

2013 - June

Space Applications Electronic Hardware Addendum to IPC/WHMA-A-620B

Supersedes IPC/WHMA-A-620AS with Amendment 1
June 2012

A standard developed by IPC

Association Connecting Electronics Industries



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Full document details: IPC IPC-WHMA-A-620B-S 2013



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Space Applications Electronic Hardware Addendum to IPC/ WHMA-A-620B

Developed by the Space Electronic Assemblies IPC/WHMA-A-620
Addendum Task Group (7-31fs) of the Product Assurance Committee
Committee (7-30) of IPC

Supersedes:

IPC/WHMA-A-620AS
with Amendment 1 -
June 2012

Users of this publication are encouraged to participate in the
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Acknowledgment

Any document involving a complex technology draws material from a vast number of sources. While the principal members of the IPC/WHMA-A-620 Space Addendum Task Group (7-31fs) of the Product Assurance Committee (7-30) are shown below, it is not possible to include all of those who assisted in the evolution of this standard. To each of them, the members of IPC extend their gratitude.

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Space Applications Electronic Hardware

Addendum to IPC/WHMA-A-620B

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0.1 SCOPE This addendum provides additional requirements over those published in IPC/WHMA-A-620B to ensure the performance of cable and wire harness assemblies that must survive the vibration and thermal cyclic environments getting to and operating in space.

Where content criteria are not supplemented, the Class 3 requirements of IPC/WHMA-A-620B apply.

0.1.1 Purpose When required by procurement documentation/drawings, this Addendum supplements or replaces specifically identified requirements of IPC/WHMA-A-620B.

0.1.2 Precedence The contract takes precedence over this Addendum, referenced standards and User-approved drawings. In the event of a conflict between this Addendum and the applicable documents cited herein, this Addendum takes precedence. Where referenced criteria of this addendum differ from the published IPC/WHMA-A-620B, this addendum takes precedence.

0.1.3 Existing or Previously Approved Designs This Addendum **shall not** constitute the sole cause for the redesign of previously approved designs. When drawings for existing or previously approved designs undergo revision, they should be reviewed and changes made that allow for compliance with the requirements of this Addendum.

0.1.4 Use of this Addendum This addendum **shall not** be used as a stand-alone document.

Where criteria are not supplemented by this addendum, the Class 3 requirements of IPC/WHMA-A-620B **shall** apply. If an IPC/WHMA-A-620B requirement is changed or added by this Addendum, the clause is identified and only the process requirements and defects for that clause are listed in Table 1 of this addendum (i.e., Target and Acceptable conditions are not listed). If a feature is not listed as a defect, it **shall** be considered acceptable. Target and Acceptable conditions (except where changed by this addendum) and Figures are provided in IPC/WHMA-A-620B.

The clauses modified by this Addendum do not include subordinate clauses unless specifically stated (i.e., changes made to 1.4 do not affect 1.4.1 unless 1.4.1 is also addressed in this Addendum). Clauses, Tables, Figures, etc. in IPC/WHMA-A-620B that are not listed in this addendum are to be used as-published.

0.1.5 Lead-Free Tin For the purpose of this document, lead-free tin is defined as tin containing less than 3 percent lead by weight as an alloying constituent. Solder alloy Sn96.3Ag3.7 is exempt from this requirement. See Table 1 of this addendum, clause 4.1.1.1.

0.1.6 Use of Lead-Free Tin The use of components, assemblies, packaging technology, mechanical hardware, and materials identified as having external surfaces (platings, metallization, etc.) of lead-free tin or assembled with lead-free tin solder alloys **shall** be prohibited unless documented and controlled through a User approved Lead Free Control Plan (LFCP). The LFCP **shall** incorporate either a replating or hot solder dip (HSD) process that completely replaces the lead-free tin finish, or a minimum of two mitigation measures.

0.1.6.1 Lead Free Control Plan The Lead Free Control Plan (LFCP) **shall** document controls and processes that assures that assemblies containing lead-free tin solder alloys and/or component finishes will perform as intended within the expected parameters of the mission, e.g., environment, duration, etc. At a minimum, the LFCP **shall**:

- Document every incidence of lead-free tin technology and prevent its use without review and approval by the User prior to implementation.
- Incorporate a minimum of two mitigation measures when the lead-free tin finish is not completely replaced through a replating or HSD process.
- Include any special design requirements, mitigation measures, test and qualification requirements, quality inspection and screening, marking and identification, maintenance, and repair processes.
- Require review and approval by the User prior to implementation.

The following documents may be helpful when developing the LFCP:

- GEIA-STD-0005-1, Performance Standard for Aerospace and High Performance Electronic Systems Containing Lead-free Solder
- GEIA-STD-0005-2, Standard for Mitigating the Effects of Tin Whiskers in Aerospace and High Performance Electronic Systems
- GEIA-HB-0005-1, Program Management/Systems Engineering Guidelines For Managing The Transition To Lead-Free Electronics
- GEIA-HB-0005-2, Technical Guidelines for Aerospace and High Performance Electronic Systems Containing Lead-free Solder and Finishes
- GEIA-STD-0006, Requirements for Using Solder Dip to Replace the Finish on Electronic Piece Parts

0.1.6.2 Mitigation Components, sub-assemblies, assemblies, and mechanical hardware identified as having lead-free tin surfaces, platings, metallization, etc., but which by package design or engineering decision are not protected by tin-lead replating or HSD, **shall** be protected by at least two process or design mitigation techniques to reduce or eliminate the risks created by metallic whiskers or migration.

the expected end-use application/environment. Use of mitigation methods **shall** require technical review and approval by the User prior to implementation. Mitigation measures that may be used are:

- a. **Design** – Components, sub-assemblies, assemblies, and mechanical hardware identified as having external surfaces, platings, metallization, etc., with a lead-free tin finish **shall** be physically positioned or mechanically isolated to ensure the growth of conductive whiskers does not adversely affect performance or reliability. Direct line-of-sight spacing between electrically uncommon conductive surfaces **shall** be sufficient to ensure whisker growth rates (1mm/yr. nominal) over the life of the mission do not violate minimum electrical spacing requirements.
- b. External surfaces, platings, metallization, etc., with a lead-free tin finish **shall** be fully coated with conformal coating with a total cured finish of not less than 100 µm [0.004 in].
- c. **Embedment/Encapsulation** – Embedment or encapsulant material **shall** fully wet and cover all surfaces of parts and areas specified by the approved engineering documentation. Cured material **shall** be void-free, be compatible with the hardware and mission environment, and **shall not** adversely affect hardware performance or reliability.
- d. Other mitigation techniques approved by the User prior to use.

0.1.7 Red Plague (Cuprous Oxide Corrosion) Red Plague (cuprous oxide corrosion) can develop in silver-coated soft or annealed copper wire when a galvanic cell forms between the copper base metal and the silver coating in the presence of moisture (H₂O) and oxygen (O₂). Once initiated, the sacrificial corrosion of the copper base conductor can continue indefinitely in the presence of oxygen. The color of the corrosion by-product (cuprous oxide crystals) may vary depending on the different levels of oxygen available, but is commonly noted as a red/reddish-brown discoloration on the silver coating surface.

Definitions For the purpose of this document:

Desiccant is defined as a chemically-inert media used to absorb moisture from the air within a sealed container or package to induce or sustain a level of dryness (desiccation).

Dew Point is defined as the temperature at which a volume of air at a given atmospheric pressure reaches saturation and the entrained water vapor precipitates and condenses.

Red Plague (Cu₂O) is defined as the sacrificial corrosion of copper in a galvanic interface comprised of silver and copper, resulting in the formation of red cuprous oxide (Cu₂O). Galvanic corrosion is promoted by the presence of

moisture and oxygen at an exposed copper-silver interface (i.e.: conductor end, pin-hole, scratch, nick, etc.).

Unit Pack is defined as the standardized unit of desiccant material, which at thermal equilibrium with air at +77°F [+25°C], will adsorb at least 3 gm [0.1 oz] of water vapor at 20% relative humidity (RH) and at least 6 gm [0.2 oz] of water vapor at 40% RH.

0.1.7.1 Red Plague Control Plan – Minimum Requirements The use of silver-coated copper wire and cable **shall** require the implementation of a User-approved Red Plague Control Plan (RPCP) to reduce and control exposure to environmental conditions and contamination that promote the development of red plague and latent damage. The minimum requirements are as outlined below.

0.1.7.1.1 Shipping and Storage Wire and cable **shall** be shipped and stored in sealed water-vapor-proof packaging (i.e.: Moisture Barrier Bag, dry pack, etc.), with capped ends, activated desiccant, and humidity indicator card. Silver-coated copper wire and cable **shall** be segregated and dispositioned if the humidity indicator card registers 70% or more RH.

- a. Water-vapor-proof protection packaging **shall** meet MIL-STD-2073-1E Method 51. Moisture Barrier Bags (MBB) **shall** meet MIL-PRF-81705, TYPE 1.
- b. **Capping.** Wire and cable ends **shall** be capped with heat shrinkable end-caps conforming to SAE-AMS-DTL-23053/4, or sealed with a material such as an insulating electrical varnish for a length of approximately 25 mm [1 in].
- c. **Desiccant (Activated).** The bagged, activated desiccant **shall** conform to MIL-D-3464 Type 2 or equivalent. The minimum quantity of desiccant to be used (unit packs) **shall** be based on the protective package's interior exposed surface area, in accordance with MIL-STD-2073-1E, Method 50, Formula 1, or equivalent.
- d. **Humidity Indicator Card.** The humidity indicator card **shall** be either an Irreversible Indication (50-60-70-80-90% RH) card or a combination Irreversible/Reversible Humidity Indicator (50-60-70-80-90% RH) card conforming to MIL-I-8835 or equivalent.

0.1.7.1.2 Assembly All assembly processes, including receiving inspection and kitting, **shall** be conducted in an environmentally-controlled and monitored area where dew point is not attained and the relative humidity is less than 70% RH.

- a. Wire and cable **shall not** be removed from its protective packaging until it has reached thermal equilibrium with the assembly environment to prevent condensation.
- b. Aqueous solvents **shall not** be used for cleaning and flux removal.



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0.1.7.1.3 Limited Life Article

- a. Silver-coated copper wire and cable that has exceeded a shelf life of 10 years from manufacturing date **shall not** be used on assemblies fabricated to this standard.
- b. Completed cable/harness assemblies incorporating silver-coated copper wire and cable with a storage or use life exceeding 10 years from date of assembly **shall** be identified, inspected and tested, and tracked as a limited-life article.

0.1.8 White Plague (Fluorine Attack) To reduce the risk of fluorine attack (White Plague), when fluoropolymer-insulated silver-coated copper wiring is either stored in sealed packaging (e.g.: vapor-proof bagging, MBB) or used in enclosed environments / compartments, the fluorine evolution rate **shall not** exceed 20 PPM when tested in accordance with SAE AS4373E Method 608, Fluoride Offgassing. Bulk wiring and harness assemblies exhibiting fluorine attack **shall** be rejected.

Table 1 IPC/WHMA-A-620B Space Applications Requirements

A-620B Reference	Space Applications Requirement (as changed by this Addendum)
1.1	Scope This standard prescribes practices and requirements for the manufacture of Cable, Wire and Harness Assemblies. Note: This clause is unchanged from IPC/WHMA-A-620B. It is included here to clarify that the Scope of the space addendum does not replace nor alter Scope of the base document.
1.2	Purpose This Standard describes materials, methods, tests and acceptability criteria for producing crimped, mechanically secured, or soldered interconnections and the related assembly activities associated with cable and harness assemblies. Any method that produces an assembly conforming to the acceptability requirements described in this standard may be used. Note: This clause is unchanged from IPC/WHMA-A-620B. It is included here to clarify that the Purpose of the space addendum does not replace nor alter Purpose of the base document.
1.8	Classes of Product If an IPC/WHMA-A-620B clause is not addressed by this addendum, the Class 3 requirement in IPC/WHMA-A-620B shall apply.
1.11	Personnel Proficiency All instructors, operators, and inspection personnel shall be proficient in the tasks to be performed. Objective evidence of that proficiency shall be maintained and be available for review. Objective evidence should include records of training to the applicable job functions being performed, work experience, testing to the requirements of this standard, and/or results of periodic reviews of proficiency. Training shall be in accordance with the IPC/WHMA A-620-Space Addendum Training and Certification Program or a supplier developed program that shall be made available for review and approval upon request by the User. All training shall be traceable to a Master IPC Trainer (MIT).
1.11.1 [new]	Vision Requirements All instructors, operators and inspection personnel shall meet the following vision requirements as a condition of proficiency. The vision requirements may be met with corrected vision. The vision tests shall be administered by a qualified examiner, accepted by the User, using standard instruments and techniques. Results of the visual examinations shall be maintained and available for review. The following are minimum vision requirements; alternate vision industry recognized tests may be used. Binocular vision is not required. a. Near Vision. Jaeger 1 at 355.6 mm [14 in] or reduced Snellen 20/20, or equivalent. b. Color Vision. Ability to distinguish red, green, blue, and yellow colors. Note: A practical test using color coded wires and/or color coded electrical parts, as applicable, is acceptable for color vision testing.

A-620B Reference	Space Applications Requirement (as changed by this Addendum)
1.13.3	Materials and Processes The materials and processes used to assemble, manufacture, handle and store cable and wire harness assemblies shall be selected such that their combinations produce products acceptable to this standard. Connector mating surfaces and harness assemblies shall be protected. When major elements of the proven processes are changed, e.g., flux, solder alloy or soldering system, crimping technology, cleaning media or system, etc., validation of the acceptability of the change(s) shall be performed and documented. The method of validation shall be agreed upon between the Manufacturer and User. Changes shall be approved by the User prior to use. Limited shelf life items shall be stored and controlled in accordance with material manufacturer's recommendations, or in accordance with the Supplier's documented procedures for controlling shelf life and shelf life extensions. For adhesives, potting material and other polymers: • The material specification or other documented procedure shall be followed for mixing and curing. • Material shall be used within the pot life (working time) specified by the material supplier or used within the time period indicated by a documented system. • When curing conditions (temperature, time, infrared (IR) intensity, etc.) vary from the material manufacturer's recommended instructions, they shall be documented and available for review. • Equipment used for measuring viscosity, mixing, applying and curing silicone material shall not be used for processing other material. • A mix record shall be created for each mixed batch of multi-part polymers used. At a minimum, this record shall include the date mixed, Manufacturer's part number and date/lot code, shelf-life expiration date (of all parts of the mix), and the mix ratio for all constituents used. • For one-part polymers, the Manufacturer's part number and lot/date code, and shelf life expiration date shall be documented. • Materials shall be cured in accordance with a documented cure schedule and within the thermal limitations of the hardware. Objective evidence of full cure for each batch of material shall be documented. A witness sample may be used for this verification. • If used, non-liquid fillers, e.g., thickening agents, thermal property enhancers, etc., shall be treated to remove detrimental moisture and other volatiles. • Non-porous containers and mixing tools shall be used. Containers and mixing tools shall be selected such that their use in combination cannot introduce contamination into the mix, e.g., a metal stirrer can scrape shavings from a plastic container. Note: Specific criteria regarding application and/or acceptance requirements are included where applicable throughout this document.
1.15.5	Disposition Disposition is the determination of how defects should be treated. Dispositions include, but are not limited to, rework, use as is, scrap or repair. Each disposition of "use as is" or "repair" shall be approved by the User. Repairs shall be conducted in accordance with documented procedures approved by the User. Each repair shall be approved by the User prior to implementation.
1.15.7	Conditions Not Specified The development of unique criteria for conditions not specified shall include User involvement and consent. The criteria developed shall include an agreed upon definition for acceptance of each characteristic between the Manufacturer and the User.
1.17.1	Sampling (Verification of Acceptability) Sampling for verification shall be agreed upon between the User and Manufacturer prior to use. Verification of acceptability to this standard shall be based on 100% inspection of the assemblies, including crimps, solder connections, and each successive level of assembly, e.g., securing, shielding, connectorization, etc. Visual inspection may be supplemented by the measurement of characteristics appropriate to the product being assembled, e.g., go/no-go gauges, pull force measurements, torque measurement. Partially visible or hidden features shall be acceptable provided that all of the following conditions are met: a. The visible portion, if any, of the feature is acceptable. b. Process controls are maintained in a manner assuring repeatability of assembly techniques. For requirements that do not meet any of the above conditions, non-destructive evaluation (NDE) shall be used. The NDE method shall be approved by the User prior to use.

A-620B Reference	Space Applications Requirement (as changed by this Addendum)
1.17.1.1	Lighting Illumination at the surface of workstations should be at least 1000 lm/m² (approximately 93 foot candles). Supplemental lighting may be necessary to assist in visual inspection. The light source shall provide shadowless illumination of the area being viewed unless directional or oblique lighting is specifically required. Note: In selecting a light source, the color temperature of the light is an important consideration. Light ranges from 3000-5000° K enable users to distinguish various metal and plating features and contaminants with increased clarity.
1.17.1.2	Magnification Aids When required, magnification power for assembly inspection shall be at least the minimum inspection power specified in IPC/WHMA-A-620B Table 1-2. Other magnification powers within the inspection range may be used. The magnification power requirement is based on the gauge of the wire being inspected. For assemblies with mixed wire sizes, the greater magnification may be used for the entire assembly. If the presence of a defect cannot be determined at the inspection power, the item is acceptable. The referee magnification power is intended for use only after a defect has been determined but is not completely identifiable at the inspection power. Magnification aids shall be capable of rendering true colors, proportional dimensions, and adequate resolution at the chosen magnification to perform the specified inspection. The tolerance for magnification aids is $\pm 15\%$ of the selected magnification power. Magnification aids should be maintained and calibrated as appropriate (see IPC-OI-645).
3.1	Stripping Wire insulation may be removed using chemical, thermal or mechanical strippers. Chemical solutions, pastes, and creams used to strip solid wires shall not cause degradation to the wire. Chemical strippers shall not be used with stranded wires. Chemical stripping materials shall be completely neutralized and be cleaned such that there are no residues from the stripping, neutralizing, or cleaning steps.
3.2	Strand Damage and End Cuts IPC/WHMA-A-620B Table 3-1 does not apply; there shall be no nicked, scraped or broken wire strands (see IPC/WHMA-A-620B Figure 3-3). For plated wires, a visual anomaly that does not expose basis metal is not considered to be strand damage. Smooth indentations, e.g., tooling marks, up to 10% of the conductor diameter that do not expose basis metal are not considered to be strand damage. Defect • Variation in strand length within a strand group that prevents installation to the full depth of the crimp contact area or solder cup. • Severed (broken) wire strands (see IPC/WHMA-A-620B Figure 3-2). • Deformation exceeding 10% of the diameter of the conductor. • Base metal is exposed. • Evidence of red plague (cuprous oxide). See 0.1.7.
4.1.1.1	Material, Components and Equipment – Materials – Solder Solder alloys shall be Sn60Pb40, Sn62Pb36Ag2, Sn63Pb37, or Sn96.3Ag3.7 in accordance with J-STD-006 or equivalent. Other solder alloys that provide the service life, performance, and reliability required of the product may be used if all other conditions of this standard are met and objective evidence of such is reviewed and approved by the User prior to use. High temperature solder alloys, e.g., Sn96Ag3.7, shall only be used where specifically indicated by approved drawings. Flux that is part of flux-cored solder wire shall meet the requirements of 4.1.1.2. Flux percentage is optional.
4.1.1.2	Material, Components and Equipment – Materials – Flux Flux shall be in accordance with J-STD-004 or equivalent. Flux shall conform to flux activity levels L0 or L1 of flux materials rosin (RO) or resin (RE). Use of any other flux shall be approved by the User prior to use. When other activity levels or flux materials are used, data demonstrating material and process compatibility through testing agreed upon between the Manufacturer and User shall be provided. Note: Flux or soldering process combinations previously tested or qualified in accordance with other specifications do not require additional testing. Type H or M fluxes shall not be used for tinning of insulated wires except for solid wires with insulation bonded to the wire, e.g., magnet wire. For all fluxing applications where adequate cleaning is not practical, only flux types RO or RE of the L0 flux activity level, or equivalent, shall be used.