JERG-0-043E(E)

General

STANDARD FOR SURFACE MOUNT SOLDERING PROCESS FOR SPACE USE

Mar. 29, 2022

Japan Aerospace Exploration Agency

This is an English translation of JERG-0-043E and does not constitute itself.
Whenever this document conflicts with the original document in Japanese, the original document takes precedence.

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1. GENERAL

1.1 Purpose

This standard describes the requirements for surface mount soldering process used in rockets and artificial satellites (hereinafter the "spacecraft") and the components installed on such spacecraft.

1.2 Scope

(1) This standard sets forth the requirements for the soldering of surface mounted parts in order to achieve highly reliable electrical connections.

(2) This standard shall apply when specified by contractual specifications. In this case, this standard must be followed by the supplier and subcontractors who will execute a part of the scope of any contract. However, when the type of wiring board specified in a contract is a mixed type lead through and surface mount types, JERG-0-039 Standard for Soldering Process for Space Use (hereinafter referred to as "JERG-0-039") shall apply to lead through mounting, and this standard shall apply to the surface mounting. While this standard will not apply to hybrid IC and microwave IC, the qualification tests of the design conditions shall be in accordance with these ss.

(3) When application of this standard is specified in the specifications and no other instructions are issued, the applicable objects and items in this standard shall be as set forth in paragraph 1.2.1 in accordance with the category of the developed items. Decisions on exemptions to this standard shall be subject to presentation of the reason for such exemption and consultation with Japan Aerospace Exploration Agency (hereinafter referred to as the "JAXA").

(4) BGA/CGA is based on JERG-0-054.

1.2.1 Type of development model, development model definition

When the design, prototype building, and the manufacture of the spacecraft is made, the following classification shall apply.

(1) Engineering Model (EM [*1] etc.)

As a minimum, the following paragraphs of this standard shall apply to the engineering model for environmental tests and life tests. If the environmental test and life test is not conducted, this standard does not need to be applied.

4.2 Education, training, and qualification

4.5 Manufacturing conditions

4.6 Quality assurance

(2) Actual Model (PM [*2], PFM [*3], and FM [*4])

This standard shall apply to actual models.

(3) Repair and Spare Parts

This standard shall apply to repair and spare parts.

[*1] EM : Engineering Model
[*2] PM : Prototype Model
[*3] PFM : Proto-Flight Model
[*4] FM : Flight Model

1.2.2 Foreign products

Regardless of the provisions in paragraph 1.2.1, the following documents may be applied instead of this standard to devices installed on spacecraft whose design, prototype building, manufacturing, and modification are performed outside Japan, and application of this standard is difficult.

a. J-STD-001*S "Space Applications Electronic Hardware Addendum to IPC J-STD-001* Requirements for Soldered Electrical and Electronic Assemblies"
b. ECSS-Q-ST-70-08C "Manual soldering of high-reliability electrical connections"
c. ECSS-Q-ST-70-38C "High-reliability soldering for surface-mount and mixed technology"

1.3 Supplement

(1) Examination of the Soldering Processes

The supplier shall prepare the document for requalification of the soldering process and qualification test of the soldering process, including at least items (a) to (c) listed below, in the format shown in Figure 1-1, which shall be subject to examination by JAXA. The examination shall be conducted as a part of PDR and CDR.

a. New aspects of the process and the impact thereof on important quality characteristics
b. Extent of constraints on functional and performance verification during the testing and inspection processes
c. Frequency of nonconformance of comparable articles in the past

(2) Incorporation of review results

The supplier shall incorporate the review results regarding the application of this standard into the materials (drawings, manufacturing process specifications, procedures, administrative rules, etc.) relevant to the implementation items (design standardization, engineering documentation, shop floor control) of the quality, reliability, or safety/development assurance program plan.

(3) Product verification

The supplier shall plan and conduct manufacturing engineers' verification about initial-lot products to which the review results are applied, products normally commercially unavailable, and mission-critical products.

Soldered Parts Mounting Method Plan and Checklist

Parts shapes or As-assembled configuration thereof	Mounting Method	Staking method	Specifications of PWB, etc.	Soldering type Hand soldering: H Wave Soldering: W Reflow Soldering: R	Necessity of manufacturing engineer's witnessing	* Necessity of recertification	Necessity of process certification test	Remarks: Reasons and supplementary comments

* Indicate "Required" when required to adopt a new process with no history of previous application to space flight vehicles or when any change has been made to the content of the certification.

Other special issues:

Figure 1-1 Soldered parts mounting method plan and checklist form

2. RELATED DOCUMENTS

The related documents are as follows. Disclosure of some JAXA documents and materials may be restricted.

2.1 Applicable documents

The documents listed below form a part of this standard to the extent specified herein. Unless otherwise specified, their latest versions at the time of application of this standard shall be used.

(1) JAXA standards

a.	JERG-0-039	Standard for Soldering Process for Space Use
b.	JERG-0-040	Standard for Electronic Bonding Process for Space Use
c.	JERG-0-041	Standard for Electrical Wiring Process for Space Use
d.	JERG-0-042	Standards for Printed Wiring Boards and Assemblies for Space Use
e.	JERG-0-054	Standard for BGA/CGA Mounting Process for Space Use

(2) Public standards

ANSI Standards

a.	J-STD-004	Requirements for Soldering Fluxes
b.	J-STD-005	Requirements for Soldering Pastes
c.	J-STD-006	Requirements for Electronic Grade Solder Alloys and Fluxed and Non-Fluxed Solid Solder for Electronic Soldering Applications

JIS standards

a.	JIS Z 3282	Soft Solders—Chemical compositions and forms
b.	JIS Z 3284	Solder Paste

IPC standards

a.	J-STD-001	JOINT INDUSTRY STANDARD Requirements for Soldered Electrical and Electronic Assemblies
b.	IPC-TM-650	Test Methods Manual

2.2 Reference documents

The following documents provide information supplementary to the contents of this standard:

JIS standards

a. JIS K 3362 Test Method of Household Synthetic Detergent
b. JIS K 3363 Testing Method for Biodegradability of Synthetic Detergent
c. JIS K 8101 Ethanol (99.5) (Reagent)
d. JIS K 8839 2-Propanol (Reagent)

MIL standards

a. MIL-STD-202 Test Methods Standard, Electronic and Electrical Component Parts
b. MIL-STD-1276 Leads for Electronic Component Parts

FEDRAL standards

a. TT-I-735 Isopropyl Alcohol

ASTM standards

a. ASTM B 488 Standard specification for Electrodeposited Coatings of Gold for Engineering Uses
b. ASTM B 545 Standard specification for Electrodeposited Coating of Tin
c. ASTM B 700 Standard specification for Electrodeposited Coating of Silver for Engineering use

AMS standards

a. AMS 2418 Plating Copper
b. AMS 2422 Plating, Gold

SAE-AMS (Aerospace Material Specification) standards

a. SAE-AMS-P-81728 Plating, Tin-Lead (Electrodeposited)
b. SAE-AMS-QQ-N-290 Nickel Plating (Electrodeposited)

IPC standards

a. IPC-SM-782 Surface Mount Land Patterns
b. J-STD-001*S Space Applications Electronic Hardware Addendum to J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies
Note that * indicates the latest version.

JAXA document

a. JERG-0-043-TM001 Collection of Technical Data of Standard for Surface Mount Soldering Process for Space Use (JERG-0-043)

ESA documents

a. ECSS-Q-ST-70-08C Manual soldering of high-reliability electrical connections
b. ECSS-Q-ST-70-38C High-reliability soldering for surface-mount and mixed technology"

3. TERMS AND DEFINITIONS

Reference shall be made to Appendix I for the terms and definitions used in this standard.

4. GENERAL REQUIREMENTS

4.1 General

(1) The supplier shall ensure highly reliable solder joints for electrical connections through the appropriate design, control of tools, selection of materials, work processes, working environment, and by careful operation by trained operators qualified for the work.

(2) The supplier shall verify that the soldering complies with the requirements of this standard (design and manufacturing conditions). In addition, the supplier shall establish and maintain design standards and process specifications according to the requirements of this standard and shall manufacture and provide control based on such design standards and process specifications.

(3) The design engineer responsible for the design of surface mounted electronic devices (including design of patterns of the wiring boards) shall have adequate knowledge of the requirements of this standard.

(4) Unless application of this standard is specified in the specification or other documents for the parts, internal connection of parts are not subject to the requirements of this standard. The supplier shall guarantee that the internal solder connections of parts will not melt or deteriorate from pretinning or external connections.

4.2 Training and certification

Training and certification shall conform to JERG-0-039.

4.3 Design requirements

The design requirements for the wiring board and its assembly shall be in accordance with JERG-0-042. Additional design requirements for soldering are shown as follows. For the fine pitch package, the contents of JERG-0-043-TM001 Technical Data 19 (paragraph 2.2 JAXA Document) shall be reflected.

(1) The specifications of herein shall apply to the products of which the design temperature of the soldered section is within -30°C to +100°C. When the temperature is outside this range, countermeasures in the design shall be incorporated.

(2) As a rule, solder pastes conforming to J-STD-005 or JIS Z 3284 shall be used in soldering. When rosin flux cored solder is used, the type of the flux shall be either RO-L0 or RO-L1 (R or RMA). Composition of the solder shall be Sn63/Pb37 or Sn60/Pb40 or the equivalent in accordance with J-STD-006 or JIS Z 3282. Lead-free solder shall not be used instead of Sn63/Pb37 and Sn60/Pb40. Where reliability of joining as specified in paragraph 4.3(4) etc. cannot be assured, Sn-Ag and Sn-Au alloys may be used.

(3) Metals to be joined shall have properties which ensure wettability for the solder alloy and soldering shall be possible using rosin base flux as a rule.

(4) Materials of the parts to be joined with solder shall be a combination of materials that have a thermal expansion coefficient not significantly different. Where thermal stress significantly affects the solder joint, the reliability of the joint shall be established after a comprehensive study of the joining method, surface plating, and the type of solder used, including reduction of temperature change by thermal control in the system.
(5) Application of fixing of parts by bonding and conformal coatings shall be in accordance with JERG-0-040.
(6) As a rule, inspection of the soldered joint can be made. BGA/CGA is based on JERG-0-054.

4.4 Process certification tests

4.4.1 Requirement category for certification of the soldering process

When either of the cases shown in the Table below applies, a certification test under the subject shall be conducted to verify the effectiveness of the process or provide proof that the process is verified.

As to thermal shock test, the evaluation test confirmed that the severity (with compatibility) of the test is equivalent to that of temperature cycling test required by JERG-0-039.

[Reference] For Comparative Evaluation in Thermal Shock Test and Temperature Cycling Test, refer to refer to JERG-0-043-TM001Techinical Data 20.

	Requirement Category	Test Item
1	When temperature condition of -30°C to +100°C at the soldered area cannot be satisfied during warehousing, storage, and in operation.	Thermal shock test (I)
2	When verification by the test is considered necessary as the results of study of coefficient of thermal expansion under paragraph 4.3(4).	Thermal shock test (II)
3	When mounting by soldering other than the method specified in this standard is employed, Note) Three test items specified in the right column shall be separately conducted for different samples as a rule. When thermal shock test (II) falls under the requirement category 1, the thermal shock test (I) shall apply.	Thermal shock test (II) Insulation reliability test Vibration resistance test
4	Where resonance is anticipated in vehicle launching and in operation with the wiring board in installed condition.	Vibration resistance test

4.4.2 Test method and conditions

(1) Thermal shock test (I)

The test shall establish the upper and lower limit temperature with allowance for the pattern of temperature change predicted by thermal analysis. The condition where exposure of the solder joint of the sample to the upper and lower limit temperature for 30 minutes, respectively, shall be employed, but when longer exposure time is expected because of the pattern, the exposure time shall be adjusted accordingly.

The number of thermal cycles shall be determined based on the required service life, and the criteria for the external and internal defects and electrical characteristics shall conform to that of the thermal shock test (II).

(2) Thermal shock test (II)

Five hundred cycles of temperature changes between -30°C and +100°C shall be repeated. This is the minimum requirement for design and manufacturing, and test conditions shall be set in consideration of the required service life of the device. Retention time for each temperature shall be 30 minutes at the solder joint of the sample, and the speed of temperature change between -30°C and +100°C shall be within 5 minutes in ambient temperature.

The criteria after completion of 500 cycles shall be as follows (see paragraph 5.11 for details).

a. Visual inspections shall be made at each 100 cycles or less with a minimum of 15x magnification, and cracks where the length is 1/2 or more of the terminal width will be detected as defects of the solder joint, and such data shall be Weibull analyzed. The scale parameter (η) shall not be less than 500 cycles.

b. Samples after completion of 500 cycles shall be inspected and sectional analysis of the solder joint where depth of the crack is considered largest and where severity in thermal stress design is considered high shall be performed to confirm that the depth of the crack shall not exceed 1/3 of the thickness of solder fillet.

c. Electrical characteristics shall be measured and no anomalies shall be observed after completion of 500 cycles.

(3) Vibration test

Condition of the vibration test shall be determined in consideration of the environment of use. Conditions shall be determined after consultation with JAXA as required. Criteria at the end of the test shall be as follows, and all the requirements shall be satisfied.

a. Visual inspection shall be conducted with minimum of 15x magnification, and no crack of which depth is 1/2 or more of the terminal width in the solder joint shall be allowed.

b. Electrical characteristics shall be measured, and no anomalies shall be observed.

Where resonance is expected, tests shall be conducted using a vibration spectrum with allowance against the expected vibration pattern based on vibration analysis. In particular, attention shall be paid to the installation method of the wiring board and to the resonance of the wiring board induced by mass distribution on the board. The time of the test shall be determined in consideration of time duration for the launch.

(4) Insulation reliability test

The test shall be conducted with the electrical loads for actual application continuously applied in the environment at 60°C and 90% to 95% RH. Time duration of the test shall be determined based on the expected environmental conditions. When condensation may be possibly take place during warehousing, storage, or in operation, condensation cycle test simulating such conditions shall be conducted.

Criteria at the end of the test shall be as follows and all the requirements shall be satisfied.

a. Functioning status of the wiring board shall be continuously monitored during the test and no anomalies shall be allowed.

b. After completion of the test, visual inspection of the sections where spacing between conductors is small shall be conducted with minimum of 15x magnification, and no electrochemical migration shall be allowed.

― NOTE ―

In planning of the certification test of the soldering process, detail manufacturing specifications of the sample (surface treatment, dimensions, clearance, work conditions, manufacturing equipment, etc.) and inspection specifications (external shape of the fillet, amount of solder, etc.) and test conditions (environment, monitor items, etc.) shall be clearly defined.
Combined testing shall be considered for the devices used repeatedly.
Test conditions such as combined environment shall be referred to JERG-0-043-TM001 Technical Data 19.

[Reference]

For Evaluation of Fine Pitch Package and Surface Mounting Method, refer to JERG-0-043-TM001 Technical Data 19.

For Comparative Evaluation in Thermal Shock Test and Thermal Cycle Test, refer to JERG-0-043-TM001 Technical Data 20.

4.5 Manufacturing conditions

(1) Where soldering is applied at both sides of the wiring board, adequate consideration shall be made for effect of heat generated by soldering at each side on the material of the parts and for effect on the preexisting solder joint by soldering applied later.

(2) Unless otherwise specified in the contract, soldering rework may be allowed (including rework of local area after removal of solder on terminals entirely) to the extent specified in this standard. In such a case, the area to be reworked or entire wiring board shall be cleaned before rework. However, it shall be confirmed such cleaning may not adversely affect reliability of the parts. When necessary, parts at the reworked area shall be replaced.

(3) Repair of the wiring board is prohibited in principle. However, where no adverse effect on functions, performance, reliability, etc. is expected, damage on the circuit may be processed in accordance with the procedure specified in the contract.

(4) X-ray inspection etc. shall be made as appropriate in order to determine whether penetration of solder is adequate or to confirm the absence of possible internal defects such as void.

(5) Adequate care shall be taken for storage and handling of materials and parts (including those susceptible to electrostatic discharge) in order to avoid contamination and electrical or physical damages.

(6) For safety and health of workers, protective glasses, gloves, ventilation system shall be used.

4.5.1 Manufacturing environment

Manufacturing environment shall conform to JERG-0-039.

4.5.2 In-process storage and handling

(1) Metal surface to be soldered shall not be touched with bare hands. If touched accidentally, the area shall be cleaned immediately. Where handling of the product by hand is unavoidable, lint-free gloves or fingerstalls shall be used.

(2) Appropriate protection shall be used in order to avoid damage, electrochemical migration of foreign substances, and contamination to the wiring board assembly during or after mounting of parts.

(3) In particular, after printing of the solder paste and mounting of the parts the work shall be transferred to the next processing steps immediately in order to avoid problem due to property change of the solder paste.

4.5.3 Electrostatic discharge control

Electrostatic discharge control shall conform to JERG-0-039.

4.6 Quality assurance

Quality assurance shall conform to JERG-0-039.

5. DETAILED REQUIREMENTS

5.1 Detail design conditions

5.1.1 Thermal stress

(1) In order to reduce thermal stress in the solder joint, combination of parts and the wiring board shall be as follows.

a. When a part equipped with terminals in a stress relief configuration is mounted.
… Combination with any type of the wiring board is acceptable as a rule.

b. When a part equipped with terminals in a non-stress relief configuration is mounted.
…. Study of thermal stress due to difference in coefficient of thermal expansion shall be made, and combinations shall be limited to the wiring board type to which the service life can be guaranteed. Where necessary, the service life shall be verified by the test specified in paragraph 4.4.2 (2) of this standard.

i) In case of the concave fillet like in LCC configuration (Figure 5-1 (4)).

ii) In case of the convex fillet (Figure 5-1 (2) and (3)). Where spacing between the solder joints are up to about 3 mm, combination of materials with different coefficient of thermal expansion (e.g. alumina element assembly and glass epoxy board) may satisfy the requirements, however where spacing exceeds about 3 mm, such combination is difficult to be applied.

(2) Where the requirement is not satisfied under (1) b. above, extension of life by the following method shall be considered, or changing in parts and the printed wiring boards or improvement of temperature condition shall be considered.

a. Use of solder alloys that have better thermal fatigue properties
…. See paragraph 5.3.1 of this standard

b. Consideration of other bonding method
…… A method where a joint is not adversely affected by thermal stress such as a wire bonding method.

— NOTE —
In the case of a part that generates significant heat internally, evaluation of solder joint by the power cycle test shall be considered.

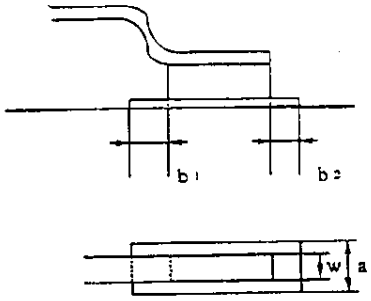
[Reference]
For verification of thermal stress and strain due to various combinations of parts and printed wiring boards, refer to JERG-0-043-TM001 Technical Data 1.
For verification of thermal fatigue life of solder joints due to various combinations of parts and printed wiring boards, refer to JERG-0-043-TM001 Technical Data 19.

5.1.2 Design of a solder land

Design of the appropriate solder land shall be made to respective parts in order to form appropriate solder fillet which shall be documented. Shape of land to be used as reference is

shown in Figure 5-1.

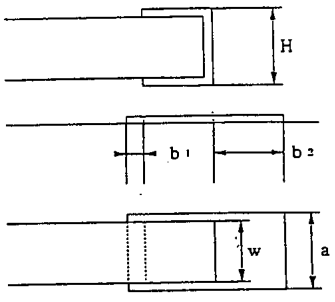
(1) In the case of Gull Wing Lead type terminal (Terminal pitch 0.5 or more)



b1 ≥ 0.5 mm, b2 ≥ 0.2 mm

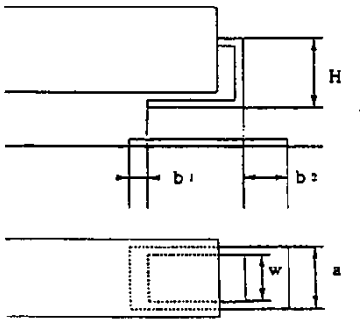
- In the case of QFP and SOP
  e - β ≥ a ≥ W
  Where, e: Pitch spacing, W: Lead width (Nominal dimension of the part)
  β: Constant determined by the pitch spacing (β = 0.3 mm for 0.635 mm or more, β = 0.2 mm for less than 0.635 mm)
- In the case of part having 2 or 3 terminals (transistor, diode, etc)
  a ≥ W + 0.5

(2) In the case of Chip Parts type terminal (External dimensions 2.0 x 1.25 or more)



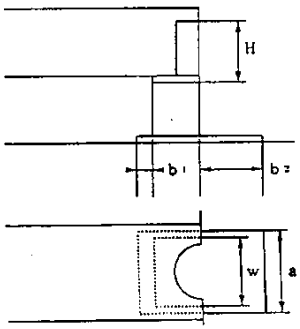
0 mm ≤ b1 ≤ 0.2 mm
H ≤ b2 ≤ H + 0.2 mm
W ≤ a ≤ W + 0.3 mm
W: Part width (Nominal dimension of the part)

(3) In the case of L-Leaded Parts type terminal
(External dimensions 3.2 x 1.6 or more)



0 ≤ b1≤ 0.1 mm
H - 0.2 mm ≤ b2 ≤ H
W ≤ a ≤ W + 0.4 mm, W: Lead width (Nominal dimension of the part)

(1) In the case of LCC Parts type terminal (External dimensions 3.2 x 1.6 or more)



0 ≤ b1≤ 0.1 mm
H - 0.2 mm ≤ b2 ≤ H
W ≤ a ≤ W + 0.4 mm, W: Lead width (Nominal dimension of the part)

Figure 5-1 Geometry of solder land for principal parts (unit: mm)

Note 1: The corners of the rectangular land may be rounded as required, although all the drawings show a rectangular land shape.

[Reference]
For verification of thermal fatigue life due to configuration of solder land, refer to JERG-0-043-TM001 Technical Data 3.
For evaluation of fine pitch package and surface mounting method, refer to JERG-0-043-TM001 Technical Data 19.

5.2 Manufacturing process, tools, and equipment

5.2.1 Manufacturing process

(1) In general, reflow soldering or hand soldering methods shall be used in order to achieve stable soldering and to avoid damage to the parts.

— NOTES —

i) If the flow-soldering method is employed, an adequate study shall be made for stability of the process, and the certification test of the process as set forth in Requirement 3 under paragraph 4.4.1 shall be conducted to prove satisfactory result because it is not good for achieving quality and fillet formation in soldering.

ii) Difference of skills among workers significantly affects quality in hand soldering, so it shall be completed by qualified trained workers under paragraph 4.2.

(2) The following requirements shall be satisfied when total heating is used.

a. Appropriate temperature profiles shall be established.

b. No damage shall be caused that may affect the quality and reliability of the electronic parts and wiring boards.

— NOTES —

Because a variety of process versions are available in reflow process, the following points shall be considered in selecting the process.

i) In the process principally using IR rays, temperature distribution on the same wiring board tends to be large due to differences in the heat absorption factor between parts and due to differences in the heat capacity of parts.

ii) In the process of VPS (Vapor Phase Soldering) temperature increases from preheating to full heating are very steep, and it shall be demonstrated that quality and reliability of electronic parts are not adversely affected.

(3) The following requirements shall be satisfied when local heating is used.

a. Heating shall be possible without direct contact with the solder as a rule.

b. No damage that may affect quality and reliability of the electronic parts and the wiring board shall be caused.

c. When solder paste is used, soldering shall be possible for preheating and full heating respectively, as a rule.

d. Temperature of the part terminal (soldered portion) shall reach +30°C to 50°C above the liquid phase point of the solder used.

― NOTES ―

When a solder paste is used:

i) In resistance heating methods such as pulse heating method, solder may be directly heated, which is not desirable due to potential changes in the solder microstructure. A method using heating through the lead terminal shall be used.

ii) In the method using a laser, considerable heat is applied in very short period of time. In order to investigate effect of such heating on quality and reliability of the solder joint, adequate process certification test shall be conducted to demonstrate, and absence of a problem shall be demonstrated.

[Reference]
For comparison of soldering methods, refer to JERG-0-043-TM001 Technical Data 4.

5.2.2 Tools and equipment

Tools and equipment shall conform to JERG-0-039 in addition to the following requirements.

(1) Total heating equipment of the reflow method shall be controlled appropriately.

― NOTES ―

i) Impact on the solder joints due to vibration during transfer of the printed wiring board shall be avoided.

ii) The required profile shall be obtained by temperature regulation and adjustment of transfer speed.

iii) In case of heating by airflow control, the parts shall not move by airflow.

(2) The soldering iron complying with the requirements of JERG-0-039 and having the appropriate shape and size of the tip suitable for the parts shall be used.

5.3 Materials

5.3.1 Solder and flux

(1) Solder and flux shall be selected from those included in Table 5-1.

Table 5-1 Solder and flux materials

Item	Total Heating Method	Local Heating Method
Composition	As a rule, Sn63/Pb37, Sn60/Pb40, or equivalent solder complying with J-STD-006 or JIS Z 3282 shall be used. Use of lead free solder instead of Sn63/Pb37 or Sn60/Pb40 alloys is prohibited. Notwithstanding the above, the other composition may be used as shown below. (1) When the material of the terminals of the wiring board or parts is Ag-base alloy …… Sn62/Pb36/Ag2 (According to J-STD-006 or JIS Z 3282) (2) When the requirement for thermal fatigue life of the solder joint is not satisfied, with alloys Sn63/Pb37, Sn60/Pb40, and (1) above. ……Sn-Ag eutectic solder (Sn96.5/Ag3.5 or Sn95.5/Ag3.5/Cu1.0) (3) When the requirement for thermal fatigue life of the solder joint is not satisfied, even with alloys of (2) above. ……Au80/Sn20	
Property	Solder paste complying with J-STD-005 or JIS Z 3284. (Grain shape and grain size shall be selected depending on application condition such as part density.)	Either of the following shall be selected depending on the method and parts. (1) Solder paste complying with J-STD-005 or JIS Z 3284. (2) Flux cored wire solder (3) Solder preform
Flux	Fluxes RO-L0 or RO-L1 (R or RMA) complying with J-STD-004 shall be used.	

－ NOTES －

i) Among the alloy compositions of Table 5-1, (2) and (3) are high temperature solder and higher stress of the parts is introduced, and it shall be checked that the parts and printed wiring board are free of damage before use.

ii) Among the alloy compositions of Table 5-1, when Au-Sn solder is used, Au plating shall be specified as surface preparation of the parts and printed wiring board.

iii) Because some new fluxes cannot be detected by the evaluation according to J-STD-004 and rather deteriorate insulation resistance, the following evaluation is effective.

- Resistance meter evaluation (IPC-TM-650)
- Water drop electrochemical migration test

(2) Where a part that is susceptible to heat in soldering has to be used and use of low temperature solder with Bi added is considered, deterioration of mechanical strength will be a problem, and at least the following tests shall be made to verify compliance with the requirements, in addition to the process qualification test under paragraph 4.4.1.

a. Mechanical strength in the thermal shock test
b. Vibration resistance after thermal shock test
c. High temperature creep characteristics

(3) Use of water-soluble fluxes for water cleaning is prohibited as a rule. However, its use may be allowed when the flux is the non-halogen type and does not contain substances that are hard to clean due to reaction with the wiring board and when it can be demonstrated that flux residue at the narrow spacing or on the surface of parts is completely removed by water cleaning and the insulation reliability test under paragraph 4.4.1 shows satisfactory results.

[Reference]

For verification of the effect on thermal fatigue life by solder alloys, refer to JERG-0-043-TM001 Technical Data 5.

For verification of the effect of electrochemical migration of solder alloys, refer to JERG-0-043-TM001 Technical Data 6.

For verification of composition of fluxes, refer to JERG-0-043-TM001 Technical Data 7.

5.3.2 Adhesive for fixing of parts

Adhesive to fix the parts shall satisfy the requirements of JERG-0-040 and satisfy the following performance requirements.

a. Application (printing, transfer, dispensing, etc.) of the adhesive is easy and shape after application shall not significantly change.

b. Adhesive shall be heat cured and the temperature and time of curing shall not affect the reliability of the printed wiring board and the parts.

c. Even after curing, removal of parts can be made without causing damage of the printed wiring board.

5.3.3 Solvents and cleaners

(1) Solvents and detergent used for removal of the flux, debris, and other contaminants from the wiring board shall satisfy the following requirements.

a. Solvents and cleaners selected shall be capable of removing both ionizing and non-ionizing contaminants combined with variety of cleaning method (jet spray etc.).

b. Solvents and cleaners shall not cause detrimental effect on the wiring board and the parts.

c. Solvents and cleaners shall be completely removed by rinsing and drying after cleaning. Even when the solvent or detergent remains within the part or in a space between the part and the wiring board, it shall not have a detrimental effect on reliability.

(2) Examples of solvents and cleaners to be used are as shown below.

a. Ethanol (ethyl alcohol), JIS K 8101 (Reagent Grade), Special or First grades, or equivalent

b. 2-Propanol (Iso-propyl alcohol), JIS K 8839 (Reagent Grade), Special or First grades, or equivalent

c. Mixture of the solvents above

d. Other Solvents: Refer to JERG-0-043-TM001 Technical Data 8.

— NOTES —

i) CFC-113, 1, 1, 1-trichloroethane, etc. is banned substances under the Montreal Protocol on Substances That Deplete the Ozone Layer and shall not be used.

ii) When aqueous cleaners (including semi-aqueous detergent) that requires rinsing with pure water is used, attention shall be paid to the following points.

- Detergency may not be sufficient at the spaces between fine pitch leads and at the back of parts.
- Residues that are problematic for reliability tend to remain unless rinsing and drying is sufficiently made.
- Water used for rinsing shall be deionized water with resistivity of 10 kΩ·m as a minimum.

iii) Because surfactant included in alternative detergent *1 remaining on the wiring board may affect insulation reliability, care shall be taken to avoid residues of the detergent (especially in narrow spacing).

*1: Freon 1.1.3 and 1,1,1 trichloroethane alternative cleaners.

iv) When aqueous detergent or semi-aqueous detergent that contains surfactant is used, detergent penetrated into narrow spacing between parts or a part and wiring board tends to remain in such spacing because the surfactant is not easily replaced with pure water rinsing, and an appropriate cleaning method and control of the rinsing process is essential. Non-ionic surfactant *2 will significantly affect insulation reliability with an increase in number of mols of ethylene oxide in the molecule.

*2: Non-ionic surfactant: While many surfactants show its surface activity with its aqueous solution ionized, certain group of surfactants show surface activity without ionization in aqueous solution. These surfactants are collectively called non-ionic surfactants.

v) When ionic residues on the wiring board having narrow spacing between parts or a part and wiring board are evaluated, evaluation shall take into account ionic residues in narrow spacing.

vi) When detergent containing non-ionic surfactant is used, evaluation by resistivity measurement of solvent extract and by sodium chloride equivalent ionic contamination test may not provide adequate results. As method for evaluating cleanliness other than ionic residues, an analysis method of the non-ionic surfactant described in JERG-0-043-TM001 Technical Data 18 can be effectively used.

vii) Because organic acids such as dicarboxylic acid and amine-halogenated hydrobromide contained in flux and solder paste will affect insulation reliability, they shall be completely removed by cleaning to eliminate any possible residues.

viii) Because the solubility of the flux component (rosin) is dependent on solvents and cleaners, and cleaning time varies, care shall be taken. Effect on resins and rubbers is also different depending on solvents and cleaners, care shall be taken.

[Reference]
For Verification of Evaluation Method of Non-ionic Surfactant, refer to JERG-0-043-TM001 Technical Data 18.
For Evaluation Method of the Effect of Flux Residues, refer to JERG-0-043-TM001 Technical Data 21.

(3) Because some solvents and cleaners my react with the component in the flux to produce reaction products, care shall be taken on the effect in selection of combination.
(4) When the part is marked with ink, the marking may disappear or peel off due to solvent or detergent. Marking permanency tests shall be conducted in selecting solvent, detergent, and cleaning systems.

[Reference]
For comparison of principal cleaning methods, refer to JERG-0-043-TM001 Technical Data 8.
For study of cleaning ability of CFC alternative detergent for cleaning backside of parts, refer to JERG-0-043-TM001 Technical Data 9.

5.3.4 Surface treatment materials of parts and printed wiring board
Surface treatment materials used to improve solderability (principally plating) shall conform with the requirements of JERG-0-039, but the following requirements shall have precedence.

(1) The parts and printed wiring board shall be solder plated as follows except the case where Au-Sn solder alloy is used. Au plating (according to AMS 2422 and ASTM B488) shall apply in the case of Au-Sn solder alloy etc.
   a. Composition of plating – Sn 50%-Sn98% (Balance amount is Pb)
   b. Thickness – 5 μm or more
   c. Method - Electrolytic plating shall be used as a rule. Hot dipping, fusing, or electroless plating may be used provided that intermetallic compound is properly formed with the base metal.
   d. Parts with Au plated terminals shall be used after removing Au with the solder.
(2) In the case of parts and wiring board with Ag plated printed terminals, solder plating shall not be directly applied and protection against leaching shall be considered.

[Reference]
For verification of the effect of the composition of plating of terminals on thermal fatigue strength, refer to JERG-0-043-TM001 Technical Data 10.

5.4 Solder deposition

5.4.1 Solder deposition in total heating process

Deposition of solder paste on the wiring board shall be made by printing (screen printing or stencil printing) or application by the dispenser. The following requirements shall be satisfied.

(1) The following points shall be established by the process specifications as required, and process control shall be provided for application of solder paste.

a. Temperature and humidity of the solder paste application process

b. Printing conditions such as printing speed, printing pressure, penetration, clearance, parallelism of the wiring board, parallelism of squeeze, squeeze angle, parallelism of the mask, and cleaning conditions.

c. Amount of solder fed and accuracy in printing

(2) Attention shall be paid to the following points in handling the solder paste.

a. The solder paste shall be stored under the conditions specified in the material standard and shall be consumed within the specified period.

b. A container of the solder paste shall be opened after leaving at room temperature for the period recommended by the manufacturer (1 to 2 hours normally) after removal from the refrigerator in order to avoid absorption of moisture.

c. Mix well using the special mixer or mixing rod under constant temperature until the specified viscosity is reached (in case of printing process).

d. If solder paste taken out from the container is used again, it shall be verified that no problem is associated with reuse.

(3) Once solder paste is applied, installation of parts and soldering shall be made as quickly as possible within a period recommended by the manufacturer.

(4) When the printing process is used to feed solder, the following points shall be satisfied.

a. Amount of solder fed shall be such that satisfactorily forms the shape of fillet specified in paragraph 5.9.3.

b. For amount of solder fed and accuracy in printing, attention shall be paid to the following points.

i) Application of the appropriate amount of the solder without omission, bleeding, overflow, and shortage shall be confirmed. (For feed amount of solder, thickness of the mask commonly used is indicated in Table 5-2)

ii) For positioning accuracy of the print, absence of shift shall be confirmed.

Table 5-2 Solder feed amount (for reference)

The solder feed amount is determined according to the thickness of the metal mask and the shape and dimensions of the opening of the mask.	
Principal Parts	Solder Feed Amount
i) For rectangular shaped passive parts rectangular shaped with outside dimensions 2.0 mm x 1.25 mm or more having printed terminal or gull wing type active parts with 0.5 mm or more terminal pitch	*150 to 200 μm
ii) For power parts and large parts	200 to 300 μm
iii) For the parts under both i) and ii) categories on the same wiring board	Solder feed amount shall be determined after verification of quality and reliability of the solder joints.

*Note: As a result of the evaluation tests, it was confirmed that the thicker feed with the amount of 400 mm provides better quality for network resistors. (Refer to JERG-0-043-TM001 Technical Data 11.)

(5) The following points shall be satisfied when an application by solder dispenser is employed among the various types of solder feed methods.

a. In the case of the application by solder dispenser, the solder paste specific for solder dispenser shall be used.

b. Solder feed amount is determined by the diameter of needle, discharge pressure and time, and an equivalent amount to the amount of the printing method shall apply.

5.4.2 Solder deposition in local heating process

Methods for solder deposition in local heating are solder paste, solder preforms, solder wires, etc. In these cases, the following points shall be satisfied.

(1) Feeding method of solder paste shall conform to paragraph 5.4.1 of this standard.

(2) In feeding solder, the shape of the preform shall be basically the same as the shape of the land, and the amount shall be such that the shape of the fillet specified in paragraph 5.9.3 of this standard shall be satisfied.

(3) Method of feeding solder wires shall conform to paragraph 5.7 of this standard.

[Reference]

For Verification of Solder Feeding and Shape of Solder Fillet, refer to JERG-0-043-TM001 Technical Data 11.

5.5 Feeding of adhesive for fixing of parts

When feeding adhesive for fixing of the parts is made, appropriate method from printing, transfer, or application by the dispenser shall be selected.

− NOTE −
When the part is bonded on the wiring board, adhesive squeezed from the bottom of the part shall not cover the land of the board.

5.6 Installation of parts

To mount the parts on the board, automatic inserter, semi-automatic inserter, or manual method can be used. In installing the parts, the following points shall be used as reference.

(1) In installing the parts, the checkpoints such as tooling, chipping-off, wear, or blocking of the nozzles of the automatic inserter and semi-automatic inserter, shall be established in the process specifications for the purpose of process control.

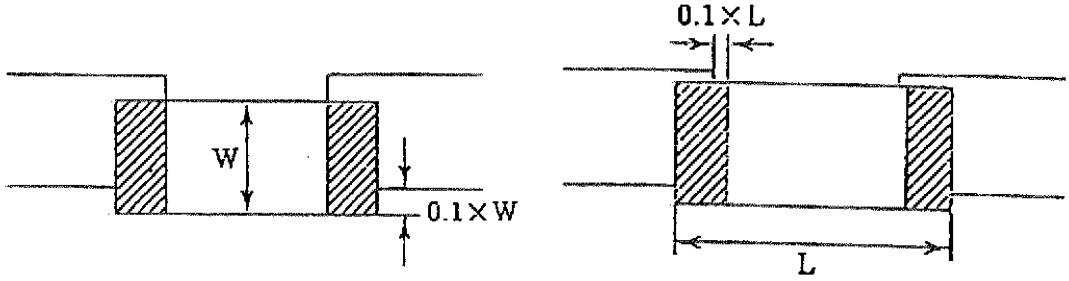
(2) For verification of the accuracy of parts installation, the following points shall be used as reference. However, the ultimate accuracy of installation shall be as specified in paragraph 5.9.3l of this standard.

a. For accuracy of installation in the direction of part width or in the direction of the width of the lead (terminal) (x-direction), accuracy within ±10% or less against the width of the part or lead shall be verified visually or by appropriate magnification.

b. For accuracy of installation in the longitudinal direction of the part or in the longitudinal direction of the lead (terminal) (y-direction), accuracy within ±10% or less against the length of the part or lead shall be verified visually or by appropriate magnification.

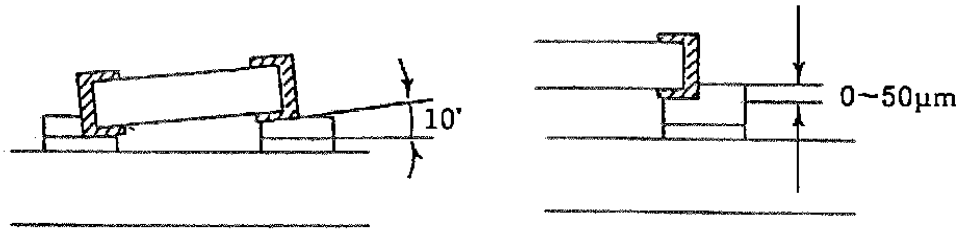
c. For the parallelism of parts installation (z-direction), accuracy within ±10° or less shall be verified visually or by appropriate magnification.

d. For deformation of the solder paste due to installation of the parts, contact of all the terminals with the solder paste and appropriate terminal sinking (0 to 50 mm as standard) shall be verified visually or by appropriate magnification, with Figures 5-2 and 5-3 as a reference.



(1) Installation accuracy in x-direction

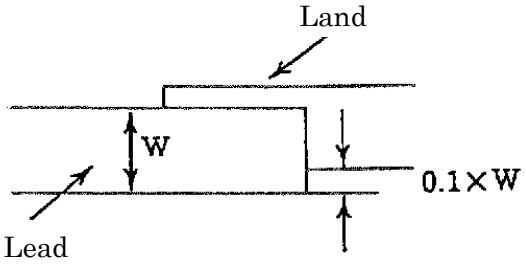
(2) Installation accuracy in y-direction



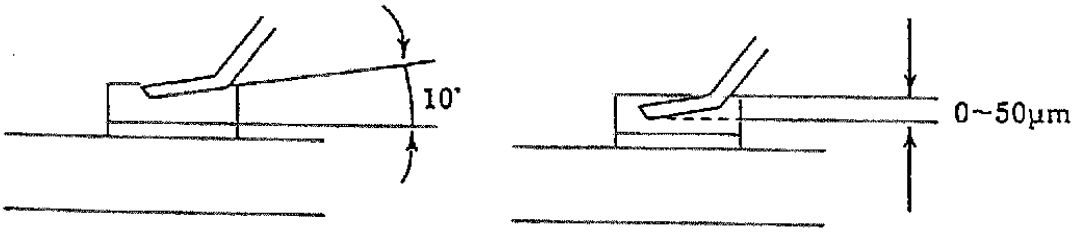
(3) Parallelism of installation in z-direction

(4) Deformation of solder paste due to installation of the part

Figure 5-2 Installation accuracy of the parts (chip and other types)



(1) Installation accuracy in x-direction



(2) Parallelism of installation in z-direction

(3) Deformation of solder paste due to installation of the part

Figure 5-3 Installation accuracy of the parts (gull wing lead type terminal)

5.7 Soldering

Soldering preparation such as confirmation of the parts used and the tools used shall be complied to JERG-0-039.

5.7.1 Total heating process

When the total heating method is used, the following points shall be satisfied.

(1) Temperature profiles for Sn63/Pb37, Sn60/Pb40, and Sn-Ag solder alloys are shown in Figure 5-4 and Table 5-3 for reference.

By VPS method, the temperature profile shown in Figure 5-4 and Table 5-3 is difficult to attain because of the difficulty in regulating temperature increases, accordingly, temperature profiles shall be determined after verification of the quality of solder joints.

(2) For the method of acquiring temperature profiles, use a dummy wiring board and thermocouples attached to the surface of the board, at the terminal of the part, and on the surface of the part with the high temperature solder (melting point 300°C) or the adhesive according to the detail requirements as follows.

a. For locations where the thermocouples are attached, measurements shall be made at three or more points on the surface of the printed wiring board shown in Figure 5-5 unless there are any of the following problems.

b. Where a wiring board or parts having lower guaranteed temperatures for soldering is used or a part with lower maximum allowable temperature for the parts or package is installed, the temperature on the surface of the board, at the terminal of the part, and on the surface of the part shall be measured according to the configuration and fulfillment of the guaranteed maximum temperature for soldering shall be verified.

c. In particular, in case of the soldering method using infrared rays as primary heat source, measurement shall be made very carefully because temperature distribution on the wiring board is significantly affected by differences in the heat absorption rate and heat capacity of the parts.

(2) Control of the temperature profile shall be provided.

— NOTES —

i) Depending on the flux contained in the solder paste, quality of solder joints may significantly decrease due to abnormal reaction when the temperature profile shown in Figure 5-4 and Table 5-3 is used. In such a case, the behavior in soldering shall be investigated using thermal analysis to determine temperature profile suitable for the material concerned.

ii) Soldering by total heating process exceeding once shall not be applied as a rule, other than the case where soldering by total heating is applied for both sides of the wiring board once at each side or where soldering by local heating to mount additional parts is applied. None the less, heat resistance of the parts and wiring board used shall be considered even when soldering by total heating is applied for both sides of the board, once at each side or when soldering by local heating to mount additional parts.

iii) The applicable range of the heat resistance in soldering is limited to the lead in the case of parts with leads. Some parts have different maximum allowable temperature of the package and maximum temperature in soldering. Maximum allowable temperature of the package shall be confirmed for respective parts.

iv) Where a terminal of the part and attachment land having large area are soldered using solder paste, care shall be taken to provide a relief for the vaporized flux because void is easily generated.

[Reference]

For verification of the reliability of solder Joints by repeated reflow processes, JERG-0-043-TM001 Technical Data 12.

Table 5-3 Temperature profile for reference by total heating process

	Item	Specific Detail
I	Heat build-up period for preheating	The preheating temperature shall be reached at constant rate within 30 to 60 seconds continuously with the heat rate of 2.0°C to 5.0°C/sec.
II	Preheating period	Preheating temperature shall be maintained for 60 ± 30 seconds at 150°C ± 10°C. However, this preheating period may be extended within this range when a void is generated in the solder joint.
III	Heat build-up period for actual heating	The actual heating temperature shall be reached at constant rate within 20 to 40 seconds continuously with the heat rate of 2.0°C to 5.0°C/sec.
IV	Actual heating period	(1) In addition to verification of absence of poor wetting with solder and breakage of the parts due to heat, the following requirements shall be satisfied. (2) For Sn63/Pb37 or Sn60/Pb40 solder alloys, 30 to 60 seconds at 200°C or above, and the peak temperature shall be 240°C or below. (3) For Sn-Ag solder alloys, 30 to 60 seconds at 210°C or above, and the peak temperature shall be 255°C or below.
V	Cooling period	Cooling shall be made continuously.

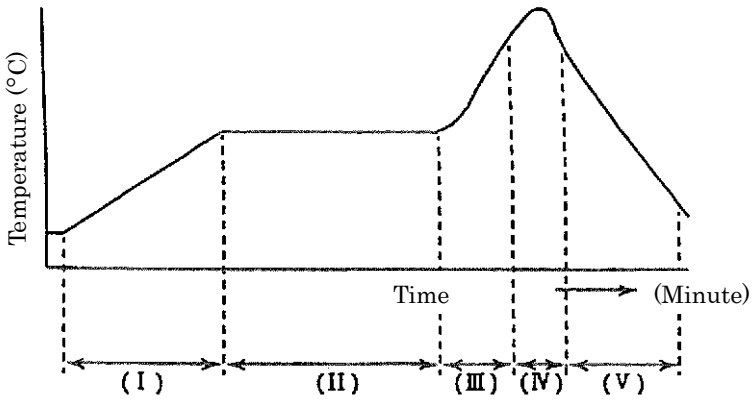


Figure 5-4 Temperature profile for reference

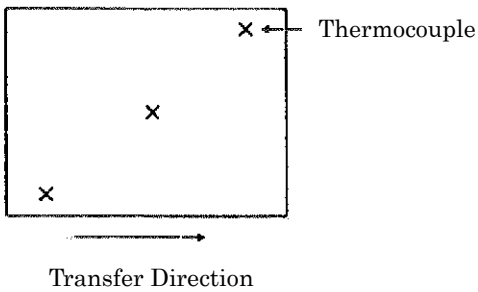


Figure 5-5 Location of the thermocouples for acquiring temperature profile

5.7.2 Local heating process

Where the local heating method is used, the following requirements shall be satisfied. When methods other than this are used, appropriate evaluation shall be made in advance.

(1) The procedure for hand soldering shall conform to the requirements of JERG-0-039, except the followings.

a. In feeding the solder, an appropriate amount of solder shall be melted with the soldering iron in contact with the land and with the solder in contact with the land; quickly remove the soldering iron when solder is melted.

b. The chip of the soldering iron shall be placed on the surface so that temperature of the surface to be joined reaches the temperature for soldering as quickly as possible.

c. When heat capacity of the soldered section is large, a hot plate shall be used as the auxiliary heat source.

― NOTES ―

For hand soldering of multilayer ceramic capacitors, take care regarding the following matters.

i) Make the soldering iron touch only the land of printed circuit board and do not let it touch the electrodes of the multilayer ceramic capacitor.

ii) When soldering, pre-heating the circuit board and multilayer ceramic capacitor using a hot plate and spot heater, etc. is recommended.

iii) After the soldering, avoid rapid cooling.

(2) Where laser soldering or light beam soldering is used, the section to be heated shall be limited to the section where the solder is fed, and the beam shall not irradiate the part or leads other than the solder. However, when the geometry of the terminals of the part is not a lead type and does not satisfy the condition for soldering above, a dummy land shall be provided for irradiation by the beam because damage of the part due to leaching may be possible.

(3) Where pulse heat soldering is used, the following points shall be satisfied.

a. Equipment and soldering condition suitable for configuration of the work shall be established and used.

b. When the heat capacity of the work is large, a hot plate shall be used as the auxiliary heat source so that temperatures as low as possible and soldering time as short as possible can be established as the soldering condition.

[Reference]

For verification of soldering condition by local heating process and reliability of the solder joints, refer to JERG-0-043-TM001 Technical Data 13.

5.8 Cleaning and cleanliness test

5.8.1 Cleaning

(1) Soak cleaning, ultrasonic cleaning, shower cleaning, and brush cleaning methods are available and the cleaning methods and conditions that will not adversely affect the materials of the wiring board or parts and satisfy the cleanliness specified in paragraph 5.8.2 shall be selected.

(2) When aqueous cleaners are used, adequate rinsing with deionized water (10 kΩ·m or more) and complete drying shall apply.

― NOTES ―

i) Ultrasonic cleaning shall not be used for assemblies on which electronic parts such as ICs, diodes, transistors are mounted.

ii) Do not Clean with the detergents that will affect the parts shown in JERG-0-043-TM001 Technical Data 14.

iii) Cleaning shall apply as quickly as possible after soldering is complete.

[Reference]

For assessment of wash solvent resistance with respect to parts and materials, refer to JERG-0-043-TM001 Technical Data 13.

5.8.2 Cleanliness test

(1) Cleanliness test is performed in order to monitor effectiveness of cleaning of the board assembly after soldering. The board assembly designated shall be tested before application of conformal coating.

(2) Test method employed shall be either of the following as a rule.

a. Resistivity of the solvent extract

b. Sodium chloride (NaCl) equivalent ionic contamination test

(3) When ionic residues locally present cannot be detected by the above test methods (e.g., extraction is impossible by NaCl equivalent ionic contamination test due to configuration of the part), ion chromatographic method shown in paragraph 5.8.2(7) is effective.

(4) Allowable limit

Within the range shown in Table 5-4.

Table 5-4 Allowable limit for cleanliness test

Test Method	Initial Value	Final Value
Resistivity of Solvent Extract	60 kΩ·m	20 kΩ·m or more
Sodium Chloride Equivalent Ionic Contamination Test	200 kΩ·m	Less than 1.55 μg/cm^2(10.0 μg/in^2)

(5) Resistivity of solvent extract

Resistivity of the solvent extract shall be measured as follows.

a. The test solution shall be 75% isopropyl alcohol and 25% deionized water by volume. This solution shall be passed through the mixed bed de-ionizing cartridge. Resistivity of the solution after passing through the cartridge shall exceed 60 kΩ·m .

b. A funnel, washing bottle, and a container shall be washed using the test solution. The test solution shall be prepared in an amount at 1.55 ml/cm2(10 ml/in2) for the area of board assembly at both sides.

c. The test solution shall be slowly poured over both sides of the board until the prepared amount is consumed.

d. Resistivity of this extract shall be measured using a resistivity meter.

(6) Sodium chloride equivalent ionic contamination test

Sodium chloride equivalent ionic contamination test shall be conducted as follows.

a. The test solution shall be 75% isopropyl alcohol and 25% deionized water. It shall be checked out that the composition of the test solution is correct at the beginning of the test and at 4-hour intervals. If fluctuations in composition check data are small and do not adversely affect the test result, the interval periods may be extended.

b. The equipment used shall be calibrated at the same interval with the interval for composition check of the test solution using the reference solution with known amount of NaCl.

c. Initial and standard purity of the test solution shall exceed 200 kΩ·m prior to measurement of each sample.

d. The automated device for conducting this test is available in the market and may be used. Such deice is recommended when control of cleaning is made continuously. This device will indicate amount of NaCl per rectangular inch in micrograms, and in order to obtain accurate result, careful calibration shall be made for individual flux.

(7) Ion chromatographic method

Measurement by ion chromatographic method shall be made as follows.

a. Drop 30 ml of deionized water (200 kΩ·m or more) using a syringe on the surface of the wiring board where a part is removed.

b. Rub the section of the part stripped from the board against the section of the board from which the part is removed, and dissolve the residues in deionized water (200 kΩ·m or more).

c. After dissolving for 5 minutes, suck up the deionized water (200 kΩ·m or more) using a syringe and add deionized water (200 kΩ·m or more) to make 50 ml solution.

d. Inject the solution of (c) above into the ion chromatography instrument for measurement.

[Reference]

For Verification of the Evaluation Method of Wiring Board Cleanliness, refer to JERG-0-043-TM001 Technical Data 15.

5.9 Quality assurance

5.9.1 Records

The following records shall be made available.

(1) Process control record of solder feeding
(2) Process control record of parts installation
(3) Process control record of adhesive feeding for fixing of parts
(4) Process control record of soldering.
(5) Record of cleaning and cleanliness test
(6) Record of visual inspection
(7) Record of operators and inspectors qualification
(8) Record of environmental conditions (temperature and humidity)
(9) Calibration record of manufacturing and inspection tools and equipment
(10) Record of dehumidification of wiring boards (assembly)

5.9.2 Inspection

The following inspections shall be made at appropriate stages in the processes.

(1) Visual inspection
(2) Non-destructive testing
(3) Functional test
(4) Cleanliness test

5.9.3 Visual inspection

The requirements for surface mounting are as follows. Other than those provided below shall be in accordance with JERG-0-039.

Visual inspection shall be made for all the solder joints and the peripheries using Inspection Magnification shown in Table 5-5. When result of inspection using the Inspection Magnification of Table 5-5 is doubtful, acceptance shall be determined using the Acceptance Judgment Magnification in Table 5-5. Higher magnification shall be used as necessary.

For acceptance criteria in visual inspection of solder joints shall be in accordance with (1) and (2) below and J-STD-001*S.

Table 5-5 Magnification for visual inspection

Objects of Inspection	Inspection Magnification	Acceptance Judgment Magnification*
Surface Mounting	10x	20x
Surface Mounting (Pitch 0.65 mm or less)	20x	40x

* When result of inspection using the Inspection Magnification is doubtful, acceptance shall be determined using the Acceptance Judgment Magnification.

(1) Acceptance criteria

a. As a rule surface of the solder shall be shiny and smooth. However, dull surface due to oxidization film on smooth solder joints is acceptable.

b. For solder joints of the part of which the height of the terminal is large like tantalum capacitor, discontinuity of the curvature of the surface may be formed at the point where solder fillet formed from the terminal of the part and the solder fillet formed from the land meet and it may look that a line is formed, but such joint is acceptable.

c. The complete wetting by solder shall be established.

d. Shape of the solder fillet shall comply with the shape specified in Tables 5-6 through 5-14.

(2) Rejection criteria

Conditions as shown below are inappropriate solder joints and constitute a ground for rejection if any one of such conditions applies.

a. Scorching, burning, melting of the part and leaching of the terminal

b. Scorching of the wiring board material and separation of the conductor

c. Presence of dropping out of the part unsecured lead, dislocation, and Manhattan-style construction of the parts

d. Un-melted solder, non-wetting by solder, bridging and solder ball

Unless special provision is applicable to the foreign substances, stationary substance (will not move by external force applied with a stick etc.) of which dimension deducted from the minimum distance between patterns satisfies minimum required conductor spacing may be acceptable when coating is applied.

e. Cracks in the solder joints

f. Flux residues after cleaning

However, very small amount of flux residues that can be demonstrated harmless based on the evaluation data of the electrochemical migration resistance test according to objective evidence and technical judgment, can be excluded.

[Reference]

For the relationship between solder fillet shape and service life, refer to JERG-0-043-TM001 Technical Data 16.

For comparisons of acceptance criteria for visual inspection, refer to JERG-0-043-TM001 Technical Data 22.

For acceptance criteria in visual inspection of solder joints, refer to JERG-0-043-TM001 Technical Data 23.

Table 5-6 Visual inspection criteria for soldering of chip parts

Feature	Dim.	Requirements
Max. Side Overhang	A	0.25 W or 0.25 P whichever is less. Minimum space between electrodes shall be maintained.
End Overhang(Not indicated in the sketch)	B	Not permitted
Min. End Joint Width	C	0.75 W or 0.75 P whichever is less
Min. Side Joint Length	D	0.75 T or 0.13 mm whichever is less
Max. Fillet Height	E	Fillets may be formed on electrodes but shall not extend beyond the electrode to the body of the part.
Min. Fillet Height	F	0.3 H or 1 mm whichever is less
Solder Thickness	G	0 to 0.3 mm
Electrode Thickness	H	Value specific to the part
Min. Land and Electrode Overlap	J	Overlap shall be maintained.
Width of Land	P	Design value
Electrode Width	W	Value specific to the part
Max. Installation Gradient	θ	10°

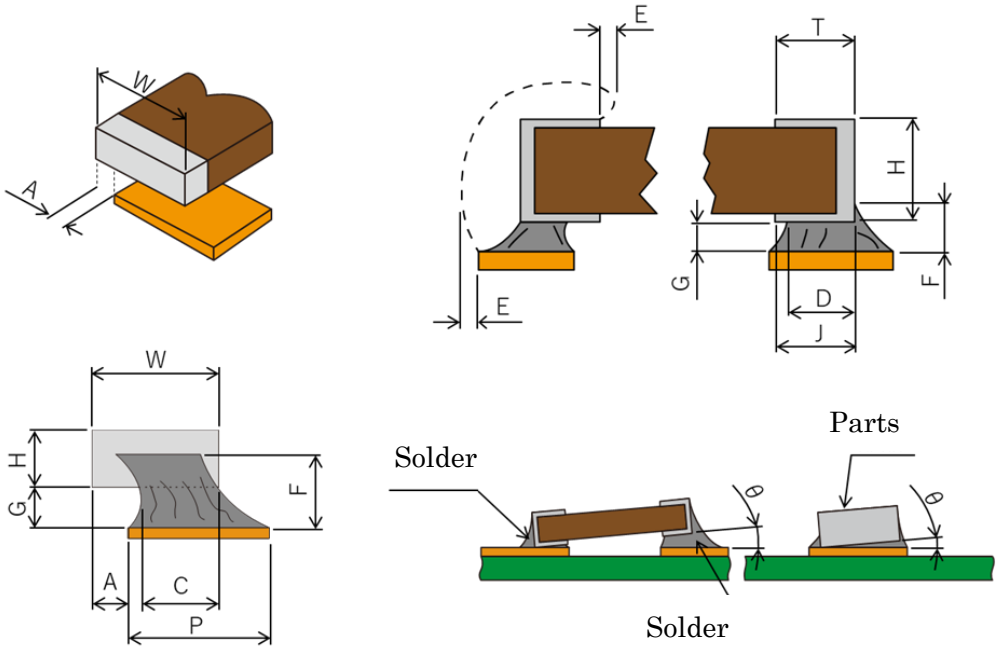
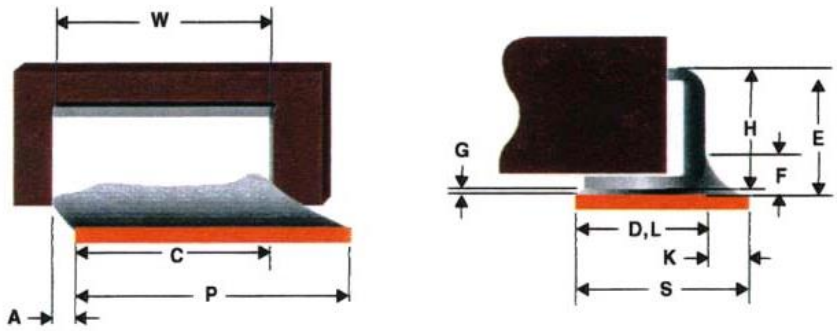


Figure 5-6 Chip parts

Table 5-7 Visual inspection criteria for soldering of L-leaded parts

Feature	Dim.	Requirements
Max. Side Overhang	A	0.25 W or 0.25 P whichever is less. Minimum space between terminals shall be maintained.
Max. Toe Overhang (Not indicated in the sketch)	B	Not permitted
Min. End Joint Width	C	0.75 W or 0.75 P whichever is less
Min. Side Joint Length	D	0.75 L
Max. Fillet Height	E	H+G, Solder shall not be in contact with the body of the part.
Min. Fillet Height	F	0.3 H or 1 mm whichever is less
Solder Fillet Thickness	G	0 to 0.3 mm
Lead height	H	Value specific to the part
Min. Land Extension	K	0.5 H or 0.5 mm whichever is less
Lead Length	L	Value specific to the part
Land Width	P	Design value
Land Length	S	Design value
Lead Width	W	Value specific to the part

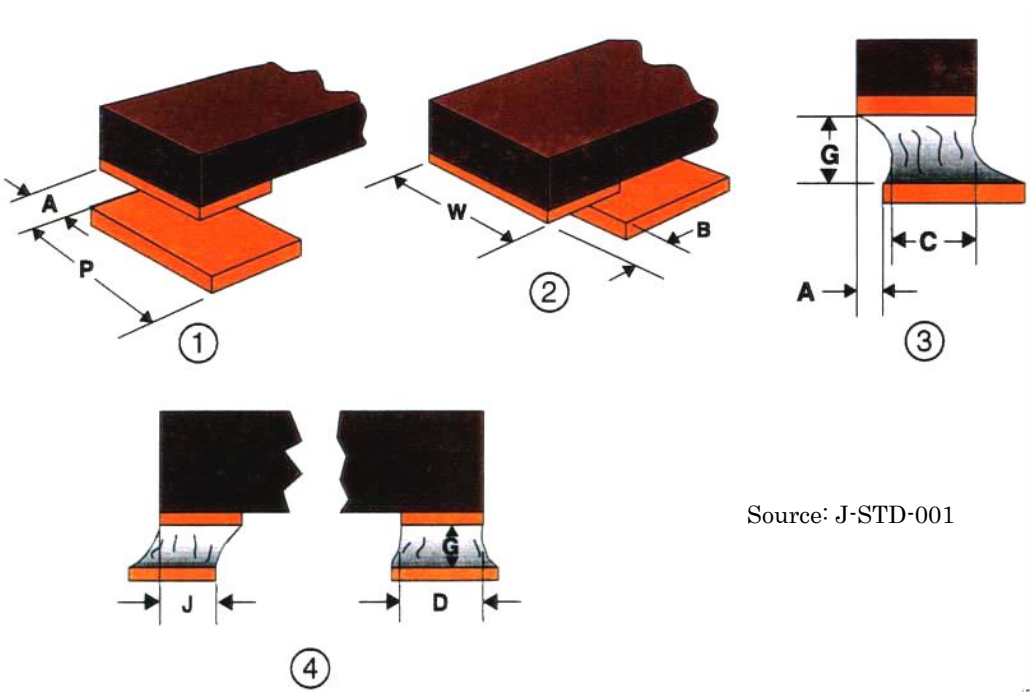


Source: J-STD-001

Figure 5-7 L-Leaded parts

Table 5-8 Visual inspection criteria for soldering of bottom terminal parts

Feature	Dim.	Requirements
Max. Side Overhang	A	Minimum spacing between electrodes shall be maintained.
End Overhang	B	Not permitted
Min. End Joint Width	C	0.75 W or 0.75 P whichever is less
Min. Side Joint Length	D	Satisfactory fillets shall be formed.
Solder Thickness	G	While height is not specified, satisfactory fillet shall be formed.
Land and Electrode Overlap	J	Overlap shall be maintained.
Land Width	P	Design value
Electrode Width	W	Value specific to the part

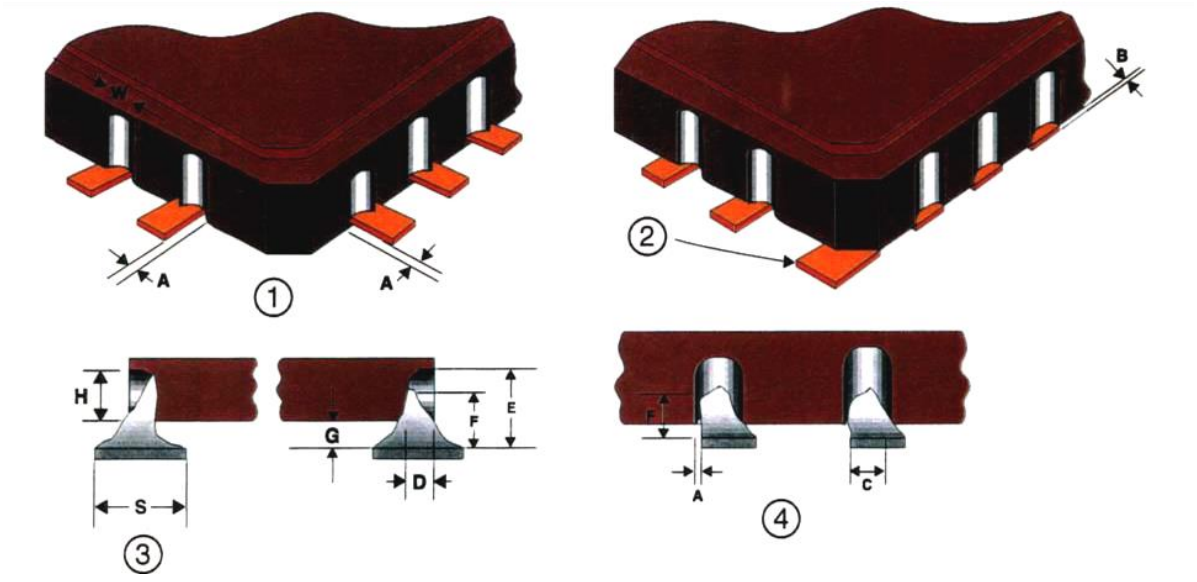


Source: J-STD-001

Figure 5-8 Bottom terminal parts

Table 5-9 Visual inspection criteria for soldering of LCC parts

Feature	Dim.	Requirements
Max. Side Overhang	A	0.25 W. Minimum spacing between terminals shall be maintained.
End Overhang	B	Not permitted
Min. End Joint Width	C	0.75 W
Min. Side Joint Length	D	Depth of castellation
Max. Fillet Height	E	The maximum fillet may extend past the top of the castellation provided it does not contact the body. Does not violate minimum electrical clearance.
Min. Fillet Height	F	G + 0.5 H
Solder Thickness	G	Wetting shall be evident.
Electrode Height	H	Value specific to the part
Land Length	S	Design value
Electrode Width	W	Value specific to the part

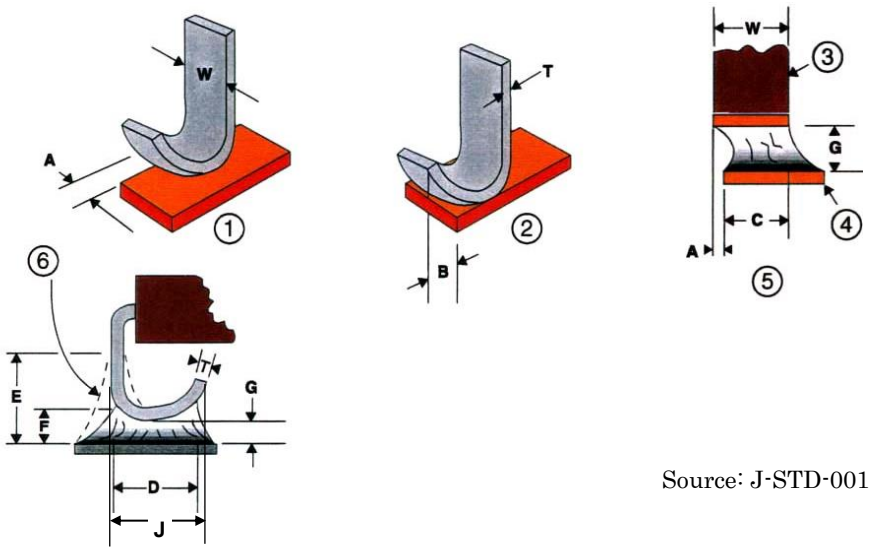


Source: J-STD-001

Figure 5-9 LCC parts

Table 5-10 Visual inspection criteria for soldering of J-leaded parts

Feature	Dim.	Requirements
Max. Side Overhang	A	0.25 W. Minimum spacing between terminals shall be maintained.
Max. Toe Overhang	B	0.25 W
Min. End Joint Width	C	0.75 W
Min. Side Joint Length	D	1.5 W or 0.7 J whichever is less
Max. Heel Fillet Height	E	Solder shall not be in contact with the body of the package.
Min. Heel Fillet Height	F	Points where the lead starts to deflect shall be reached. Heel fillets shall be formed.
Max. Solder Thickness	G	0.75 mm
Lead Thickness	T	Value specific to the part
Lead Width	W	Value specific to the part



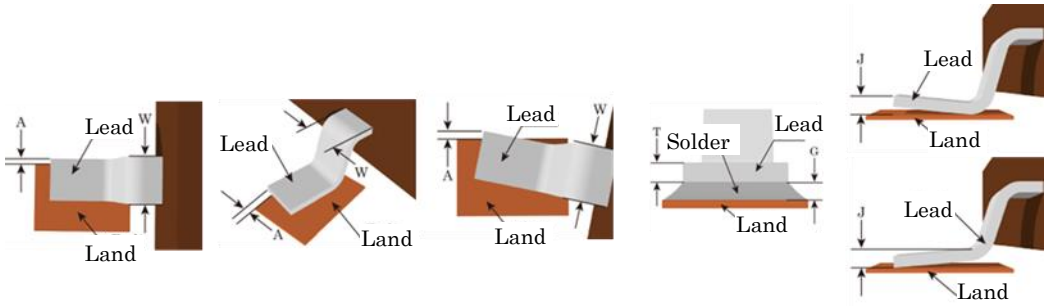
Source: J-STD-001

Figure 5-10 J-Leaded Parts

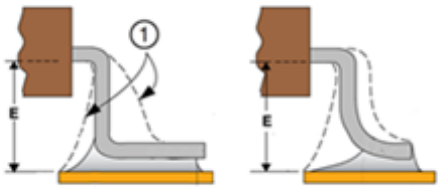
Table 5-11 Visual inspection criteria for soldering of gull wing lead parts

Feature	Dim.	Requirements
Max. Side Overhang	A	0.25 W or 0.5 mm whichever is less
Max. Heel Fillet Hight	E	The solder fillet may span the bend of the lead shoulder. Solder shall not contact with component molds or seals. Surface mount components with 42 alloy or similar metal leads shall not have solder extending below the body.
Max. Solder Thickness	G	2 T
Max. Lead Deflection	J	3 T

[Reference]
For maximum heel fillet height of gull wing leaded terminal parts, refer to JERG-0-043-TM001 Technical Data 27.



Judgment criteria figure for locations A, G, and J



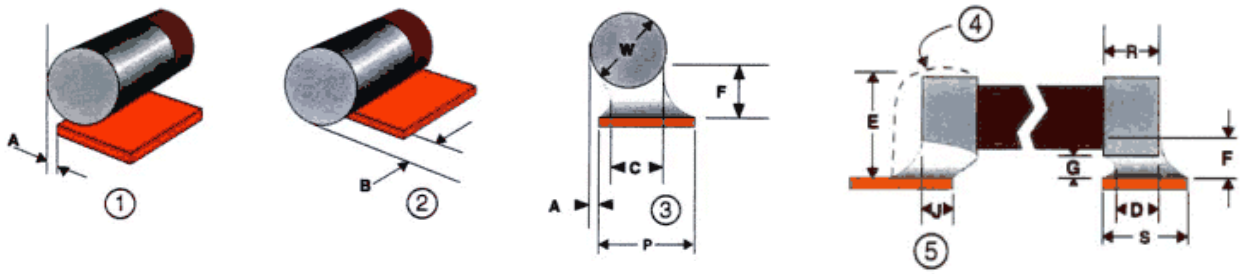
Judgment criteria figure for location E
①: See the required values for E in Table 5-11.
Source of E location: J-STD-001

Figure 5-11 Gull wing lead parts

― NOTES ―
For ①, the case where the solder is unavoidably raised during reflow is assumed.

Table 5-12 Visual inspection criteria for soldering of MELF parts

Feature	Dim.	Requirements
Max. Side Overhang	A	0.25 W or 0.25 P whichever is less. Minimum spacing between electrodes shall be maintained.
End Overhang	B	Not permitted
Min. End Joint Width	C	0.5 W or 0.5 P whichever is less
Min. Side Joint Length	D	0.75 R or 0.75 S whichever is less. Not applicable to parts with electrodes at the side only.
Max. Fillet Height	E	Fillets may be formed on electrodes but shall not extend beyond the electrode to the body of the part.
Min. Fillet Height	F	G+0.25W or G+1.0mm, whichever is less
Solder Thickness	G	Wetting shall be evident.
Land and Electrode Overlap	J	0.75R. Not applicable to parts with electrodes on the side only.
Land Width	P	Design Value
Electrode Length	R	Value specific to the part
Land Length	S	Design Value
Electrode Diameter	W	Value specific to the part



Source: J-STD-001

Figure 5-12 MELF parts

Table 5-13 Visual inspection criteria for soldering of plate electrode parts (diode parts)

Feature	Dim.	Requirements
Max. Side Overhang	A	As specified in Chip part (Table 5-6)
Max. End Overhang	B	As specified in Chip part (Table 5-6)
Min. Joint Width	C	As specified in Chip part (Table 5-6)
Max. Fillet Height	E	As specified in Chip part (Table 5-6)
Min. Fillet Height	F	G+0.25H or G+0.5mm, whichever is less
Solder Thickness	G	As specified in Chip part (Table 5-6)
Electrode Height	H	Value specific to the part
Land and Electrode Overlap	J	As specified in Chip part (Table 5-6)
Land Width	P	Design value
Electrode Width	W	Value specific to the part
Max. Installation Gradient	θ	As specified in Chip part (Table 5-6)

[Reference]
For the solder joint appearance criteria for plate electrode parts (diode parts), refer to JERG-0-043-TM001 Technical Data 24 and 25.

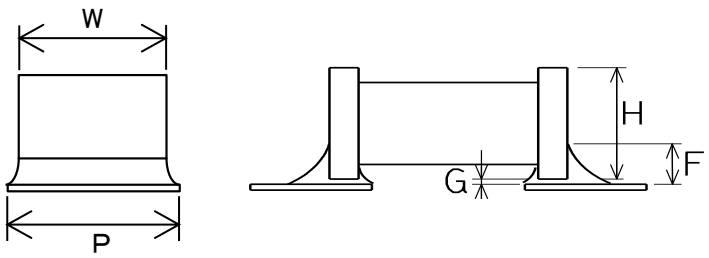


Figure 5-13 Plate electrode parts (diode parts)

Table 5-14 Visual inspection criteria for soldering of stacked capacitor parts

Feature	Dim.	Requirements
Max. Side Overhang	A	0.25 W or 0.25 P whichever is less. Minimum space between electrodes shall be maintained.
Max. Toe Overhang	B	Minimum space between electrodes shall be maintained.
Min. End Joint Width	C	0.75 W or 0.75 P whichever is less
Min. Side Joint Length	D	0.75 L
Max. Fillet Height	E	Lower surface of Capacitor
Min. Fillet Height	F	G+T
Solder Fillet Thickness	G	Wetting shall be evident
Lead height	H	Value specific to the part
Min. Land Extension	K	Design value. Value specific to the part
Lead Length	L	Value specific to the part
Land Width	P	Design value
Land Length	S	Design value
Lead Width	W	Value specific to the part
Lead Thickness	T	Value specific to the part

[Reference]
For the solder joint appearance criteria for stacked capacitor parts (diode parts), refer to JERG-0-043-TM001 Technical Data 24 and 25.

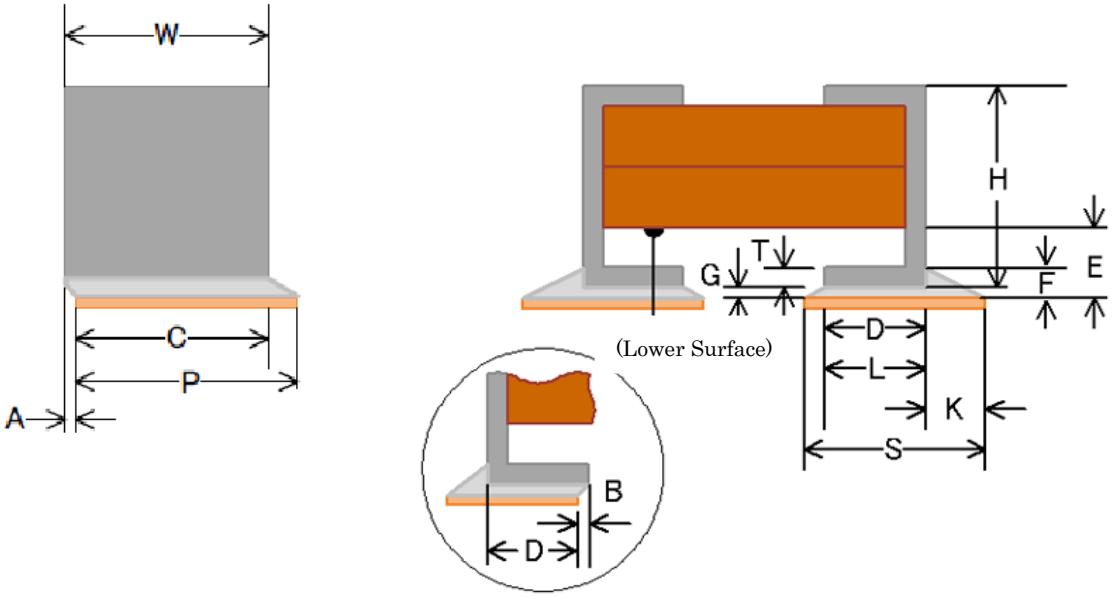


Figure 5-14 Stacked capacitor parts

5.9.4 Nondestructive inspection

Appropriate nondestructive inspections, such as X-ray inspections, shall be conducted where specified by the contract documents or as required to verify that no defect detrimental to the performance is present.

5.9.5 Functional test

After completion of inspections under paragraphs 5.9.3 and 5.9.4, electrical inspections shall be conducted to verify that no anomalies are present.

5.9.6 Cleanliness test

After cleaning, no contamination and flux residue shall be found when inspected visually. Where a cleanliness test after cleaning is specified in the technical documents, the test specified in paragraph 5.8.2 shall be successfully conducted and the results shall meet the requirements.

5.10 Rework of Solder Joint

(1) Rework of solder joints shall be classified as follows depending on the configuration of the terminals of the part.

a. Chip parts:

As a rule, local soldering shall be applied after replacement with the new parts.

b. Lead parts:

Local soldering shall be applied after removing solder at the joint and on the lead terminal. The part may be used without replacement if no problem is detected when quality is checked.

(2) Rework of the solder joint shall be made in appropriate conditions according to the local heating process specified in paragraph 5.7. As a rule, only one cycle of rework shall be applied at the same location. (See JERG-0-043-TM001 Technical Data 17. One cycle of rework shall consist of a removal of solder and a re-soldering) Rework shall be made in accordance with paragraph 5.6.5 (Rework) of JERG-0–039.

The further rework can be made if the Reliability Evaluation Data proves that there will not be any problems.

— NOTE —
Because solder lands are easily detached and removed, adequate care shall be taken in removing solder with a solder wick not to move the soldering iron more than necessary.

5.11 Evaluation and Judgment of Service Life of Solder Joint

Evaluation method and acceptance criteria for the test method and conditions specified in paragraph 4.4.2 are as follows.

5.11.1 Evaluation and judgment by visual inspection

Visual inspection criteria shown in Table 5-15 shall be satisfied.

Table 5-15 Evaluation and criteria for visual inspections

Item	Specific Details
(1) Procedure for Thermal Shock Test	Thermal shock tests shall be conducted according to the test method and conditions specified in paragraph 4.4.2. a. Sample - The material of the surface mount wiring board, configuration of solder land, and the mounted parts of the sample shall be equal to those used for the actual electronic device. Soldering shall be made using the same equipment, conditions, and materials with those used for the actual production of the electronic devices. - Evaluations shall be made for the respective parts. (It is recommended that the number of solder joints to be evaluated should be n = 50 or more per part from the accuracy point of view in determination of service life.) b. Preparation of the sample - Flux remaining on the surface of solder joints shall be cleaned before the inspection to facilitate easy detection of surface cracks in the solder.
(2) Procedure and Evaluation Method and Criteria for Visual Inspection	Visual inspections shall be made using appropriate magnification. a. Sampling rate for visual inspections - Sampling rate shall be 100 cycles or less from accuracy point of view of inspection. b. Evaluation and judgment criteria for surface cracks in the solder - Evaluation of surface cracks in the solder shall be made according to the class of the level specified in Table 5-18. Surface clack level class 4 shall be judged unacceptable.
(3) Weibull Analysis, Evaluation, and Determination Criteria for Service Life	Analysis shall be made for cracks classified as surface crack level class 4 using Weibull Probability Plotting Paper. It shall be confirmed that the characteristic life (η) satisfies 500 cycles.

5.11.2 Evaluation and judgment of crack depths

Evaluation of crack depth as shown in Table 5-16 shall be conducted, and the criteria shall be satisfied.

Table 5-16 Evaluation and criteria for crack depths

Item	Specific Details
(1) Procedure for Thermal Shock Test	Thermal shock tests shall be conducted according to the test method and conditions specified in paragraph 4.4.2. a. Sample - Same as under paragraph 5.11.1. b. Preparation of the sample - Same as under paragraph 5.11.1.
(2) Procedure for measurement of Crack Depth	Crack depth shall be measured by cross-section observation of the sample after completing 500 cycles. a. The center of the solder joint shall be cut, and the section shall be prepared by polishing or etching the surface for the measurement of crack depth using an appropriate optical microscopy. b. The number of sections of the solder joint to be inspected shall be n = 10 or more for each part taking variance in the samples and preparing sections.
(3) Evaluation Method and Criteria	- The evaluated crack depth shall be classified according to the crack depth level class specified in Table 5-19. Cracks classified as crack depth level class 3 or higher shall be determined unacceptable, and all the solder joints inspected shall be classified as crack depth level class 0, 1 or 2.

5.11.3 Evaluation and judgment by electrical characteristics

Inspection and evaluation of electrical characteristics as shown in Table 5-17 shall be conducted, and the criteria shall be satisfied.

Table 5-17 Evaluation and criteria for electrical characteristics

Item	Specific Details
(1) Procedure for Thermal Shock Test	Thermal shock tests shall be conducted according to the test method and conditions specified in paragraph 4.4.2. a. Sample - Same as under paragraph 5.11.1. b. Preparation of the sample - Same as under paragraph 5.11.1.
(2) Procedure for Electrical Characteristics Evaluation	Inspection of electrical characteristics of solder joints shall be conducted at both normal and test temperatures after completing 500 cycles.
(3) Criteria	No anomalies shall be detected when conductive resistances before and after the test are compared.

Table 5-18 Crack level class on solder surface based on visual inspection
(chip type parts)

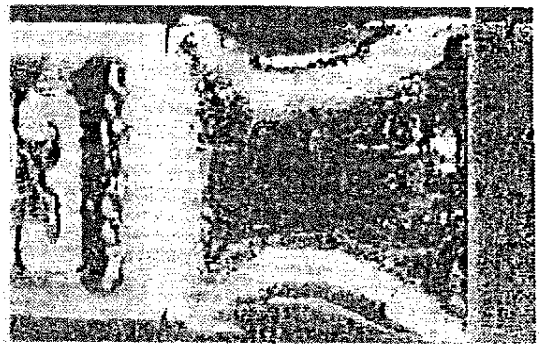
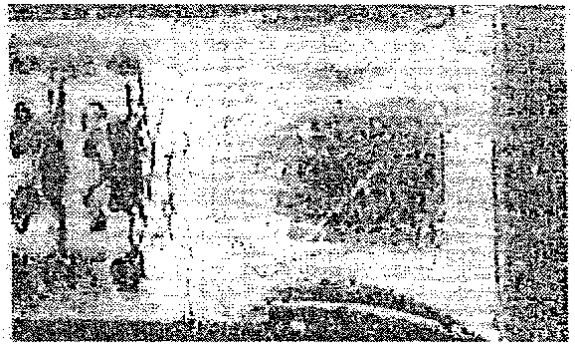
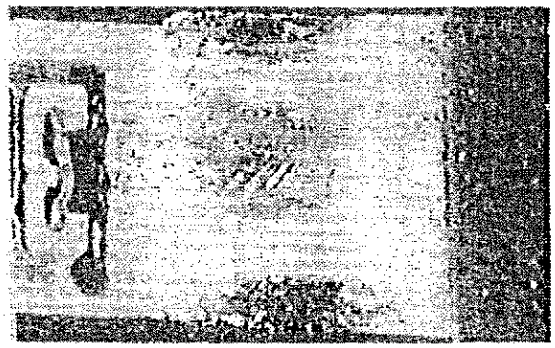
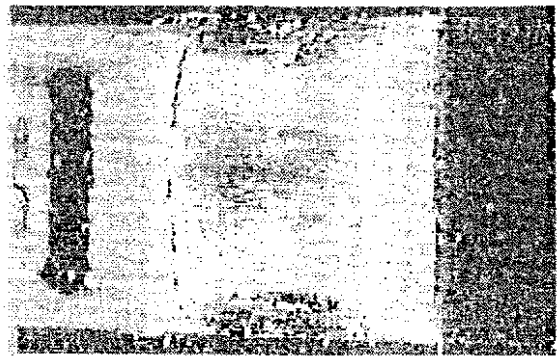
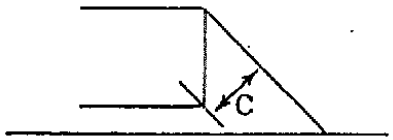
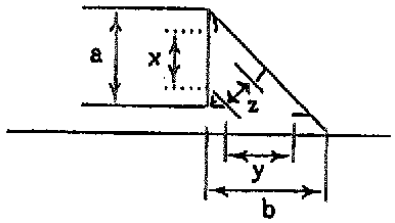
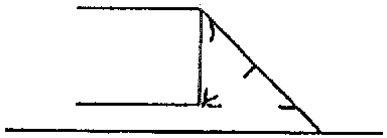
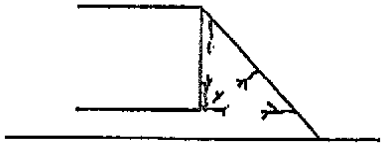
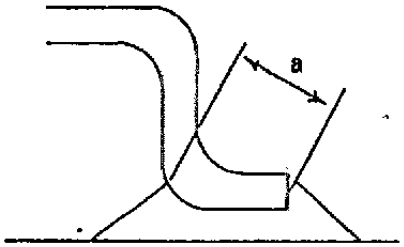
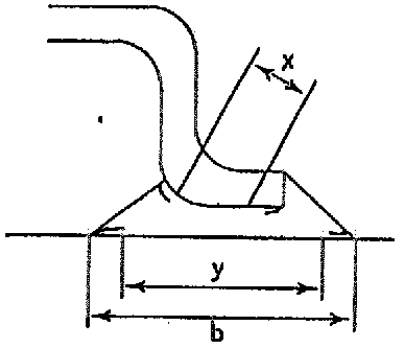
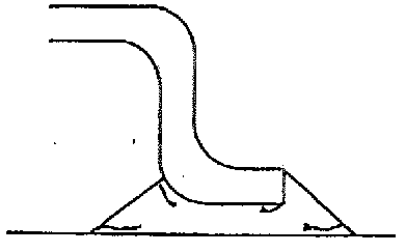
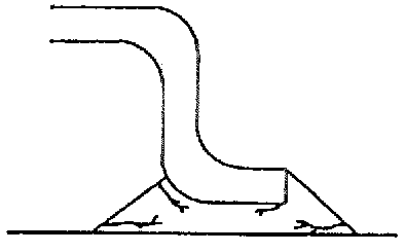
Surface Crack Level Class		Typical Example
1	Wrinkles and cracks shall not be observed on the surface of solder fillets.	
2	Wrinkles that are not deep enough to be considered cracks are observed on the surface of the solder fillet (especially the boundary between the part terminal and solder).	
3	The length of cracks on the solder fillet surface must be less than 1/2 of the component width.	
4	The length of crack on the solder fillet surface must be longer than 1/2 of the component width.	

Table 5-19 Crack depth level class of solder joints

Class		0	1	2	3
Principal Configuration of Parts	1	 No cracks are observed in the solder	 X ≥ 4/5a Y ≥ 4/5b Z ≥ 4/5c Conditions for all X, Y, and Z are satisfied.	 2/3a ≤ X < 4/5a 2/3b ≤ Y < 4/5b 2/3c ≤ Z < 4/5c Conditions for all X, Y, and Z are satisfied.	 X < 2/3a Y < 2/3b Z < 2/3c Any condition of either X, Y, or Z is satisfied.
	2	 No cracks are observed in the solder	 X ≥ 4/5a Y ≥ 4/5b Conditions for all X and Y are satisfied.	 2/3a ≤ X < 4/5a 2/3b ≤ Y < 4/5b Conditions for all X and Y are satisfied.	 X < 2/3a Y < 2/3b Any condition of either X or Y is satisfied.

Appendix I Terms and definitions

Terms and definitions used in this standard are as follows:

(1) Crack (or Solder Crack)

Fissure of the material. In this standard, a phenomenon that occurs by generation of thermal stresses in the solder joint due to differences in the coefficient of thermal expansion between the wiring board, parts, and solder alloy.

(2) Eutectic Structure

A mixture of more than one crystalline substance produced by solidification of the mixture of such substances in the liquid phase when the mixture is gradually cooled. In the case of Sn and Pb alloy, 62.7Sn-37.3Pb produces the eutectic system, and at the temperature of 183°C, the alpha phase (Pb) and beta phase (Sn) crystallize simultaneously, and the eutectic structure is formed.

(3) Finite Element Method (FEM)

One of the structural and strength analysis methods using computer simulations.

(4) Gull Wing Lead

A surface mount part lead that flares outward from the part body.

(5) Intermetallic Compound

An alloy phase formed between the solder alloy and material of the conductor and has a harder and more brittle property than the original metals. Between Sn and Cu in the solder joints, intermetallic compounds consisting of the epsilon phase (Cu_3Sn) and the eta phase (Cu_6Sn_5) are formed.

(6) Land

A portion of a conductive pattern usually, but not exclusively, used for connection or attachment, or both, of parts. Square lands are principally used for the connection to surface mount parts, and round lands are used for parts with leads.

(7) Laser Soldering

A type of reflow soldering method where the Nd:YAG laser or CO_2 laser is used as the heat source. The Nd:YAG laser is principally used as the heat source as non-contact type heat source in the surface mount method.

(8) LCC (Leadless Chip Carrier)

A surface mount package component without leads, and the pads are arranged on the side of the package. (Usually a ceramic package IC)

(9) Leaching

A phenomenon where components of the material joined with solder diffuses into the solder alloy partially or totally, which results in erosion of the material.

(10) Light Beam Soldering

A method of soldering where energy generated by the concentration of reflected light at the second focal point irradiated from a light source such as xenon arc lamp located at the first focal point of the elliptical mirror is used. Features of non- contacting rapid and local heating can be achieved.

(11) Marginal Life (or Failure Time)

Time duration from start of the operation of the device or equipment to a failure. In this standard, marginal life is defined as the number of cycles to the first occurrence of an open circuit detected by the electrical inspection.

(12) MELF (Metal Electrode Face)

A surface mount part with a cylindrical shape.

(13) Migration (or Electrochemical Migration)

Migration is a phenomenon, a special instance of electrochemical corrosion, where the metal component transfers from the cathode to the anode when the potential difference is applied between the electrodes in humid conditions. Typical example is migration of Ag solder.

(14) Orange peel

The state of the solder surface with either of the following appearances: roughness, significant irregularities, presence of spots, and presence of striations.

(15) Residue

Substances of solder or flux that adhere and remain on the wiring board, conductors, resist, and parts mounted on the board, and may cause failure.

(16) Rework

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

(17) Scale Parameter (η)

One of the parameters in the Weibull Analysis. Scale parameter is the time duration (life) when 63.2% of total samples fail in the analysis using the Weibull probability paper frequently used in the reliability data analysis, whatever the type of failure. In this standard, the Weibull analysis is conducted for the number of failures in the visual and electrical inspections.

(18) Solder Paste

A material where the solder powder is mixed in the flux material in the emulsion state, and various additives are added to prevent separation of the solder powder and flux and to add viscosity to the paste, thixotropic effect, and printability.

(19) Thermal Stress

Stresses introduced by nonuniform temperature distribution or temperature change in a structure or material which is constrained against expansion or contraction due to the external constraints.

(20) Thick Film Electrode

Conductors or terminals formed by baking in atmospheric air or inert gas atmosphere after the paste of Ag-Pd, Cu, etc., is coated, sprayed, or printed principally on the ceramic wiring board.

(21) VPS (Vapor Phase Reflow Soldering)

The reflow soldering method where the latent heat of condensation generated from the heating medium, such as inert organic solvent heated to evaporation when its vapor condenses.

(22) X-ray Micro Analyzer

One of the surface analysis methods where low energy electrons are injected onto the solid surface and identification of the elements present on the solid surface is made by detecting X-rays generated from the surface in return.