



# Baseline Requirements for Hot Solder Dip

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## 1 Introduction

This document was prepared by Six Sigma to assist customers in standardizing the requirements for Hot Solder Dip (HSD) services. The requirements established in this document are intended to provide a high degree of control for the HSD process.

The intent of this document is for Six Sigma's customers to incorporate these baseline requirements into their purchasing information.

## 2 Scope

This document defines the baseline requirements for Six Sigma's HSD services. Some applications may have unique requirements that exceed the scope of this baseline document. In those cases, modifications to the baseline document will be negotiated with the customer.

## 3 Applicable Documents

The following documents of the issue currently in effect, form part of this document to the extent specified herein:

ANSI/ESD S20.20: *Electrostatic Discharge Control and Protection of Electrical and Electronic Parts and Assemblies*

ANSI/NCSL Z540.3: *Requirements for the Calibration of Measuring and Test Equipment*

ASTM-B568: *Standard Test Method for Measurement of Coating Thickness by X-Ray Spectrometry*

IPC/JEDEC:

J-STD-001: *Requirements for Soldered Electrical and Electronic Assemblies*

J-STD-002: *Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires*

J-STD-004: *Requirements for Soldering Fluxes*

J-STD-006: *Requirements for Electronic Grade Solder Alloys and Fluxed and Non-fluxed Solid Solders for Electronic Soldering Applications*

J-STD-020: *Moisture/Reflow Sensitivity Classification for Non-hermetic Solid State Surface Mount Devices*

J-STD-033: *Handling, Packing, Shipping and Use of Moisture/Reflow Sensitive Surface Mount Devices*

IPC-TM-650-2.3.25: *Detection and Measurement of Ionizable Surface Contaminants by Resistivity of Solvent Extract (ROSE)*

ISO 10012: *Measurement Management Systems - Requirements for Measurement Processes and Measuring Equipment*

JEDEC:

JESD22-B101: *External Visual*

JESD625: *Requirements for Handling Electrostatic-Discharge-Sensitive (ESDS) Devices*

MIL-STD-750: *Test Method Standard for Semiconductor Devices*

MIL-STD-883: *Test Method Standard, Microcircuits*

MIL-STD-1686: *Electrostatic Discharge Control Program for Protection of Electrical and Electronic Parts, Assemblies and Equipment*

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#### 4 Informative References

- ASTM-B487: *Standard Test Method for Measurement of Metal and Oxide Coating Thickness by Examination of a Cross Section*
- GEIA-STD-0005-2: *Standards for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronics Systems*
- ISO 9001: *Quality Management Systems – Requirements*
- JEDEC:
- JEP140: *Beaded Thermocouple Temperature Measurement of Semiconductor Packages*
  - JESD22-A109: *Hermeticity*
  - JESD22-B102: *Solderability*
  - JESD22-B106: *Resistance to Soldering Temperature for Through-Hole Mounted Devices*
  - JESD22-B108: *Coplanarity Test for Surface-Mount Semiconductor Devices*
  - JESD31: *General Requirements for Distributors of Commercial and Military Semiconductor Devices*
- J-STD-001[ ]S: *Joint Industry Standard, Space Applications Electronic Hardware Addendum*
- J-STD-035: *Acoustic Microscopy for Nonhermetic Encapsulated Electronic Components*
- MIL-PRF-38535: *General Specification for Integrated Circuits (Microcircuits) Manufacturing*
- NASA-STD-8739.2: *Workmanship Standard for Surface Mount Technology*
- SAE AS5553: *Counterfeit Electronic Parts; Avoidance, Detection, Mitigation, and Disposition*

#### 5 Definitions

For the purposes of this standard, the following terms and definitions shall apply:

- Conflict minerals:** Minerals determined by the US Secretary of State to be financing conflict in the Democratic Republic of the Congo or an adjoining country.
- Customer:** The organization or entity requesting or authorizing the solder dip process to be performed.
- Direct material:** Material used in manufacturing processes which becomes an integral part of the product
- Dross:** Oxide and other contaminants that form on the surface of molten solder.
- 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.
- GIDEP:** Government Industry Data Exchange Program
- Ionic Contamination:** Process residues such as flux activators, fingerprints, etching and plating salts, etc., that exist as ions and when dissolved, increase electrical conductivity.
- Process Monitor:** The regularly scheduled periodic sample measuring of a parameter during normal performance of production operations in accordance with the supplier’s documented program plan. The parameter to be measured, the frequency of measurement, the number of sample measurements, the conditions of measurement, and the analysis of measurement data shall vary as a function of the requirements, capability, and criticality of the operation being monitored.
- Rework:** The reprocessing of articles or material that will make it conform to drawings, specifications, and contract.

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

*Specialty metals:* Metals as defined in Defense Federal Acquisition Regulation Supplement (DFARS).

*Supplier:* The organization or entity performing the solder dip process.

*Wetting, Solder:* The formation of a relatively uniform, smooth, unbroken, and adherent film of solder to a base metal.

## 6 General Requirements

### 6.1 Order of Precedence

Product shall meet the requirements specified in: (1) the contract or purchase order, (2) this document, and (3) the references cited herein. In the event of a conflict, the order of precedence shall be as listed above. Nothing in this document, however, supersedes applicable laws and regulations unless a specific exemption has been obtained.

### 6.2 Requirements Flow Down

When this document is contractually required, the applicable requirements of this document shall be imposed on all applicable subcontracts and purchase orders.

### 6.3 Deviations

The supplier is responsible for assuring that any deviations from this document are evaluated, coordinated with, and submitted to the customer for approval prior to use or implementation. Deviations from this document shall be in writing.

### 6.4 Quality Management System

The supplier's quality management system (QMS) shall be assessed and registered as conforming to the current revisions of ISO9001 and AS9100 by current, accredited, third party certification through members of the International Accreditation Forum.

### 6.5 Counterfeit Mitigation

The supplier shall maintain a counterfeit item risk mitigation process internally and with its suppliers using SAE AS5553 as a guide.

Supplier shall purchase direct materials (including components) only from the OEM or OCM, or their Authorized Distributor. If these direct materials are suspect or confirmed counterfeit, then the supplier shall issue a GIDEP report and shall ensure these materials are quarantined.

### 6.6 Specialty Metals

The supplier shall maintain a specialty metals compliance program internally and with its suppliers.

Note: Titanium, Alloy 42, and Kovar are specialty metals as defined in DFARS.

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**6.7 Conflict Minerals**

The supplier shall maintain a conflict minerals compliance program for products that contain conflict minerals. The supplier shall conduct a Reasonable Country of Origin Inquiry (RCOI) on the source and chain of custody of the applicable conflict minerals.

Note: Cassiterite (the metal ore from which tin is extracted) is considered a “conflict mineral”.

**6.8 GIDEP**

The supplier shall participate in the Government Industry Data Exchange Program (GIDEP), including monitoring and acting on GIDEP reports that affect product delivered to the customer.

**6.9 Facility**

Facility cleanliness, environmental conditions (i.e., temperature and humidity), and lighting within the work areas shall conform to the requirements in J-STD-001 § *Facility* (for Class 3 products).

**6.10 Electrostatic Discharge (ESD)**

The supplier shall have an Electrostatic Discharge Control Program to protect ESD sensitive electronic devices during manufacturing, test, inspection, packaging, and shipping.

ESD sensitive devices shall be handled in accordance with JESD625, ANSI/ESD S20.20, and MIL-STD-1686.

**6.11 Moisture Sensitive Components**

Moisture sensitive components, as classified by J-STD-020, shall be handled in accordance with J-STD-033.

**6.12 Competence, Awareness, and Training**

All instructors, operators, and inspection personnel shall be proficient in the tasks to be performed. Personnel proficiency shall conform to the requirements in J-STD-001 § *Personnel Proficiency* (for Class 3 products).

**6.13 Control of Monitoring and Measuring Devices**

Inspection, measuring, and test equipment used to meet quality requirements shall be maintained and controlled in accordance with ANSI/NCSS Z540.3 or ISO 10012.

**6.14 Identification and Traceability**

Each production lot shall be identified with a unique number that appears on both the handling containers and the job packet documentation. Traceability for all direct and critical indirect materials shall be retained and provided upon request.

Personnel traceability shall be maintained through the use of controlled QA stamps, operator initials, or employee numbers.

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**6.15 Change Notification**

The supplier shall have a documented system for change management. This system shall include a process to monitor internal changes and the assessment of those changes as to the impact to customers. An appropriate customer notification methodology shall be in place.

**6.16 In-Process Storage and Handling**

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 the components.

**6.17 Verification at Supplier's Premises**

When verification at the supplier's premises is required, the intended verification arrangements and the method of product release shall be included in the purchasing information.

**7 Documentation Requirements**

**7.1 Internal Documentation**

The supplier shall incorporate the requirements of this document into the supplier's internal documentation system.

**7.2 Lot Travelers**

The supplier shall provide a copy of the applicable lot traveler including yield report with each shipment.

**7.3 Certificate of Conformance**

The supplier shall provide a Certificate of Conformance (C of C) attesting that all the applicable specifications, drawings, and purchase order requirements have been met. This C of C shall be in accordance with MIL-PRF-38535.

**7.4 Records Retention**

The supplier shall retain quality records pertaining to process verification, manufacture, and inspection for a minimum of 10 years. These records shall be made available to the customer upon request.

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## 8 Equipment, Tools, and Materials

### 8.1 Dry Bake Oven

Ovens used for dry bake shall comply with the requirements of J-STD-033.

### 8.2 Dipping Equipment

A robotic system that is capable of transporting the components through the solder dip process shall be utilized. As a minimum, the system shall be capable of controlling the following:

- Duration of flux application
- Preheat time
- Solder dip immersion speed, immersion angle, and direction of travel
- Dwell time in solder
- Solder dip withdrawal speed, withdrawal angle, and direction of travel
- Cooling time

### 8.3 Flux

The flux apparatus shall be compatible with the fluxes used.

Fluxes used for solder dip shall be free of halogens (e.g., chlorine, fluorine) and shall meet the requirements of J-STD-004. Inorganic acid (type IA) fluxes shall not be utilized.

### 8.4 Preheat

The preheat apparatus shall consist of a non-contact heat source which is capable of preheating components to achieve the desired temperature profile and avoid thermal shock. Microwave, radio frequency, or inductive heating methods shall not be utilized.

### 8.5 Solder

Solder baths shall be compatible with the temperatures, solders, and chemicals used. A provision shall be made for control of solder dross and burned flux.

Solder baths shall be capable of maintaining the solder temperature within  $\pm 3^{\circ}\text{C}$  of the set point. Solder baths shall be grounded.

Soldering oils and dross reducers may be applied to the surface of the solder wave or solder bath. Soldering oils and dross reducers shall not interfere with component cleanliness.

#### 8.5.1 Tin-Lead Solder

For tin-lead solder-dip, the solder alloy shall be Sn63-Pb37 in accordance with J-STD-006.

#### 8.5.2 Lead-Free Solder

For lead-free solder-dip, the solder alloy shall be Sn96.5-Ag3.0-Cu0.5 (SAC305) in accordance with J-STD-006.

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## 8.6 Cool Down Apparatus

A non-contact cooling source should be provided to achieve the desired temperature profile.

## 8.7 Cleaning Equipment

Cleaning equipment and solutions shall be compatible with fluxes used. Ultrasonic cleaning equipment shall not be used on components.

## 8.8 Optical Equipment

Optical equipment used for outgoing inspection shall conform to the following:

- An optical aid capable of providing a minimum of 7× magnification.
- Inspection light sources that provide shadow-less illumination.
- Magnification aids that permit simultaneous viewing with both eyes.

## 8.9 Cleaning Solutions

The solutions used for the removal of flux and other residues shall be selected for their ability to remove both ionic and non-ionic contamination. The cleaning solutions utilized shall not degrade the components. Only the following solvents (or mixtures thereof) shall be utilized:

- Deionized water – One (1) mega-ohm minimum resistivity
- 2-Propanol (Isopropyl Alcohol)
- Detergent cleaners and saponifiers – Care shall be taken to ensure compatibility with components

## 9 Preparation for Solder Dip

### 9.1 Incoming Inspection

A sample (45 components minimum) from every lot shall be inspected to ensure that the components are in good condition and do not have any anomalies that would prevent successful processing.

### 9.2 Dry Bake

All moisture-sensitive components must complete all solder dip processing, including rework, prior to the stated floor life in accordance with IPC/JEDEC J-STD-033. Dry bake may be required (refer to § *Moisture Sensitive Components* within this document).

### 9.3 Masking

Masking techniques may be used to prevent solder or flux intrusion into undesirable regions of the component. Care shall be taken in the selection, application, and removal of masking materials to avoid damage.



## 10 Solder Dip

### 10.1 Flux

Flux shall be applied to the components in a consistent and repeatable manner either before or after preheat.

### 10.2 Preheat

Components shall be preheated as necessary to avoid component damage due to thermal shock or differential heating. Temperature-sensitive components shall be preheated to  $125^{\circ}\text{C} \pm 25^{\circ}\text{C}$ . Preheat rate should not exceed  $4^{\circ}\text{C}$  per second. Heat shall not be applied in sufficient intensity to degrade or damage the component.

### 10.3 Solder Dip

10.3.1 After flux and preheat the component terminations shall be immersed in the molten solder. The dwell time shall be 1 second minimum (to ensure wetting and complete removal of noncompliant finishes). Repeated flux and solder dip is permitted (if necessary, to obtain sufficient wetting and remove the previous finish). The immersion time in solder shall not exceed 6 seconds per side.

10.3.2 Solder Temperature

(A) For tin-lead solder dip, the solder temperature shall not exceed  $255^{\circ}\text{C}$ .

(B) For lead-free solder dip, the solder temperature shall not exceed  $265^{\circ}\text{C}$ .

10.3.3 Hand dipping is not allowed.

### 10.4 Cooling

After solder dip, the components should be cooled down to minimize thermal shock before cleaning. The cool down rate should not exceed  $5^{\circ}\text{C}$  per second.

### 10.5 Cleaning

The components shall be thoroughly cleaned to remove all flux residues and other contaminants. After cleaning, the components shall be capable of passing the cleanliness requirements (refer to § *Ionic Cleanliness* within this document). Components shall be cleaned in a manner that will prevent thermal shock and/or detrimental intrusion of cleaning solutions into components that are not totally sealed.



## 11 Visual Inspection

- 11.1 Each component shall be examined at 7× minimum magnification. Components shall be inspected in accordance with JESD22-B101, MIL-STD-883 Method 2009, and MIL-STD-750 Methods 2068 & 2071, as applicable.
- 11.2 For components with hot solder dip over compliant coatings (refer to Table 1), the solder shall extend beyond the effective seating plane. If the seating plane is not defined, the solder shall extend to within 1.0 mm of the lead/package interface. For leadless chip carrier devices, the solder shall cover 100% of the contact pad and 95% of the metallized castellation.

Table 1. Compliant coatings.

Finish	Required Underplate
Hot Solder Dip (> 3% Pb)	N/A
Sn-Pb Plate (> 3% Pb)	N/A
Gold	Nickel
Palladium	Nickel
Gold Flash over Palladium	Nickel
Nickel Plate	N/A
Nickel Cladding	N/A

Note: Electroless nickel shall not be used on flexible or semi-flexible leads.

- 11.3 For components with hot solder dip over base metal or noncompliant coatings, the solder shall extend to the glass seal or point of emergence of the metallized contact or lead through the package wall. For leadless chip carrier devices, the solder shall cover 100% of the contact pad and metallized castellation.
- 11.4 Components that fail inspection shall be reworked, or separated and clearly identified.

## 12 Rework

Rework of components by hand dipping shall not be permitted. Components shall not be reworked more than twice without customer approval.



### 13 Testing

The following tests are recommended after all processing is complete:

#### 13.1 Leak Testing

For hermetic components, leak testing is required.

#### 13.2 Acoustic Microscopy

For non-hermetic components, acoustic imaging is recommended; however, it is not performed by the supplier unless specifically requested in the purchasing information.

#### 13.3 Coplanarity Testing (Lead Scanning)

For components with gull-wing formed leads, coplanarity testing is recommended; however, it is not performed by the supplier unless specifically requested in the purchasing information.

### 14 Final Bake

Prior to shipment, all moisture-sensitive components shall be dry-baked and packaged in accordance with J-STD-033.

### 15 Process Monitors and Controls

#### 15.1 Flux

Flux specific gravity shall be controlled and monitored a minimum of once per shift. Controls shall include a flux change/replacement schedule.

#### 15.2 Solder Bath

There shall be a documented control system to ensure contamination of the solder bath does not exceed the specified limits in accordance with J-STD-001 § *Solder Purity Maintenance* (for Class 3 products), with the exception of Sn, which is maintained within +/- 2% of nominal value due to typical measurement uncertainty.

Solder bath temperature shall be verified a minimum of once per shift and shall be within  $\pm 3^{\circ}\text{C}$  of the set point. The instrument used to verify compliance shall be independent of the solder temperature control system.

#### 15.3 Temperature Profiles

There shall be a documented control system to ensure that solder dip temperature profiles are designed, implemented, and monitored to avoid thermal shock to the component. Temperature measurements should be made in accordance with JEP140.

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**15.4 Ionic Cleanliness**

There shall be a documented control system to ensure that the components are clean after processing. As part of the control system, the components shall be tested in accordance with IPC-TM-650-2.3.25 to ensure their ionic cleanliness. Contamination shall be less than 1.56 µg/cm<sup>2</sup> NaCl equivalent ionic or ionizable residue.

The frequency of testing shall be a minimum of once per production shift unless the process control system data supports a change in frequency.

**15.5 Solderability**

There shall be a documented control system to ensure that the components are capable of passing dip and look solderability test per MIL-STD-883 (Method 2003) or J-STD-002. As part of the control system, components shall be periodically tested to ensure compliance. Eight (8) hour steam-conditioning is required. Solderability test shall be considered destructive.

**15.6 Acoustic Microscopy**

There shall be a documented control system to ensure that the solder-dip process is not causing delamination in non-hermetic components. As part of the control system, non-hermetic components shall be periodically analyzed by acoustic microscopy. After solder dip, components shall meet the requirements specified in J-STD-020 § *Criteria*.

**15.7 Solder Thickness**

There shall be a documented control system, which includes periodic analysis of components, to ensure that solder thickness meets the requirements in Table 2. Finish thickness measurements shall be performed in accordance with ASTM B487 or ASTM B568.

Table 2. Solder thickness requirements per MIL-PRF-38535.

Termination Shape	Minimum Thickness micrometer (micro-inch)
Round leads	1.52 (60)
All shapes other than round leads with ≤ 25 mil pitch	3.80 (150)
All shapes other than round leads with > 25 mil pitch	5.08 (200)

Lead finish thickness measurements shall be taken at the seating plane on surface mount leads (such as J-bend and gull-wing type leads) and approximately halfway between the seating plane and the tip of the lead on all other lead types. On all lead shapes other than round, the finish thickness measurement shall be taken at the crests of major flats. Finish thickness measurements for package elements other than leads shall be taken at the center of major flats.



## 16 Process Validation

A qualification lot should be run for process validation; however, it is not performed by the supplier unless specifically requested in the purchasing information. This will ensure that the process is not causing any reliability risk and is suitable for a particular device. Typical process validation tests include:

### 16.1 Prior to Process:

- Visual inspection and recording of anomalies
- Acoustic imaging (non-hermetic components)
- Temperature profile development

### 16.2 Process:

- Hot solder dip process including pre-bake

### 16.3 After Process:

- Visual inspection
- Leak testing (hermetic components only)
- Acoustic imaging (non-hermetic components)
- Ionic cleanliness
- Solderability
- Lead fatigue
- Solder coating thickness and composition
- Metallurgical analysis

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## 17 Change History

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02/02/2006	A	8148	Initial Release.	R. Winslow
07/11/2007	B	9689	Major rewrite to align with GEIA (draft) STD-0006.	M. Cruz & T. Hiraishi
06/05/2012	C	15140	Moved JEP140: <i>Beaded Thermocouple Temperature Measurement of Semiconductor Packages</i> from Applicable Documents to Informative Ref. section.	D. Albright
11/25/2013	D	16727	Change leak test to required, instead of recommended, for Hermetic parts. Ref. CAR#1682.	R. Doucette
2/1/2014	E	16957	Added § on Quality Management System, Counterfeit Mitigation, Specialty Metals, Conflict Minerals, and GIDEP. Minor edits throughout the document.	M. Cruz & R. Winslow
2/10/2015	F	18079	Added exception for solder bath purity to accommodate measurement uncertainty. CAR#1832.	A. Tabarez