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SOLDERING OF ELECTRICAL CONNECTIONS (HAND OR MACHINE), STANDARD FOR

ENGINEERING DEVELOPMENT DIRECTORATE

National Aeronautics and
Space Administration

John F. Kennedy Space Center

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ABBREVIATIONS AND ACRONYMS

AWG	American Wire Gage
°C	degree Celsius
DE	Engineering Development Directorate
°F	degree Fahrenheit
GSE	ground support equipment
KSC	John F. Kennedy Space Center
mm	millimeter
NASA	National Aeronautics and Space Administration
NHB	NASA handbook
STD	standard

SOLDERING OF ELECTRICAL CONNECTIONS (HAND OR MACHINE), STANDARD FOR

1. SCOPE

This standard establishes the requirements for soldering of electrical connections on ground support equipment (GSE) that does not directly interface with flight hardware, or where the requirements of NHB 5300.4 (3A-2) are not appropriate to design or project needs. It is not the intent of this standard to give detailed instructions as to procedure.

2. APPLICABLE DOCUMENTS

The following documents form a part of this document to the extent specified herein. When this document is used for procurement, including solicitations, or is added to an existing contract, the specific revision levels, amendments, and approval dates of said documents shall be specified in an attachment to the Solicitation/State of Work/Contract.

2.1 Governmental.

2.1.1 Specifications.

Federal

QQ-S-571	Solder, Electronic (96 to 485 Degrees C)

2.1.2 Standards.

Military

MIL-STD-2000	Standard Requirements for Soldered Electrical and Electronic Assemblies

2.1.3 Documents.

National Aeronautics and Space Administration (NASA)

NHB 5300.4 (3A-2)	Requirements for Soldered Electrical Connections

(Copies of specifications, standards, drawings, and publications required by contractors in connection with specified procurement functions should be obtained from the procuring activity or as directed by the Contracting Officer.)

2.2 Non-Governmental.

American National Standards Institute (ANSI)

ANSI/IPC J-STD-001	Requirements for Soldered Electrical and Electronic Assemblies

(Application for copies should be addressed to the American National Standards Institute, 1430 Broadway, New York, NY 10018.)

3. REQUIREMENTS

3.1 Documentation Requirements. - Contractors shall prepare the necessary procedures to fulfill the requirements of this document. Contractor-prepared documents shall be submitted for approval as required by the contract.

3.2 Personnel Training. - Operations covered by this standard shall be performed by persons certified in accordance with this standard. The contractor shall provide training in these requirements. The contractor shall certify each person upon successful demonstration of his ability to solder samples of the type of hardware which will be used in assigned work. The contractor shall prepare and maintain records of personnel training and performance. Certified personnel may be issued individual certificates, or in lieu thereof, the contractor may utilize a continually updated certification list.

3.3 Personnel Qualifications. - Should the proficiency of an individual be questioned, the procuring activity or its designated representative may require the individual to demonstrate proficiency in the areas concerned.

3.4 Facilities. - The contractor shall operate and maintain soldering areas in a clean, orderly condition and shall:

a. Promptly remove dirt, grease, oil, solder splatter, wire insulation cuttings, and other foreign matter.

b. Frequently and thoroughly clean work benches and floors, including corners and aisles.

3.5 Environmental Conditions. - The contractor shall take adequate precautions to maintain the required quality of solder connections. Environmental conditions (recommended only) for soldering operations are:

a. Temperature: 24 ±5.5 degrees Celsius (°C) [75 ±10 degrees Fahrenheit (°F)]

b. Relative humidity: maximum, 60 percent. Contractor controls for humidity of 30 percent or lower shall be in accordance with ANSI J-STD-001.

c. Light intensity: minimum, 1075 lux (100 footcandles) at work surface.

3.6 Tools and Equipment. - The tools and equipment shall be maintained in a clean, workable condition. Defective or worn tools shall be removed from the work area.

3.7 Materials. - Materials shall be suitable for intended use and shall not degrade the quality of the solder junction, metals being joined, or parts.

3.7.1 Solder. - Solder shall conform to QQ-S-571 composition SN60, SN62, or SN63.

3.7.2 Flux. - Liquid resin or nonresin fluxes shall be in accordance with ANSI J-STD-001.

3.7.3 Cleaning Agents. - Cleaning agents shall be nonconductive, noncorrosive, and shall not dissolve, discolor, or degrade the quality of parts or materials. Cleaning agents shall not be used in any manner which will carry flux residue onto contact surfaces, such as those in switches, potentiometers, or connectors.

3.7.4 Cleaning Agents Selection. - Cleaning agents selection shall be in accordance with ANSI J-STD-001.

3.8 Preparation for Soldering.

3.8.1 Insulation Removal. - Stripping tools or machines shall be of correct size for the wire used. After stripping, the conductor shall be checked and damage such as nicks, cuts, or gouges shall not be allowed. There shall be no damage to the insulation.

3.8.2 Wire Lay. - The lay of the wire strands shall be restored if disturbed.

3.8.3 Tinning of Stranded Conductors. - Stripped ends of stranded wires shall be tinned to prevent untwisting and separation of wire strands.

3.8.4 Wicking. - Solder flow along the conductors and under the insulation is permitted, but shall not obscure the individual wire strands at the termination end of the insulation. There shall be no damage to the insulation due to heat.

3.8.5 Solid Hookup Wire. - Solid hookup wire shall not exceed a length of 25 millimeters (mm) (1 inch) between supports. Wire lengths exceeding 25 mm shall be secured. (Example: conformal coating or clamping.)

3.8.6 Stress Relief. - Each conductor terminating at a connection point shall have sufficient slack in the form of a gradual bend to eliminate any possibility of breakage.

3.8.7 Mechanical Support. - Wire bundles shall be supported so that the soldered connections are not subjected to mechanical loads.

3.8.8 Mechanical Splices. - Conductors shall not be spliced except as authorized by the contract.

3.9 Mounting of Glass Encased Components. - Glass encased components mounted on printed circuit boards that are to be conformal coated, shall be enclosed in transparent sleeving prior to mounting.

3.10 Lead Bending Requirements. - The inside radius of the bend of component leads shall not be less than the lead diameter. The distances from the bend to the end seal shall be approximately equal at each end of the part. Care shall be taken not to bend the lead against the component body or lead weld.

3.11 Attachment of Conductors to Terminals.

3.11.1 Insulation Clearance. - The insulation shall not be imbedded in the solder joint. The contour of the conductor shall not be obscured at the termination end of the insulation. The maximum insulation clearance shall be less than two wire diameters including insulation, but in no case shall permit short circuiting between adjacent conductors.

NOTE

The maximum insulation clearance shall not exceed 6.4 mm (0.25 inch).

3.11.2 Turret and Straight Pin Terminals. - The side route shall be used as a connection on this type terminal. Conductors shall be wrapped one half turn minimum; two full turns maximum around the post. The ends of the conductors shall not extend beyond the base dimensions more than two diameters of the uninsulated conductor.

3.11.3 Bifurcated Terminals. - Top, side, or bottom routes, or combinations thereof, are permitted on this terminal. The conductor ends shall not extend past the base dimensions more than two diameters of the uninsulated conductor, but in no case shall permit inadvertent contact with other conducting elements.

3.11.4 Hook or Pierced Terminal. - If bends are used to attach conductors to this type terminal, they shall not exceed one full turn. Protrusion of conductor ends shall be limited to avoid damage to insulation sleeving where used.

3.11.5 Solder Cups. - Conductors shall be attached to the solder cup in the following manner:

a. Conductors shall be bottomed in the cup and shall be in contact with the inner wall of the cup.

b. The maximum number of conductors shall be limited to those which can be inserted into the cup without modification of the cup or conductors.

c. When it is necessary to install more than one stranded conductor into a single solder cup, each conductor shall be properly stripped and the strands shall be combed out. The strands of all conductors shall be twisted together into a single wire and tinned.

d. The resulting conductor shall not exhibit an effective [equivalent diameter in mm or American Wire Gage (AWG)] size greater than the recommended wire rating [equivalent diameter (mm) or AWG] of the solder cup.

e. The strands being combed and intertwined for the same solder cup shall not vary in size by more than four [equivalent diameter (mm) or AWG] wire sizes.

3.11.6 Insulation Tubing Application. - Insulation tubing shall be used for electrical insulation, as appropriate. Examples include floating terminals, hook terminals, and solder cups which are not protected by insulating, grommets, potting, conformal coating, or adequate geometrical separation to prevent inadvertent contact with other conducting elements.

3.11.7 Cordwood Termination. - Only in the case of cordwood termination may a component lead be used as a tie point with other component leads. In all other applications, a terminal must be used.

3.12 Soldering of Terminals. - A fillet of solder shall be formed between the terminal and each side of the conductor. The outline of the conductor shall be visible after soldering conductor sizes 0.51 mm (AWG 24) and larger. Solder spillage along the outside surface of the terminal is permissible to the extent that it approximates tinning and does not interfere with the assembly or function of the connection.

3.12.1 Cup Terminals. - The solder shall form a fillet between the conductor and the cup entry slot. The fillet shall follow the contour of the cup opening. Solder spillage along the outside surface of the cup is permissible to the extent that it approximates tinning and does not interfere with the assembly or function of the connection.

3.12.2 Hook or Pierced Terminals. - The terminal hole need not be filled with solder as long as there are proper fillets between the conductor and terminal.

3.12.3 Wicking. - Flow of solder along the wire and under the insulation is permitted. Solder shall not obscure the individual wire strands at the termination of insulation. There shall be no damage to insulation due to heat.

3.12.4 Terminals Mounted on Bus Bars or Printed Circuits. - Terminals mounted on bus bars or printed circuits shall be soldered (a full-circumference fillet) to every metallic object where contact is made.

3.13 Removal of Flux and Impurities. - After the solder has solidified and cooled, visible flux and impurities shall be carefully removed from the solder connection using a cleaning agent as specified in 3.7.3.

3.14 Printed Circuit Boards.

3.14.1 Component Leads. - Leads that extend through the board, are clenched over and are in contact with the circuit pattern, should extend in the direction of the circuit except as noted. The maximum lead length shall be twice the pad radius and a minimum of one times the pad radius. Leads that are not clenched over shall extend through the circuit a maximum of three times the lead diameter and a minimum of one time the lead diameter. The contour of the end of the lead shall be discernible after soldering.

NOTE

The extension of the lead beyond the pad or circuit dimensions shall not be cause for rejection if there is a clearance of three times the lead diameter between the lead and the nearest circuit, lead, or component.

3.14.2 Splicing. - Splicing of printed circuits shall not be permitted.

3.14.3 Soldering. - Printed circuit boards may be either hand or machine soldered. If a contractor desires to use machine soldering, the procedure and process control shall be submitted in accordance with 3.1. The finished product shall meet the requirements of this document.

3.14.4 Eyelets, Tubelets, and Plated Through Holes. - Eyelets, tubelets, and plated through holes shall not be used unaided as an electrical connection. A piece of bus wire or component lead must be soldered on both sides of the double-sided circuitry.

3.15 Characteristics of Acceptable Solder Connections. - The illustrations contained within ANSI J-STD-001 and MIL-STD-2000 shall be used to demonstrate acceptable soldering, mounting, and assembly.

3.16 Soldering Process Waste Disposal. - Controls of waste materials generated during the soldering process shall conform to the following rules. No person may collect, transport, store, recycle, use, or dispose of waste materials generated during the soldering process in any manner which endangers the public health or welfare or the environment. These waste materials must not be discharged into soils, sewers, drainage systems, septic tanks, surface or groundwaters, water courses, or marine waters. Care shall be taken not to mix the wastes generated during soldering and during the use of cleaning agents. Containers/tanks used for the disposal of wastes shall be labeled with the type of waste contained therein. Care shall be taken to reduce all wastes generated during the soldering process through the preplanned use of material amounts needed to complete the process.

4. QUALITY ASSURANCE PROVISIONS

4.1 Inspection Requirements. - The supplier is responsible for the performance of all inspection requirements as specified herein. The procuring activity, or its designated representative, reserves the right to perform any or all of the inspections set forth in the specification to assure that the end item conforms to the prescribed requirements.

4.1.1 Acceptance Criteria. - All machine or hand soldered connections shall be quality inspected for the following:

a. Clean, smooth, undisturbed surface.

b. Concave fillets between conductor and terminals are desired; however, convex fillets will be acceptable as long as the outline of the conductor is visible.

c. Complete wetting of the conductor and terminal in the connection area.

4.1.2 Rejection Criteria. - Acceptable solder connections or areas shall not exhibit the following:

a. Damaged, cracked, or charred insulation.

b. Improper insulation clearance.

c. Separation of wire strands.

d. Part improperly supported or positioned.

e. Part marking not visible.

f. Part damaged.

g. Damaged or loose terminals.

h. Loose conductors.

i. Cut or nicked leads or wires.

j. Visible flux residue or other contamination.

k. Improper wrap or stress relief.

l. Cold solder joint.

m. Overheated joint.

n. Fractured joint.

o. Improperly bonded joint (demarcation line).

p. Pitted or porous joint.

q. Insufficient solder.

r. Splattering of solder on adjacent areas.

s. Excess solder (examples: peaks, icicles, bridging or conductor outline not visible).

t. Conductor pattern separated from the board.

u. Burns on base materials.

v. Discoloration which is continuous between conductors (examples: measling, delamination, halo effect, etc.).

NOTE

Exposed bare copper shall not be cause for rejection if the lead or wire has not been damaged.

4.2 Rework. - Rejected solder connections may be reworked by wicking the solder by means of liquid flux and shielded or stranded wire, or by use of a mechanical solder tool. A solder connection may also be reworked by the application of liquid flux and reheating the solder connections.

5. PREPARATION FOR DELIVERY

Preparation for delivery shall be in accordance with procurement documents, where applicable.

6. NOTES

6.1 Intended Use. - This standard is intended to establish the requirements for soldering electrical connections on GSE that does not directly interface with a flight item.

6.2 Ordering Data. - Procurement documents should specify:

a. Title, number, and date of this standard.

b. Contractor's soldering procedure shall be submitted as required by the contract (3.1 and 3.14.3).

NOTICE. The Government drawings, specifications, and/or data are prepared for the official use by, or on the behalf of, the United States Government. The Government neither warrants these Government drawings, specifications, or other data, nor assumes any responsibility or obligation, for their use for purposes other than the Government project for which they were prepared and/or provided by the Government, or an activity directly related thereto. The fact that the Government may have formulated, furnished, or in any way supplied the said drawings, specifications, or other data is not to be regarded, by implication or otherwise, as licensing in any manner the holder or any other person or corporation, nor conveying the right or permission, to manufacture, use, or sell any patented invention that may relate thereto.

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STANDARDIZATION DOCUMENT IMPROVEMENT PROPOSAL

INSTRUCTIONS

1. The preparing activity must complete blocks 1, 2, 3, and 8. In block 1, both the document number and revision letter should be given.
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I RECOMMEND A CHANGE:	1. DOCUMENT NUMBER KSC-STD-E-0010A	2. DOCUMENT DATE AUGUST 19, 1994

3. DOCUMENT TITLE
Soldering of Electric Connections (Hand or Machine), Standard For

4. NATURE OF CHANGE *(Identify paragraph number and include proposed rewrite, if possible. Attach extra sheets as needed.)*

5. REASON FOR RECOMMENDATION

6. SUBMITTER

a. NAME *(Last, First, Middle Initial)*	b. ORGANIZATION	
c. ADDRESS *(Include Zip Code)*	d. TELEPHONE *(Include Area Code)*	7. DATE SUBMITTED

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