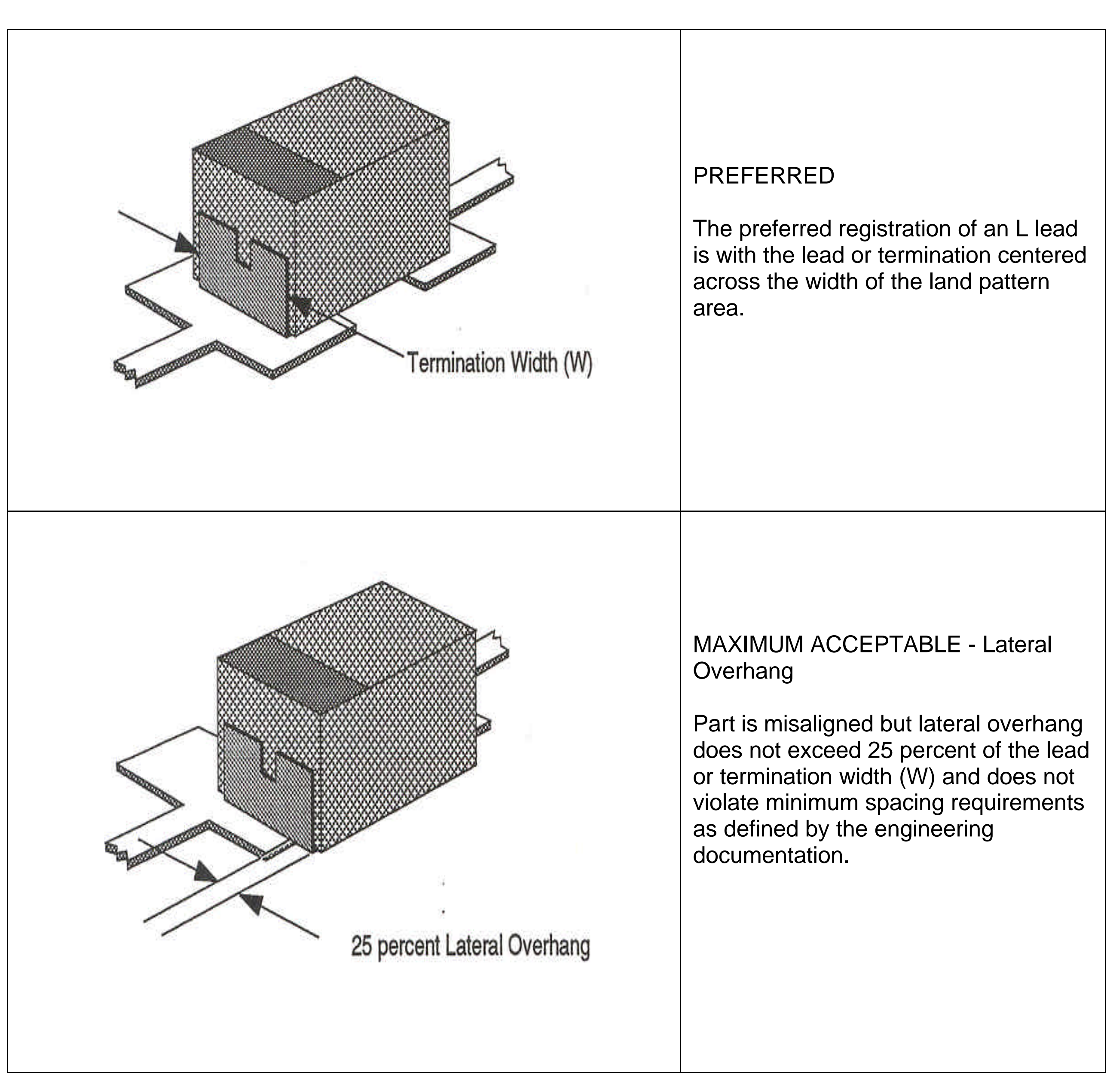


FIGURE B-8. J-Lead Solder



	PREFERRED The preferred registration of an L lead is with the lead or termination centered across the width of the land pattern area.
	MAXIMUM ACCEPTABLE - Lateral Overhang Part is misaligned but lateral overhang does not exceed 25 percent of the lead or termination width (W) and does not violate minimum spacing requirements as defined by the engineering documentation.

FIGURE B-9. L-Lead Registration to Land

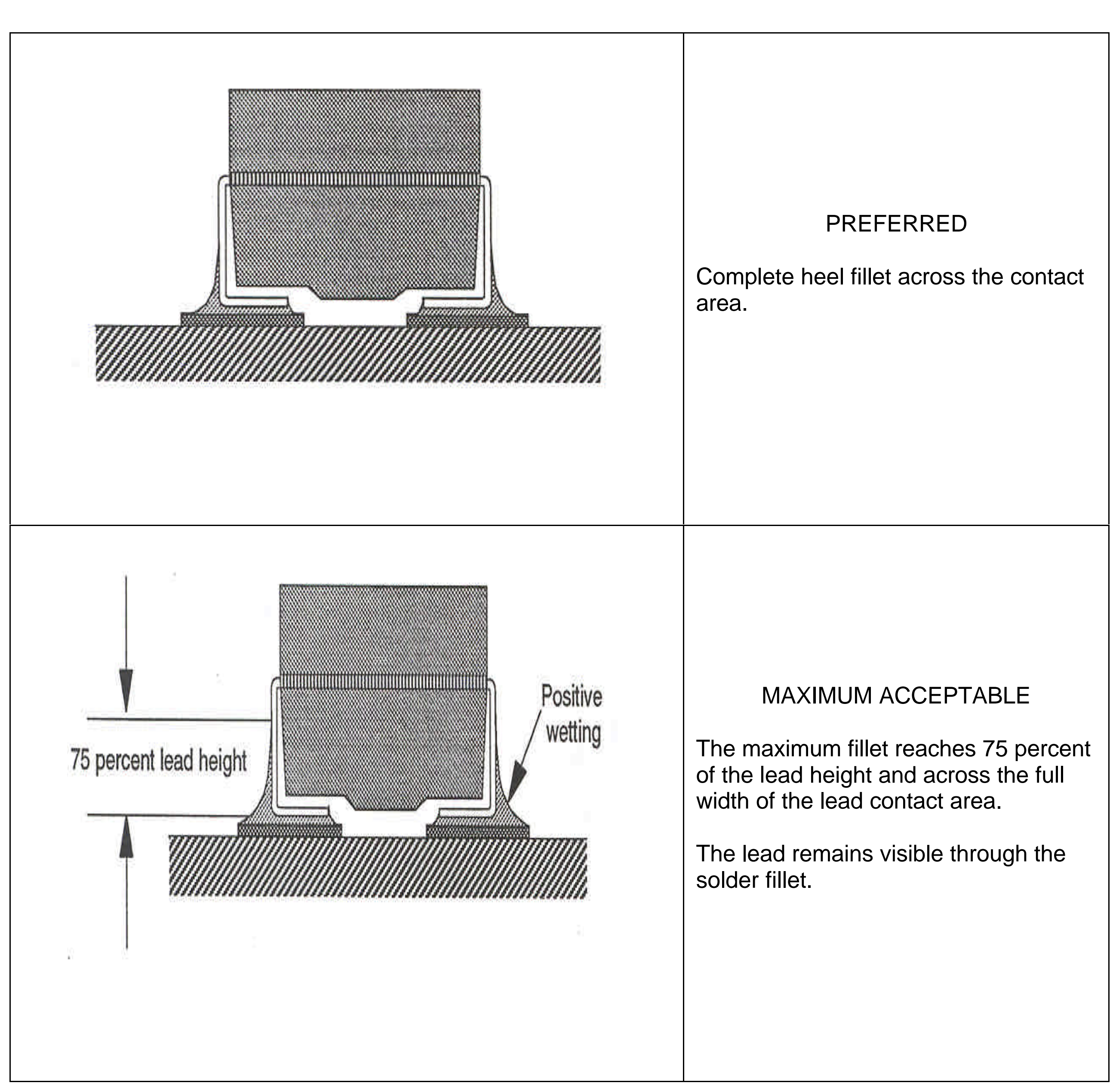


FIGURE B-10. L-Lead Solder

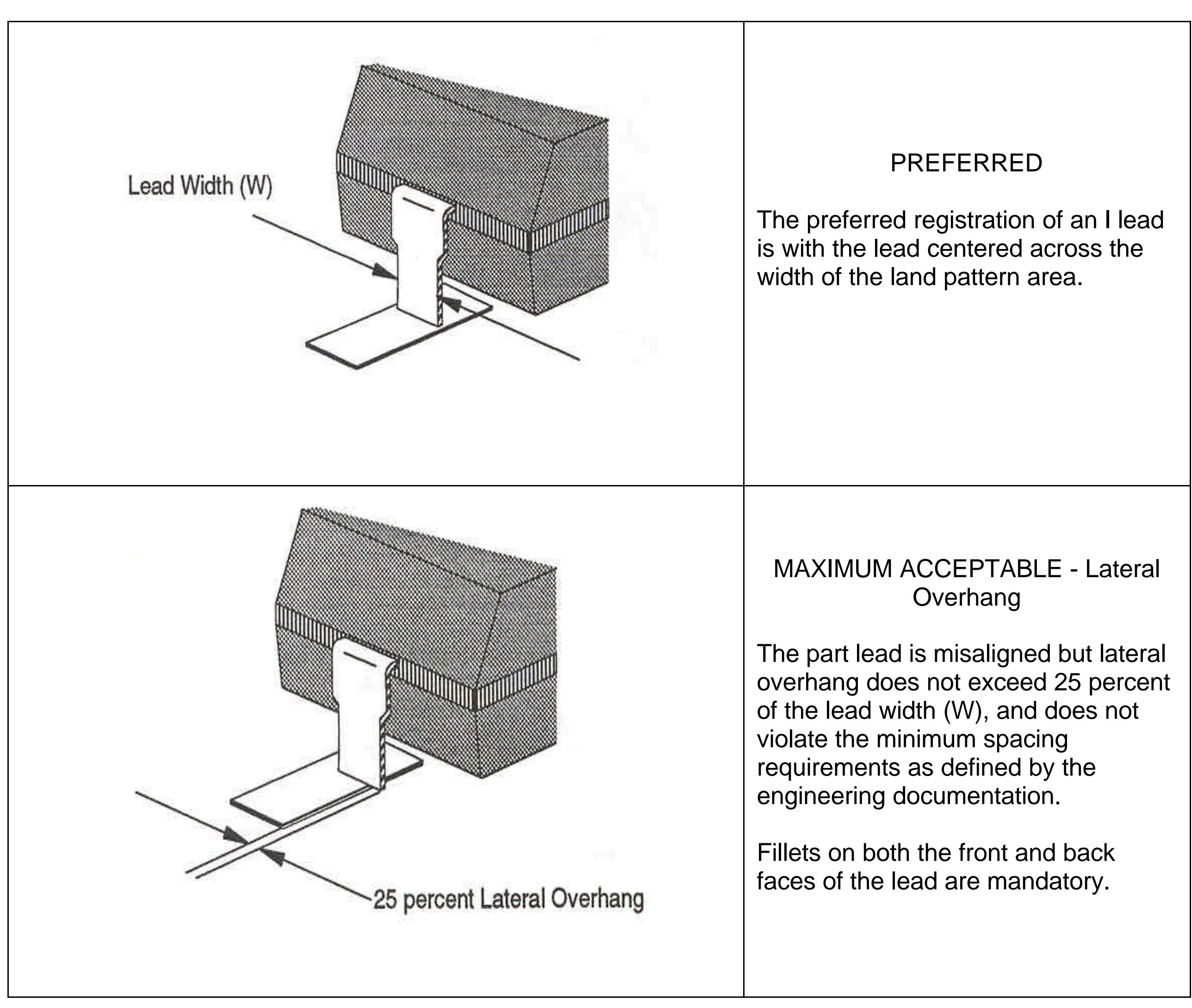


FIGURE B-11. I-Lead Registration to Land

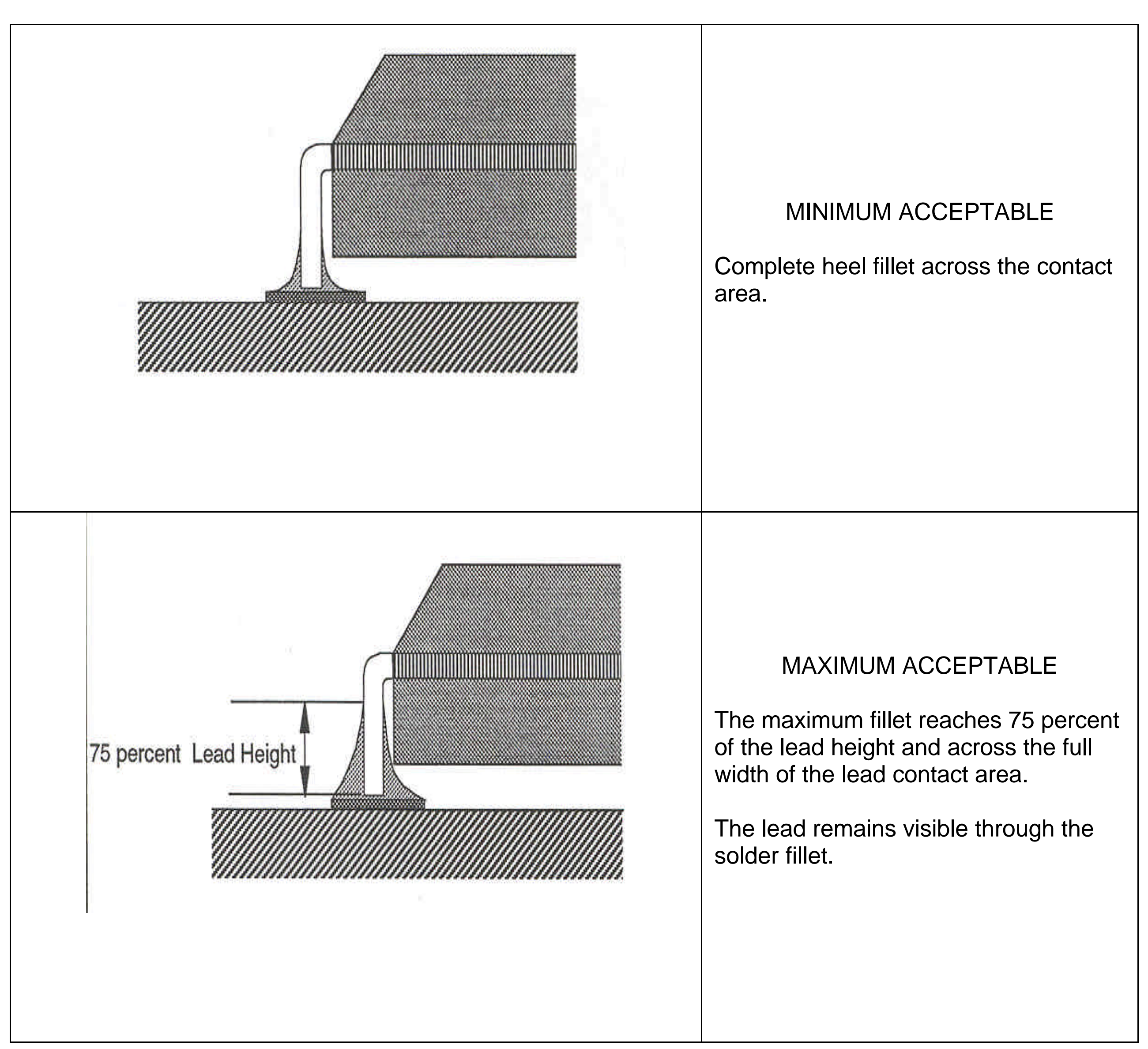


FIGURE B-12. I-Lead Solder

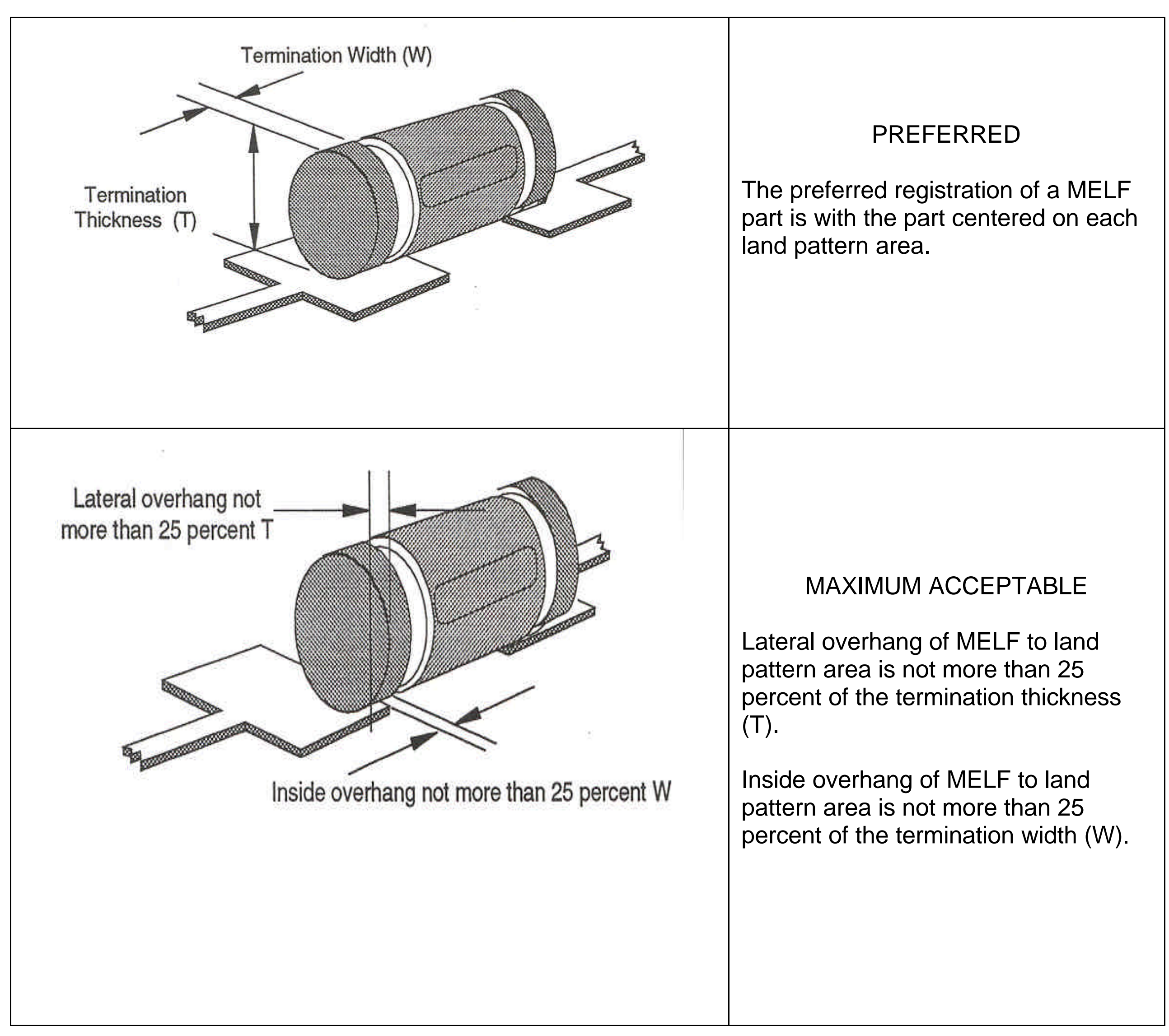


FIGURE B-13. MELF Registration to Land

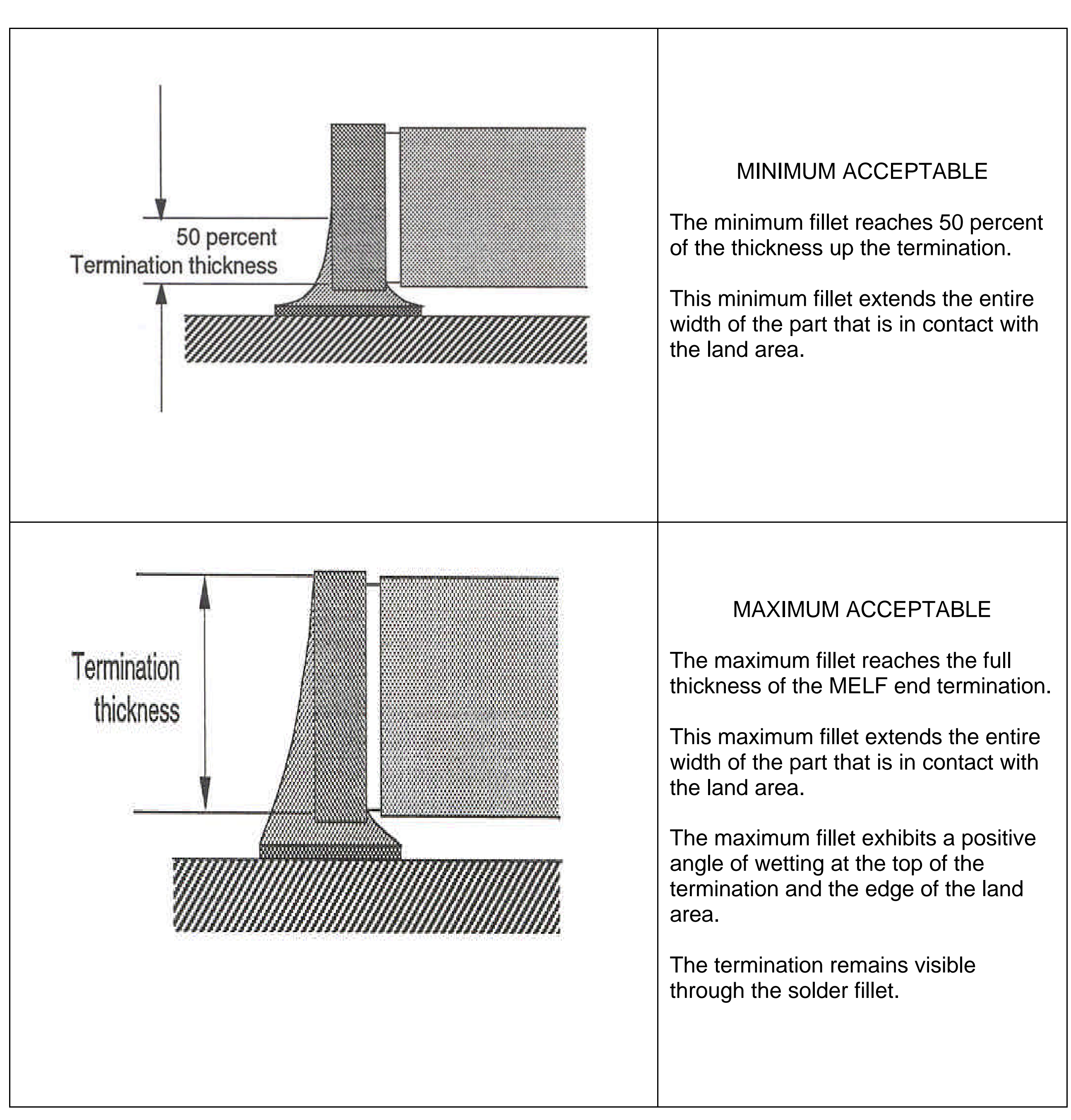


FIGURE B-14. MELF Solder

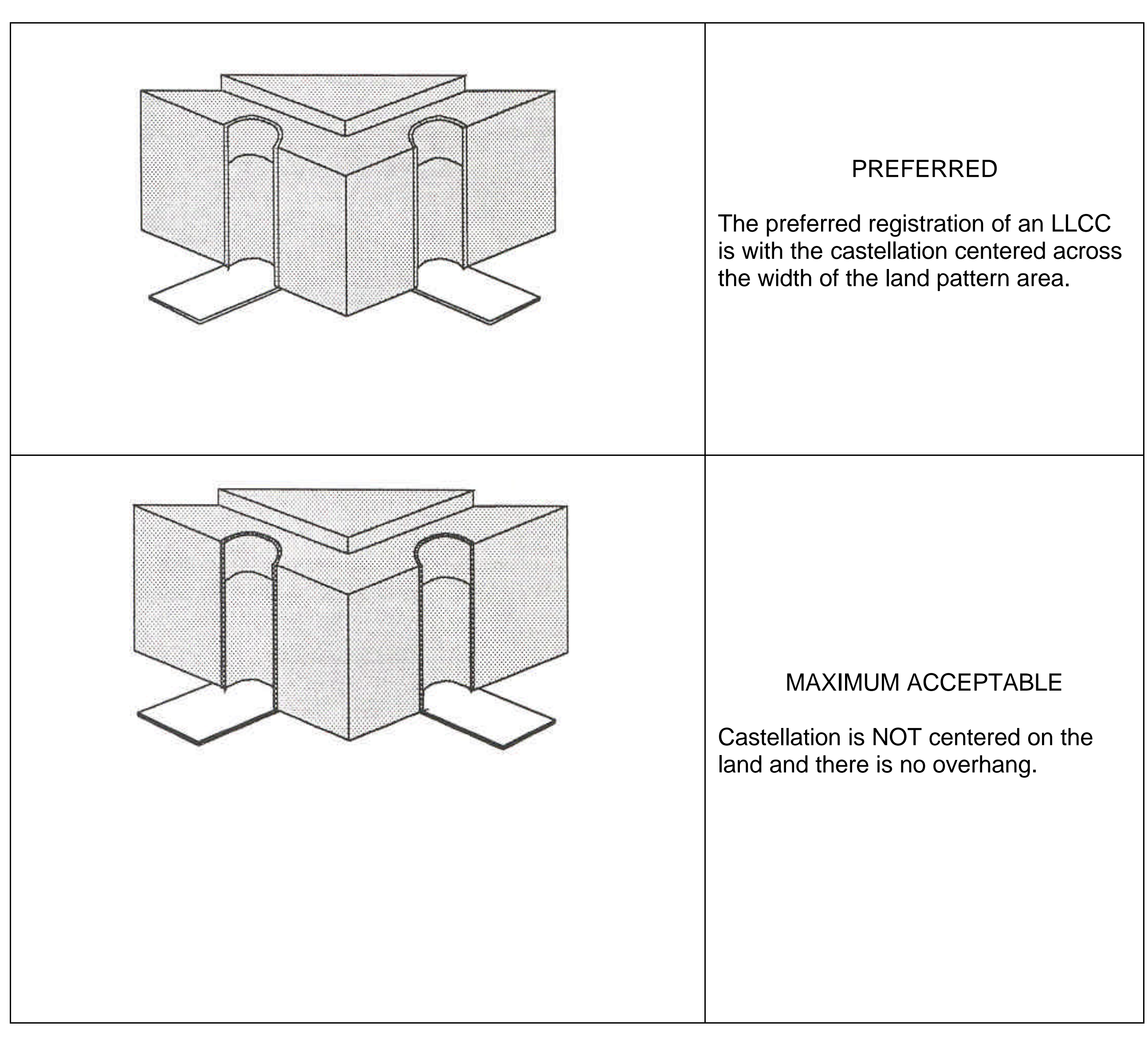
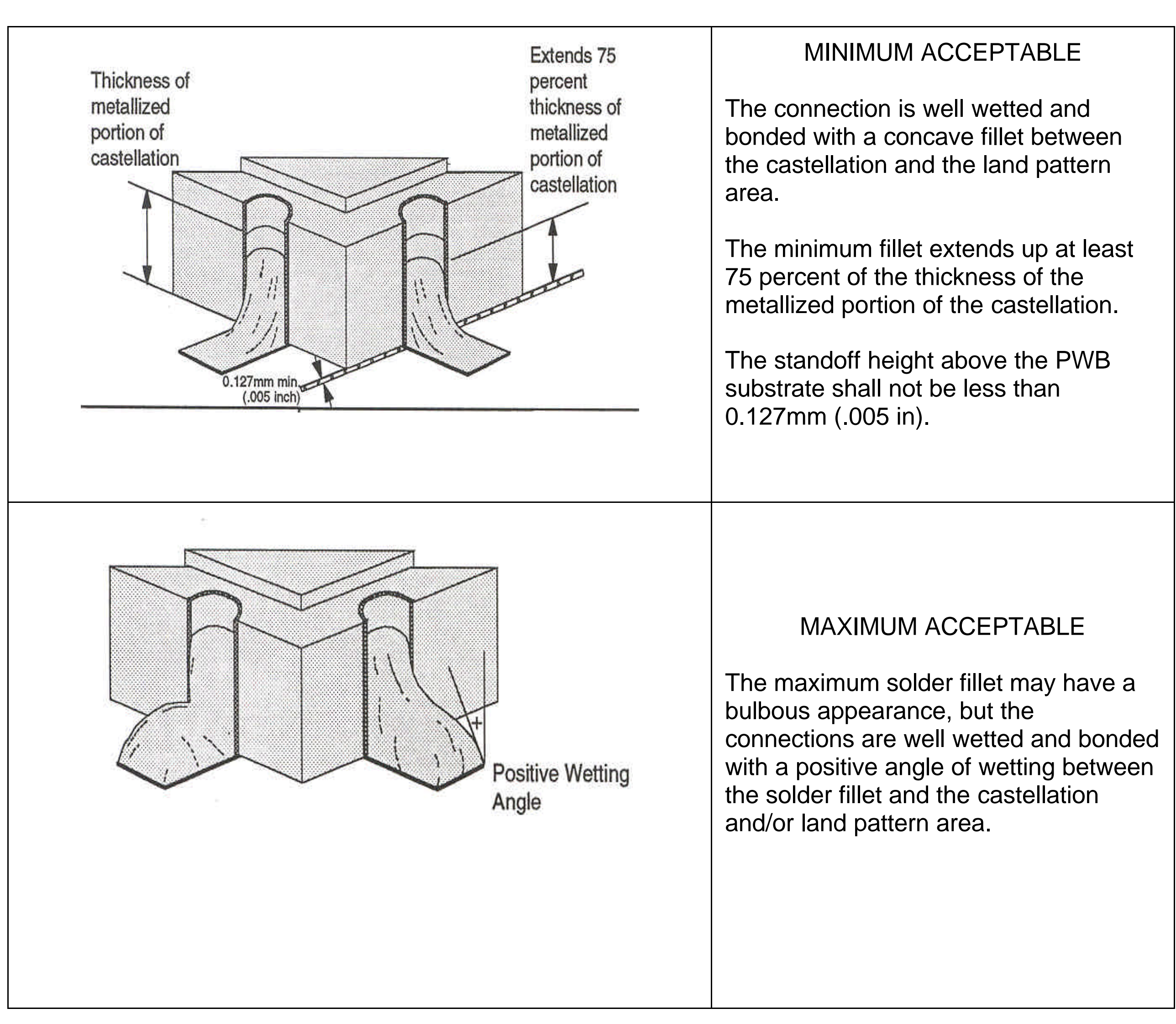


FIGURE B-15. LLCC Castellation Registration to Land



	MINIMUM ACCEPTABLE The connection is well wetted and bonded with a concave fillet between the castellation and the land pattern area. The minimum fillet extends up at least 75 percent of the thickness of the metallized portion of the castellation. The standoff height above the PWB substrate shall not be less than 0.127mm (.005 in).
	MAXIMUM ACCEPTABLE The maximum solder fillet may have a bulbous appearance, but the connections are well wetted and bonded with a positive angle of wetting between the solder fillet and the castellation and/or land pattern area.

FIGURE B-16. LLCC Castellation Solder

NASA TECHNICAL STANDARD IMPROVEMENT PROPOSAL

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3. NAME OF SUBMITTING ORGANIZATION		
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