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

Supersedes IPC/WHMA-A-620AS
March 2011

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Association Connecting Electronics Industries

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

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

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

0.1 SCOPE This addendum provides additional requirements over those published in IPC/WHMA-A-620A 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-620A apply.

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

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-620A, 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** to be used as a stand-alone document.

Where criteria are not supplemented by this addendum, the Class 3 requirements of IPC/WHMA-A-620A **shall** apply. If an IPC/WHMA-A-620A 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 in Table 1 of this addendum, it **shall** be treated as it is identified in IPC/WHMA-IPC-A-620A, e.g., acceptable or process indicator. Target and Acceptable conditions (except where changed by this addendum) and Figures are provided in IPC/WHMA-A-620A.

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-620A 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**:

a. Document every incidence of lead-free tin technology and prevent its use without review and approval by the User prior to implementation.

b. Incorporate a minimum of two mitigation measures when the lead-free tin finish is not completely replaced through a replating or HSD process.

c. Include any special design requirements, mitigation measures, test and qualification requirements, quality inspection and screening, marking and identification, maintenance, and repair processes.

d. 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 whisker formation in 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 basis metal and the silver coating in the presence of moisture (H_2O) and oxygen (O_2). 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 (Cu_2O) 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 (Cu_2O). 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.

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.

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

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
1.1	**Scope** This standard is a collection of visual, material, process, electrical and mechanical quality acceptability requirements for Cable, Wire and Harness Assemblies. It was prepared by the Industry Technical Guidelines Committee of the Wire Harness Manufacturers Association and the Product Assurance Committee of IPC – Association Connecting Electronic Industries. **NOTE:** This clause is unchanged from IPC/WHMA-A-620A. 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, acceptance criteria and tests for producing crimped, mechanically secured, or soldered interconnections and the associated lacing/restraining criteria associated with cable and harness assemblies. **NOTE:** This clause is unchanged from IPC/WHMA-A-620A. It is included here to clarify that the Scope of the space addendum does not replace nor alter Scope of the base document.
1.5	**Uncommon or Specialized Designs** IPC/WHMA-A-620, as an industry consensus document, cannot address all of the possible product design combinations. However, the standard does provide criteria for commonly used technologies. Where uncommon or specialized technologies are used, it may be necessary to develop unique acceptance criteria. The development of unique criteria **shall** include User involvement and consent and the criteria developed **shall** include an agreed upon definition for acceptance of each characteristic. Whenever possible, new criteria or criteria on specialized products should be submitted, using the Standard Improvement Form included at the end of IPC/WHMA-A-620A, to the IPC Technical Committee to be considered for inclusion in upcoming revisions of this standard.
1.7	**Classes of Product** If an IPC/WHMA-A-620A clause is not addressed by this addendum, the Class 3 requirement in IPC/WHMA-A-620A **shall** apply.
1.10	**Acceptance Verification** 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. Many of the examples shown in the figures are grossly exaggerated to clearly depict the condition being described. **In the case of a discrepancy, the written description or written criteria always takes precedence over the illustrations.** 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.
1.12.5	**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.
1.12.7	**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.
1.16.2	**Magnification Aids and Lighting** When required, magnification power for assembly inspection **shall** be at least the minimum inspection power specified in 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 light source **shall** provide shadowless illumination of the area being viewed unless directional or oblique lighting is specifically required. The tolerance for magnification aids is ± 15% of the selected magnification power. Magnification aids should be maintained and calibrated as appropriate (see IPC-OI-645). Supplemental lighting may be necessary to assist in visual assessment.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
1.18	**Contamination** Assemblies produced in accordance with this Addendum and protective coverings/packaging **shall** be free of all extraneous matter (including but not limited to: flux residues, wire clippings, insulation slugs, strands of shielding braid or any other item not required to be present). See 1.16.2 for magnification requirements and 4.2 for cleanliness criteria specific to soldered assemblies. When the design calls for split-ring or star lock washers, attention should be paid during installation and inspection to their propensity for scraping mating surfaces and creating metallic debris.
1.19	**Materials and Processes** The materials and processes used to assemble/manufacture cable and wire harness assemblies **shall** be selected such that their combinations produce products acceptable to this standard. 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.
1.20 [new]	**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 A-620AS Training and Certification Program or User approved training program. All training **shall** be traceable to a Master IPC Trainer (MIT).
1.20.1 [new]	**Vision Requirements** The Manufacturer is responsible for ensuring that all instructors, operators and inspection personnel 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: a. **Far Vision.** Snellen Chart 20/50. b. **Near Vision.** Jaeger 1 at 355.6 mm [14 in] or reduced Snellen 20/20, or equivalent. c. **Color Vision.** Ability to distinguish red, green, blue, and yellow colors as prescribed in Dvorine Charts, Ishihara Plates, or AO-HRR Tests. **Note:** A practical test using color coded wires and/or color coded electrical parts, as applicable, is acceptable for color vision testing.
1.21 [new]	**Adhesives, Potting Materials, and Other Polymers** • 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. • Equipment used for processing, e.g., measuring viscosity, mixing, applying, curing, etc., silicone based polymers **shall not** be used for processing non-silicone based polymers, e.g., urethane, epoxy, etc. • 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.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
1.22 [new]	**Temperature and Humidity** When ESD sensitive devices are present and humidity decreases to a level of 30% or lower, the Manufacturer **shall** verify that electrostatic discharge control is adequate, and that the range of humidity in the assembly area is sufficient to allow soldering and assembly materials to function correctly in the process, based on vendor recommendations or documented evidence of process performance. For operator comfort and solderability maintenance, the temperature should be maintained between 18°C [64.4°F] and 30°C [86°F] and the relative humidity should not exceed 70% (see 0.1.7.1.2 when processing silver plated wire). For process control, more restrictive temperature and humidity limits may be required.
1.23 [new]	**Health and Safety** The use of some materials referenced in this standard may be hazardous. To provide for personnel safety, follow the applicable local and Federal Occupational, Safety and Health Regulations.
1.24 [new]	**Storage and Handling** Connector mating surfaces and harness assemblies **shall** be protected.
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-620A Table 3–1 does not apply; there **shall be no** nicked, scraped or broken wire strands. 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. • Deformation exceeding 10% of the diameter of the conductor. • Basis metal is exposed. • Evidence of red plague (cuprous oxide). See 0.1.7.
3.4	**Twisting of Wires** These criteria apply to all cable or harness bundles, whether they are twisted pairs of the same wire type and size, or cables incorporating various wire types and sizes. The length of lay (or "twist") as measured from the midpoint of wire's crossover through a complete spiral to the next crossover midpoint of the same wire **shall** be 8 to 16 times the outer diameter of the bundle (IPC/WHMA-A-620A Figure 3-9). **Defect** • The length of lay for each twist is less than 8 or more than 16 times the outer diameter of the bundle. • There is residual twist (over-twist, kinking, pig-tails) in individual wires.
4.1.1	**Material, Components and Equipment – Materials** See 1.19.
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.
4.1.2	**Gold Removal** Gold **shall** be removed from at least 95% of the surface to-be-soldered. A double tinning process or dynamic solder wave may be used for gold removal prior to assembly. These requirements may be eliminated if there is documented objective evidence available for review that there are no gold related solder embrittlement problems associated with the soldering process being used.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
4.2.1	**Cleanliness – Presoldering** The assembly **shall** be clean of any matter that will inhibit compliance to the requirements of this standard.
4.2.2	**Cleanliness – Postsoldering** Solder connections produced using processes and materials that are required to be cleaned, e.g., rosin/resin fluxes, **shall** be cleaned in a manner that assures removal of residual flux and activators. Flux residue can degrade product performance over time based upon environmental conditions. Methods and materials that are used to clean soldered assemblies **shall** be compatible with the product and assembly materials so that the cleaning process does not adversely affect performance characteristics. Surfaces cleaned **shall** be inspected between 4X and 10X magnification and **shall** be free of visual evidence of residue or contaminants per 4.2.2.1 and 4.2.2.2.
4.3.1	**Solder Connection – General Requirements** The following general requirements are applicable to all terminals unless there is a specific requirement for a given terminal, e.g., 4.9.4. **Defect** • Solder has not wetted to the termination where solder is required (nonwetting, dewetting). • Solder forms a contact angle >90°, except when the quantity of solder results in a contour which is limited by the edge of the attached surfaces. • Solder coverage does not meet requirements for the termination type. • Not soldered. • Disturbed solder. • Cold solder. • Overheated solder. • Fractured. • Insufficient. • Inclusions (foreign material). • Solder that violates minimum electrical clearance, e.g., bridges, solder splashes, solder balls, solder peaks. • Lead or wire extensions that violate minimum electrical clearance. • Contaminated solder connections, e.g., flux residues after cleaning. • Solder wicking inhibits required flexibility. • Blowholes, pinholes, and voids (where the bottom and all sides are not visible).
4.3.2.3	**Solder Connection – Soldering Anomalies – Partially Visible or Hidden Solder Connections** Partially visible or hidden solder connections are acceptable provided that the following conditions are met: a. The design does not restrict solder flow to any connection element. b. The visible portion, if any, of the connection is acceptable. c. Process controls are maintained in a manner assuring repeatability of assembly techniques. For solder connections that do not meet all of the above conditions, non-destructive evaluation (NDE) **shall** be used. The NDE method **shall** be approved by the User prior to use.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
4.4	**Wire/Lead Preparation, Tinning** In this document, the term pretinning and tinning have the same meaning, as defined in IPC-T-50: The application of molten solder to a basis metal in order to increase its solderability. Tinning is primarily performed to assure that the wire/lead to be soldered has a uniform and readily solderable surface. Tinning of stranded wire has the added benefit of bonding the individual wire strands together, thereby allowing the wire to be formed to terminals or attachment points without separation of the individual strands. Limited solder wicking during tinning or soldering of wire is permissible as long as the solder does not extend to a portion of the wire that is required to remain flexible. Solder used for tinning **shall** be the same alloy that will be used in subsequent soldering processes. Stranded wires **shall** be tinned when: • Wires will be formed for attachment to solder terminals. • Wires will be formed into soldered splices (except for mesh splices). • Wires will be used in heat shrinkable solder devices. Stranded wires **shall not** be tinned when: • Wires will be used in crimp terminations. • Wires will be used in forming mesh splices. The following criteria are applicable if tinning is required: **Defect** • Solder does not wet 100% of the portion of the wire in the required fillet area. • Stranded wire is not tinned prior to attachment to terminals, forming soldered splices (other than mesh splices), or used in heat shrinkable solder devices. • Wires strands not discernable after tinning. • Solder wicking extends to a portion of the wire which is required to remain flexible. • Length of untinned strands from end of wire insulation is greater than 1 wire diameter (D).
4.5.1	**Wire Insulation – Clearance** **Defect** • The insulation clearance is greater than 2 wire diameters or 1.5 mm [0.060 in], whichever is greater. • The clearance between the end of the insulation and the connection violates minimum electrical clearance between noncommon conductors. • Insulation interferes with formation of the solder connection.
4.8	**Connection Requirements** These criteria apply to both wires and component leads. The preferred wrap conditions achieve a mechanical connection between the lead/wire and the terminal sufficient to assure that the lead/wire does not move during the soldering operation. Typically the mechanical connection includes a 180º mechanical wrap to effect mechanical connection. Attachments should be positioned on the base of the solder termination area or previous attachment consistent with the thickness of the wire insulation. When practical, wires should be placed in ascending order with the largest on the bottom. Connection wraps **shall** be in contact with the post termination area for the full curvature of the wrap. As an exception to the wrap conditions described above, under certain circumstances, leads/wires attached to some terminal types may be routed straight through. See the specific terminal type for requirements. The criteria in this section are grouped together in subsections. Not all combinations of wire/lead types and terminal types can possibly be covered explicitly, so criteria is typically stated in general terms to apply to all similar combinations. For example, a solid wire and a multistranded wire connected to turret terminals have the same wrap and placement requirements, but only the multistranded wire could be subject to birdcaging. Terminals and solder cups **shall** not be modified to accept oversize conductors. Connections to terminals **shall** have stress relief. Attachments to terminals that require a wrap may be wrapped clockwise or counterclockwise (consistent with the direction of potential stress application). The lead or wire **shall** continue the curvature of the dress of the lead/wire and **shall not** interfere with the wrapping of other leads or wires on the terminal or overlap itself or each other.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
4.8.2.2	**Connection Requirements – Bifurcated Terminals – Bottom and Top Route Attachments** Top route connections **shall** only be used when required by approved drawings. **Defect** • Wire insulation enters base or posts of terminal. • Top route wire is not supported with filler. • Bottom route wire not wrapped to terminal base or post with a minimum 90° bend.
4.8.2.3	**Connection Requirements – Bifurcated Terminals – Staked Wires** **Defect** • Straight through wire does not extend between and beyond the posts. • Straight through wire extends beyond the base and violates minimum electrical clearance. • Straight through conductor is not in contact with the base of the terminal or the previously installed conductor, with allowance given for insulation thickness. • Any straight through wire is not staked or otherwise mechanically supported.
4.8.4	**Connection Requirements – Pierced/Perforated/Punched Terminals** **Defect** • Wire does not contact 2 sides of the terminal. • Wire does not pass through the eye of the terminal. • Wire end overlaps itself. • Terminal altered to accept oversize wire or wire group. • Strand damage exceeds allowance of Clause 3.2 of this addendum. • Wire end violates minimum electrical clearance to noncommon conductor.
4.8.5	**Connection Requirements – Hook Terminals** **Defect** • Wire is wrapped less that one wire diameter from end of hook. • Wire wrap is less than 180°. • Wire is attached outside the arc of the hook and is less than two conductor diameters or 1.0 mm [0.039 in], whichever is greater, from the base of the terminal. • Wire end overlaps itself. • Wire end violates minimum electrical clearance to noncommon conductor.
4.8.6	**Connection Requirements – Cup Terminals** **Defect** • Strand damage exceeds allowance of Clause 3.2 of this addendum. • Wire strands outside of the cup. • Wire not in contact with the back wall of the cup affects form, fit, function. • Wire placement interferes with subsequent assembly operations. • Multiple conductors are twisted together. • Wire not inserted to the full depth of the cup. (Not visually inspectable; determined through process control.) • Wire strands have been modified to fit the cup.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
4.8.7	**Connection Requirements – Series Connected Terminals** When a common bus wire connects 3 or more terminals, the end terminals **shall** meet the required wrap for individual terminals. Solder criteria are based on the individual terminal attachment. **Defect** • No stress relief between any 2 terminals (IPC/WHMA-A-620A Figure 4–42). • ***Turret Terminals*** An intermediate wrap is less than 360°, is not interwoven and is not in full contact with the base, a turret or a previously installed wire. • ***Hook Terminals*** Wire wraps less than 360° around intermediate terminal. • ***Bifurcated Terminals*** Wire does not pass between the posts or is not in contact with the terminal base or a previously installed wire. • ***Pierced/Perforated Terminals*** Wire does not contact 2 nonadjacent sides of each intermediate terminal.
4.9	**Solder Connection** **Defect** • Solder fillet is not 100% of the wire/lead and terminal interface. • Wire/lead not discernible in solder connection. • Blowholes or pinholes where all inner surfaces are not visible. • Any evidence of nonwetting or dewetting to wires or terminals. • Height (climb on wire) of solder is less than 50% of wire diameter (D).
4.9.1	**Solder Connection – Turret Terminals** **Defect** • Solder is wetted to less than 100% of the contact area between the wire/lead and terminal interface.
4.9.2	**Solder Connection – Bifurcated Terminals** **Defect** • Solder is wetted to less than 100% of the contact area between the wire/lead and terminal interface for side or bottom entry. • Solder is wetted to less than 100% of the height of the terminal post for top route connections.
4.9.4	**Solder Connection – Pierced/Perforated Terminals** **Defect** • Solder is not wetted to 100% of the contact area between the wire/lead and terminal interface.
4.9.5	**Solder Connection – Hook Terminals** **Defect** • Solder is not wetted to 100% of the contact area between the wire/lead and terminal interface.
4.9.6	**Solder Connection – Cup Terminals** **Defect** • A fillet is not formed along 100% of the surfaces of contact between the wire and terminal. • Solder buildup on the outside of the cup affects form, fit, or function. • Solder fill less than 100%. • Wire not in contact with the back wall of the cup when it affects form, fit, or function.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
5	**Crimp Terminations (Contacts and Lugs)** For the purposes of this section, the term "terminal" includes both lugs and contacts. In addition to the basic requirements outlined in this section, there **shall** be no damage to plating or finish. Contacts **shall** be deformed only by crimp tools. Conductor strands **shall not** be cut or modified in any manner to reduce circular mil area to fit a termination. Conductors **shall not** be tinned prior to termination, unless otherwise specified. Solid wire **shall not** be crimped except as allowed in 13.2.1. The terminal manufacturer's recommended tooling should be used to crimp the terminal. If a terminal is manufactured in accordance with a military specification or an industry specification, i.e., MS39029/SAE AS39029, then the crimping tool called out in that military/industry specification **shall** be used to crimp the terminal. If alternate tooling is used, objective evidence **shall** be available to show validity of the alternate process. **Process Controls** Crimp tools may be either manually (hand) or automatically operated. All hand tools **shall** employ some form of an integral mechanism to control the crimping operation to the extent that, once the crimping operation has been started, the crimp tool cannot be opened until the crimping cycle has been completed (full-cycle/ratcheting tools). All adjustable crimp tools **shall** be set, sealed or locked, and verified prior to use.
5.1	**Stamped and Formed – Open Barrel** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
5.1.1	**Stamped and Formed – Open Barrel – Insulation Support Crimp** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
5.1.2	**Stamped and Formed – Open Barrel – Insulation Inspection Window** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
5.1.3	**Stamped and Formed – Open Barrel – Conductor Crimp** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
5.1.4	**Stamped and Formed – Open Barrel – Crimp Bellmouth** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
5.1.5	**Stamped and Formed – Open Barrel – Conductor Bellmouth** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
5.1.6	**Stamped and Formed – Open Barrel – Carrier Cutoff Tab** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
5.2.2	**Stamped and Formed – Closed Barrel – Conductor Crimp and Bellmouth** **Defect** • Wire end is less than flush to the end of the bellmouth. • Bellmouth not evident at each end of the conductor crimp area when tooling is intended to form a bellmouth. • Terminal insulation, if present, has damage exposing metal. • Conductor extends into the mating area of the terminal (IPC/WHMA-A-620A Figure 5–39-B). • Crimp indentations not uniform. • Any conductor strands that do not enter the conductor crimp area.
5.2.3 [New]	**Stamped and Formed – Closed Barrel Without Insulation Support – Insulation Clearance** **Defect** • Insulation is greater than 1 wire diameter from the end of the entry bellmouth. • Exposed conductor violates minimum electrical clearance. • Insulation enters barrel of terminal.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
5.3	**Machined Contacts** When attaching multiple wires to a single contact: • Each wire **shall** meet the same acceptability criteria as a single wire contact. • Multiple wires **shall not** be crimped into contacts that will be installed in connectors or wire in-line junction devices (8.2.3) where the rear sealing grommet is required to provide the environmental seal. When attaching single or multiple wires to a contact the combined circular mil area of the wires **shall** comply with the circular mil area range for the contact. Each crimp tool **shall** have a minimum of four indenter blades (preferably double-indenter blades).
5.3.1	**Machined Contacts – Insulation Clearance** **Defect** • Insulation is greater than 1 wire diameter from the end of the contact barrel. • Exposed conductor violates minimum electrical clearance. • Insulation enters barrel of terminal.
6	**Insulation Displacement Connection (IDC)** Insulation displacement connection (IDC), sometimes referred to as insulation displacement termination (IDT), is a method for terminating an insulated wire to a connector or terminal without pre-stripping the insulation from the conductor. However, this method may be used for an uninsulated wire as well. It is recognized that this technology is utilized by a significant number of different connector types. This section attempts to define common acceptance criteria regardless of the connector type. The wire, the connector, tooling and assembly process **shall** be compatible. Tooling used to accomplish connector installation **shall** apply consistent and controlled force. Variations in wire gauge, wire-to-wire spacing (for multiple conductor flat or ribbon cable), insulation thickness, insulation type, application tooling, or alignment of the cable to the connector may result in an unreliable connection or in an electrical open or short circuit. It is also recognized that in some insulation displacement products, visual inspection of the wire/termination connection is not possible without destructive analysis.
6.1.1	**Mass Termination, Flat Cable – End Cutting** **Defect** • Uneven or wavy cutting of the cable end precludes compliance to any other assembly requirement. • Conductor strand protrusion from the end of the cable >25% cable thickness or violates minimum electrical clearance.
7	**Ultrasonic Welding** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
8	**Splices** Splices **shall not** be used to repair broken or damaged conductors without User approval prior to the repair. Splices **shall not** be placed within two harness diameters of a breakout, in bends, or where they may be exposed to tension, flexure, or other stresses. Splices **shall** be staggered within specified design limits. When using heat shrinkable devices, they should not be used near optics or other sensor devices. Remaining flux residues can contaminate these devices, e.g., from outgassing. For the purposes of this section, the word “sleeving” is used to describe heat shrinkable tubing, tape, or any other insulation added to cover the spliced connection. Additional criteria for sleeving damage are provided in Section 16 (Cable/Wire Harness Protective Coverings). Sleeving length should be sufficient to extend over the wire insulation on both sides of the spliced area as specified throughout this section. The recovered (shrunk) sleeve **shall** be snug (no lateral movement) to the wire splice and wire insulation maintaining sufficient sleeving thickness over the wire splice. Position appropriate sleeving/tubing/wire designations over 1 end of the wires to be spliced for later use. Wire splicing is used when replacing the entire length of a damaged wire is not feasible or when a self-lead component (inductor, transformer, choke, etc.), is installed (either during assembly or as a replacement for a failed component). If possible, replace 1 end of the wire to limit the splice to just 1 splice. If necessary, replace 1 section of the wire, which may require 2 splices.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
8.1	**Soldered Splices** Stranded wires **shall** be tinned when wires will be formed into splices (other than mesh splices, see 8.1.1) or when heat shrinkable solder devices are used. Sleeving **shall** conform to the splice contour and have a snug fit over the wire splice area and wire insulation. Sleeving **shall** cover wire insulation on both ends of the spliced area by a minimum of 2 diameters of the wire group. Solder used for tinning **shall** be the same alloy that will be used in subsequent soldering processes (see 4.4). Solder **shall** wet all elements of the termination forming a visible solder fillet joining the wires of the splice. Individual wire strands should remain discernible. Requirements in Clauses 3, 4.1 through 4.4, 4.5.2 and 16.2 are applicable to soldered wire splices.
8.1.1	**Mesh Splices** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
8.1.2	**Soldered Splices – Wrap** **Defect** • Insufficient solder fillet. • There are sharp points or projections covered by sleeving. • Conductor strands pierce the sleeving. • Sleeve or wire insulation is burned/charred. • Wire splice area is exposed. • Sleeving does not overlap wire insulation (on both ends) for a minimum of 2 diameters of the wire group. • Less than 3 wraps of each conductor. • Wraps are not tight. • There are gaps between adjacent turns. • Wraps overlap each other or the insulation of the other wire.
8.1.3	**Hook Splices** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
8.1.4	**Soldered Splices – Lap** The criteria in this section are applicable to hand soldered in-line lap splices, where 2 or more conductors overlap, are parallel and soldered. See 8.1.5 for splices formed with heat shrinkable solder devices. This type of splice requires a minimal amount of wire. Wire ends **shall** be stripped so the wires overlap a minimum of 3 wire diameters (see IPC/WHMA-A-620A Figure 8–14). Conductors should be in full contact and parallel (no twisting of the conductors). Conductors **shall not** overlap the insulation of the other wire. While overwrapping of a lap splice with a smaller diameter wire, sometimes referred to as a lash splice, does not provide a significant increase in strength to the connection, it may facilitate forming the splice. The number and spacing of turns used to hold the lapped wires in place during soldering is optional, however the wraps **shall not** overlap, i.e., cross over themselves, and **shall not** extend beyond the end of either conductor being spliced. The option to wrap (or "lash") a lap splice is decided at the design level. Lap splices **shall** be performed as indicated on the engineering documentation.
8.1.4.1	**Soldered Splices – Lap – Two or More Conductors** **Defect** • Conductors are not in full contact or are not parallel. • Solder fillet less than 100% of the length of the overlap. • Wires do not overlap a minimum of 3 wire diameters of the largest wire. • Bulges in the sleeving. • Sharp points or projections. • Conductor strands pierce the sleeving. • Sleeving is burned/charred, split, or damaged (not shown). • Conductor overlaps insulation of the other wire. • Sleeving is loose (not shown). • Sleeving does not overlap the insulation on both ends of the spliced area by a minimum of 2 diameters of the largest wire group in the splice.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
8.1.4.2	**Soldered Splices – Lap – Insulation Opening (Window)** **Defect** • The wire opening (window) is shorter in length than the stripped portion of the pickoff wire (IPC/WHMA-A-620A Figure 8–25). • Conductor overlaps insulation of the other wire (IPC/WHMA-A-620A Figures 8–25, 8–26). • The solder perform (ring) is not fully melted (IPC/WHMA-A-620A Figures 8–25, 8–26). • No visible fillet between the wire and pickoff lead (not shown). • Meltable sealing rings, if present, have not flowed (not shown). • Wire strands are exposed (not shown). • Sleeve or wire insulation burnt or charred (not shown). • The sleeve does not overlap insulation at both ends of the spliced area by a minimum of 2 diameters of the largest wire group in the splice (not shown).
8.1.5	**Soldered Splices – Heat Shrinkable Solder Devices** When heat shrinkable soldering devices are used the solder perform (ring) **shall** be completely melted and a solder fillet **shall** wet to the wires in the connection. Wire contour should be visible in the solder fillet. Terminations made using heat shrinkable solder devices are exempt from the cleaning requirements. A thermal indicator (if provided) is an aid for deciding when to stop heating. Its presence or absence in the installed part is not reason for rejection of the installation. **Defect** • Solder fillet not wetted to both wires. • The solder preform ring is not fully melted. • There are sharp points or projections. • Conductor strands pierce the sleeving. • Wires do not overlap at least 3 conductor diameters. • Sleeving does not cover wire insulation on both ends at least 1 wire diameter. • Meltable sealing ring interferes with formation of required solder connection. • Meltable sealing ring does not provide 360° of seal at either end. • Sleeve is not formed tightly onto the lead and the cable. • Sleeving or wire insulation is burned or charred. • Solder has flowed beyond the meltable sealing rings or has extruded beyond the end of the heat shrinkable sleeving.
8.2.1	**Crimped Splices – Barrel** **Defect** • The sleeve does not overlap insulation at both ends of the spliced area by a minimum of 2 diameters of the largest wire group in the splice (not shown). • Any insulation gap in the splice exceeds 1 wire diameter. • Conductors extend greater than 1 wire diameter beyond crimp barrel. • Wire insulation extends into barrel splice crimp. • Barrel or seam/weld is split or cracked. (IPC/WHMA-A-620A Figure 8–36 arrow). • Crimp indentation is off the end of the barrel splice, bellmouth is not evident. • Wires are not contained in the crimp. • Conductors twisted together before insertion into the contact. • All conductor ends are not visible.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

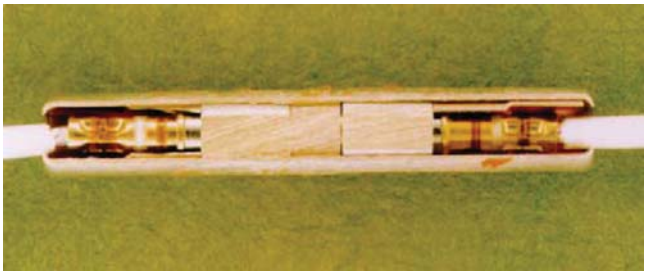
A-620A Reference	Space Applications Requirement (as changed by this Addendum)
8.2.2	**Crimped Splices – Double Sided** **Defect** • Wire insulation extends into the wire crimp barrel (IPC/WHMA-A-620A Figure 8–43, A). • Crimp indent is off the end of the splice (IPC/WHMA-A-620A Figure 8–43, B). • Wire end(s) are not visible through the inspection window(s) (IPC/WHMA-A-620A Figure 8–43, C). • Wire insulation gap is greater than 1 wire diameter including insulation (IPC/WHMA-A-620A Figure 8–43, D). • Sleeving, if required, does not overlap wire insulation at least 2 wire diameters on both ends (not shown). • Wire strands extend out of inspection window (IPC/WHMA-A-620A Figure 8–44). • Wire strands have pierced the heat shrinkable sleeve (IPC/WHMA-A-620A Figure 8–45). • Conductors twisted together before insertion into the contact. • Barrel or seam/weld is split or cracked. • Barrel with integral strain relief does not meet the insulation support requirements of 5.2.1.
8.2.3 [New]	**8.2.3 Wire In-Line Junction Devices (Jiffy Junctions)** Wire in-line junction devices, sometime referred to as "Jiffy Junctions," are essentially feed through environmentally resistant disconnect components for joining wires. Crimp contacts are terminated onto conductors (Figure 8–1 of this addendum) and then inserted into the in-line junction device as it would be with a rear-entry machined contact connector (Figure 8–2 of this addendum, shown in cross-section). The tooling, tooling verification, crimping processes, and completed terminations **shall** comply with the requirements for tool control and machined contact crimped terminations in Chapters 1 (general), 5 (crimp) and 19 (testing) of this addendum. When the circular mil area of the conductor needs to be built up so that it falls within the minimum and maximum CMA range of the contact, CMA buildup **shall** be in accordance with 5.3.5. As an exception to 9.5.2, when a sealing plug is required it **shall** be inserted shaft first.  **Figure 8–1. Crimped Contacts Outside Junction Device**  **Figure 8–2. Crimped Contacts Inserted Into Junction Device (shown in cross-section)**

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
	Defect • Multiple wire attachments, when used, do not meet the requirements of 5.3. • Insulation clearance does not meet the requirements of 5.3.1. • The conductor location does not meet the requirements of 5.3.3. • Crimping does not meet the requirements of 5.3.4. • Circular mil area (CMA) buildup, when used, does not meet the requirements of 5.3.5. • Contact installation does not meet the requirements of 9.5. • Qualification of crimped connection fails Pull Force/Tensile Test per 19.7.2. • Mated assembly fails Pull Test Contact Retention Verification Test per 19.7.5.2.
8.3	**Ultrasonic Weld Splices** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
9.1	**Hardware Mounting** When torque requirements are established, see 17.2.
9.1.1	**Hardware Mounting – Jackpost – Height** This section covers the height relationship of the face of the jackpost to the associated connector face. This is critical to obtain maximum connector pin contact. **Defect** • Jackpost face extends above the connector face (IPC/WHMA-A-620A Figure 9–2). • Face of jackpost is greater than 0.75 mm [0.030 in] below the connector face (IPC/WHMA-A-620A Figure 9–3). • Jackpost height has been adjusted by adding or removing washers not specified on the drawing.
9.2	**Strain Relief** When torque requirements are established, see 17.2. When the connector/backshell/accessory uses teeth to interlock the mating surfaces, the connector assembly procedures **shall** include a process that ensures the teeth are fully engaged prior to tightening. Figure 9-2a shows a partial connection where the alignment teeth are not fully engaged. Figure 9-2b shows an acceptable mating.  **Figure 9–2a. Incomplete Mating**  **Figure 9–2b. Acceptable Mating**
9.2.1	**Strain Relief – Clamp Fit** Clamps, as specified on the drawing, **shall** support cables, harnesses or individual wires to prevent wire movement that may place strain on the wire/connector terminations. Split lock washers incorporated as part of the backshell or strain relief clamp **shall** be fully compressed. Build-up material **shall not** be used unless specified on the drawing(s). Build-up material is referred to as “sleeving” in the following criteria. The sleeving criteria apply only when such material is applied to the wire bundle. Cable clamp fasteners **shall** be staked for at least 50% of the perimeter of the fastener after the cable clamps have been torqued. Thread extension **shall not** be more than 3 mm [0.12 in] plus one and one-half threads for bolts or screws up to 25 mm [0.984 in] long or more than 6.3 mm [0.248 in] plus one and one-half threads for bolts or screws over 25 mm [0.984 in]. **Defect** • Sleeving extension beyond clamp causes stress on the wires (IPC/WHMA-A-620A Figure 9–7, A). • The split lock washers are not collapsed (IPC/WHMA-A-620A Figure 9–7, B). • Clamps do not captivate and support the cable. • Clamps do not prevent movement of the cable. • Bundle diameter has >5% indentation or distortion caused by the clamps. • Damage to sleeving that exposes the harness or other protected material (not shown). • If spacers are required, they are not present, not mounted on both ears of the backshell, and/or are not on the same side of each ear on both sides of the backshell.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
9.2.2.1	**Strain Relief – Wire Dress – Straight Approach** **Defect** • Wire is outside the contour of the wire bundle (IPC/WHMA-A-620A Figure 9–10, A). • Wire exits connector at a sharp angle (IPC/WHMA-A-620A Figure 9–10, B). • Wire is stressed (no freedom of movement) (IPC/WHMA-A-620A Figure 9–10, C). **Note:** See 9.5.1 for criteria related to contact not seated (IPC/WHMA-A-620A Figure 9–10, D).
9.2.2.2	**Strain Relief – Wire Dress – Side Approach** **Defect** • Wire is outside the contour of the wire bundle (IPC/WHMA-A-620A Figure 9–13, A, C). • Wire exits connector at a sharp angle (IPC/WHMA-A-620A Figure 9–13, B). • Wire is stressed (no freedom of movement) (IPC/WHMA-A-620A Figure 9–13, C, D). **Note:** See 9.5.1 for criteria related to contact not seated (IPC/WHMA-A-620A Figure 9–13, E).
9.4.2	**Connector Damage – Limits – Hard Face – Mating Surface** **Defect** • Any chip or crack.
9.4.3	**Connector Damage – Limits – Soft Face – Mating Surface or Rear Seal Area** **Defect** • Any cut, fracture or tear.
9.4.4	**Connector Damage – Contacts – Exposed Pins, Protected Sockets** **Defect** • Damaged contact. • Pin is bent more than 0.5 pin diameter. • Basis metal exposed.
9.4.4.1 [new]	**Connector Damage – Contacts – Exposed Sockets, Protected Pins, e.g., MIL-DTL-83513 Micro D** **Defect** • Damaged contact. • Any misalignment of socket. • Basis metal exposed.
9.5	**Installation of Contacts and Sealing Plugs into Connectors** Contacts retention (seating/locking) **shall** be verified in accordance with 19.7.5. Verification **shall** be accomplished prior to addition of any restraining devices, including potting or molding. Unused contact locations **shall** be filled with contacts and/or plugs if specified on the documentation. The contacts are not crimped unless required for insertion. Non-metal contact insertion tools should be used to prevent connector/contact damage. Damaged contact insertion/extraction tools **shall** be discarded and replaced with a new tool. Should part of the tip of a tool break off, all pieces of the tip **shall** be accounted for. Exceptions to retention verification include: • Prewired molded connectors. • Potted or molded connectors after molding/potting. • Connectors with soldered terminals.
10	**Molding/Potting** The requirements in this section are imposed primarily to give confidence in the reliability of the wire or cable. Any allowable cosmetic anomalies should be agreed upon between the Manufacturer and the User prior to the molding or potting operation. Opaque materials preclude visual inspection for internal anomalies. Use of any other inspection technologies, including acceptance criteria, **shall** be documented and agreed upon between the Manufacturer and the User. Areas to be potted or molded **shall** be cleaned prior to material application. The requirements in this section are based on the use of materials that are within shelf life (see 1.19), and have been processed in accordance with 1.21.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
12	**Marking/Labeling** **Note:** For the purposes of this section, marking and labeling are referred to as marking, as applied by the Manufacturer. All interconnecting cables, harness assemblies and connectors **shall** be identified and permanently marked. Regardless of the marking method used, markings **shall** contain the required information, be legible, be permanent in the intended application, and **shall not** damage the product nor impair its function. Marking inspection is to be performed without magnification. Additional (non-required) information may be marked onto the product for internal purposes. This marking is not subject to the provisions of this section, provided that: • The marking does not conflict with, and is separated from, required information. • Prior to delivery nonpermanent internal markings **shall** be removed. • After removal of nonpermanent markings, there **shall** be no tape residues or other contamination present. Criteria with obvious understanding may not have illustrations.
12.3	**Permanency** **Defect** • Markings not legible or present after exposure to handling, assembly, cleaning and required environmental testing.
12.4	**Location and Orientation** Connectors **shall** be identified to facilitate mating. The identification may be placed directly on the connector, or on the cable/harness within 15 cm [5.9 in] of the connector unless specified otherwise on the drawing. For cables longer than 2.5 m [8.2 ft] and marking locations are not specified, markings **shall** be repeated at intervals no greater than 1.25 m [4.1 ft] along the length of the cable. **Defect** • Marking not in specified location(s). • If the location is not specified, the marking is more than 15 cm [5.9 in] from the breakout, end of wire (where the end product is unterminated wire or wires), or the rearmost connector accessory, e.g., backshell, boot, ferrule, etc. • Color coded marking (bands) does not read away from the connector. • Marker orientation does not meet specified requirements. • For cables longer than 2.5 m [8.2 ft] and the location is not specified, the marking is repeated at intervals of more than 1.25 m [4.1 ft].
12.6.1	**Marker Sleeve – Wrap Around** **Defect** • Any wrinkles or misalignment that affects legibility or further assembly steps. • The marker sleeve overlap is not secure (IPC/WHMA-A-620A Figure 12–11). • The marker sleeve overlap is less than 1.25 times the cable circumference (IPC/WHMA-A-620A Figure 12–12). • The overlap obscures required marking.
12.6.2	**Marker Sleeve – Tubular** **Defect** • Any splits or holes. • The marker sleeve is not sufficiently shrunk to remain secure.
12.7.1	**Flag Markers – Adhesive** There **shall not** be any exposed adhesive after flag marker attachment. **Defect** • The flag marker side or end misregistration exceeds 10% of the width of the marker.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
12.7.2	**Flag Markers – Tie Wrap** For this addendum, these criteria are applicable to all types of tie wrap attached markers. Tie wrap attached markers **shall** be installed in accordance with the tie wrap installation requirements of 14.1, 14.1.1 and 14.1.2.
13	**Coaxial and Twinaxial Cable Assemblies** For coaxial and twinaxial assemblies to function properly, it is critical to follow all assembly instructions provided by the connector manufacturer. In general, the pieces of the connectors must remain as concentric as possible. The relationship of the outside diameter (OD) of the cable center conductor/connector contact, the thickness of the dielectric, and the inside diameter (ID) of the connector body and cable shielding are critical to electrical and mechanical function of the assembly. Insulation integrity is important to preclude shorting of shields to each other or shorting of shields to the center conductor. Criteria for sleeving damage are provided in 16 (Cable/Wire Harness Protective Coverings). It is common for coaxial cable dielectric materials to shrink as a result of contact with processing materials and temperatures. This is likely to continue after the cable has been placed in use. This needs to be considered in the design, engineering and manufacturing processes. A preconditioning process **shall** be employed using an appropriate method such as thermal cycling. Center conductors **shall not** be used as connector mating contacts. Center contacts with gold plating thickness of less than 1.25 µm [50 µin] in the solder area do not need gold to be removed. Gold on mating surfaces **shall not** be removed. All adjustable crimp tools **shall** be set, sealed or locked, and verified prior to use.
13.1	**Stripping** IPC/WHMA-A-620A Table 13–1 does not apply. For center conductors, there **shall be no** nicked or broken wire strands. For plated wires, a visual anomaly that does not expose basis metal is not considered to be strand damage. Nicked shield strands **shall not** exceed 10 percent of the total number of strands. There **shall** be no severed strands. **Defect** • Braid twisted/birdcaged (IPC/WHMA-A-620A Figure 13–3 (1)). • Damage exceeds 10% of shield strands (IPC/WHMA-A-620A Figure 13-3 (2)). • Any severed shield strands. • Any cuts or breaks in outer jacket (not shown). • Outer jacket thickness is reduced greater than 20% (IPC/WHMA-A-620A Figure 13–3 (3)). • Uneven or ragged pieces (frays, tails, tags) of outer jacket are greater than 50% of the outer jacket thickness or 1 mm whichever is more (IPC/WHMA-A-620A Figure 13–3 (3)). • Internal dielectric damaged (IPC/WHMA-A-620A Figure 13–3 (5)). • Uneven cut on braid; any long strands (IPC/WHMA-A-620A Figure 13–3 (6)). • Discernible nicks or cuts in center conductor (not shown). • Burns or melted areas on dielectric. • Damage to center dielectric reducing insulation diameter by more than 10% (not shown).
13.6	**Coaxial Connector – Center Conductor Solder** **Defect** • Solder splash or spillage on sides of contact, inside walls of cavity or the terminal cover area (IPC/WHMA-A-620A Figure 13–30). • Any solder balls inside cavity (IPC/WHMA-A-620A Figure 13–31). • Excess solder on top of contact (IPC/WHMA-A-620A Figures 13–31, 32) or solder peaks/icicles (IPC/WHMA-A-620A Figure 13–30). • Any pinholes/blowholes where all inner surfaces are not visible.
13.7.2	**Coaxial Connector – Terminal Cover – Press Fit** Press fit covers **shall** be secured by using structural adhesive or other means.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
13.10	**Semirigid Coax** The acceptability of semirigid cable assemblies is greatly affected by three factors. • ***Application*** – Bend radii and deformation of a cable assembly have a greater or lesser effect depending upon the frequency the cable will carry. • ***Cleanliness*** – Mating surfaces, including test equipment **shall** be free of all foreign material, i.e., flux residue, metallic or other particles. • ***Tooling*** – Proper tooling will prevent cable deformation and surface damage. The criterion that follows will establish acceptance conditions for the most common applications. Visual inspection of the cable cannot in all cases determine its fitness for use. With the exception of obvious damage or improper solder connections, the correct function of the cable assembly will be the determining factor of acceptance. There **shall be no** nicks, scrapes or other deformation greater than 10% of the diameter of center conductor.
13.10.5	**Solder** **Defect** • Insufficient solder. • Solder fillet has voids (not shown). • Solder does not wet to connector body and cable for entire circumference. • Excess solder onto cable or connector impedes subsequent assembly operations. • Contamination, e.g., flux residue. • Solder is nonwetted or dewetted. • Shield strand is not contained in connector barrel (not shown).
13.12	**Soldering and Stripping of Biaxial and Similar Multi-Conductor Shielded Wires** **Note:** Title was changed so the criteria are applicable to all multi-conductor shielded RF cables/wires not previously covered. All stripping, shield and conductor damage, soldering, center pin location and cleaning criteria from published IPC/WHMA-A-620A apply.
13.12.1	**Soldering and Stripping of Biaxial and Similar Multi-Conductor Shielded Wires – Jacket and Tip Installation** **Note:** Title was changed so the criteria are applicable to all multi-conductor shielded RF cables/wires not previously covered. All stripping, shield and conductor damage, soldering, center pin location and cleaning criteria from published IPC/WHMA-A-620A apply.
13.12.2	**Soldering and Stripping of Biaxial and Similar Multi-Conductor Shielded Wires – Ring Installation** **Note:** Title was changed so the criteria are applicable to all multi-conductor shielded RF cables/wires not previously covered. All stripping, shield and conductor damage, soldering, center pin location and cleaning criteria from published IPC/WHMA-A-620A apply.
14.1	**Tie Wrap/Lacing Application** IPC/WHMA-A-620A Figures 14–1, 14–2 and 14–3 are provided as guidance for applying lacing. The ends start and finish with clove-hitches that are secured with square knots. IPC/WHMA-A-620A Figure 14–2 also shows running lock stitches. IPC/WHMA-A-620A Figure 14–3 is an example of a surgeon's knot. Wax impregnated lacing tape **shall not** be used. Staking material may be used to secure lacing knots. Continuous lacing **shall** only be used when specified on the engineering drawing.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

<table>
<tr><th>A-620A Reference</th><th>Space Applications Requirement (as changed by this Addendum)</th></tr>
<tr><td></td><td>Defect
• Cut end protrusion (IPC/WHMA-A-620A Figure 14-5 (1)).
• Continuous lacing does not use lock stitches.
• Wires not constrained securely and uniformly or are birdcaged.
• Cable tied with a bowknot or other nonlocking knot.
• Tie wraps/straps are inverted or not locked.
• Knots are secured by heat searing.
• Double lock stitch not used where required.
• Branch lacing not started on trunk (IPC/WHMA-A-620A Figure 14-8 (1)).
• Excess lacing trimmed either too close to knot (less than 6 mm [0.25 in]) (IPC/WHMA-A-620A Figure 14-8 (2)), or too far from knot (greater than 13 mm [0.5 in]) (IPC/WHMA-A-620A Figure 14-8 (3)).</td></tr>
<tr><td>14.1.1</td><td>Tie Wrap/Lacing Application – Tightness
Defect
• Bundle diameter has >5% indentation or distortion caused by the restraining devices.
• Restraining devices move longitudinally.</td></tr>
<tr><td>14.2.1</td><td>Breakouts – Individual Wires
Defect
• A restraining device is not used prior to each breakout.
• If continuous lacing is used, there is no double lock stitch before the first wire breakout (not shown) or before and after any breakout of 4 or more wires.</td></tr>
<tr><td>14.3.2</td><td>Routing – Bend Radius Bend radius is measured along the inside curve of the wire or wire bundles.
Table 14–1 Minimum Bend Radius Requirements
<table>
<tr><th>Cable Type</th><th>Space Addendum</th></tr>
<tr><td>Coaxial Fixed Cable, Note 2</td><td>6X OD[1]</td></tr>
<tr><td>Coaxial Flexible Cable, Note 3</td><td>10X OD[1]</td></tr>
<tr><td>Shielded and Unshielded Wires and Cables</td><td>3X OD[1] for ≤AWG 10
5X OD[1] for >AWG 10</td></tr>
<tr><td>Polyimide Insulated Wire</td><td>10X OD[1]</td></tr>
<tr><td>Composite, (AS 2759/80-/92)</td><td>6X OD[1]</td></tr>
<tr><td>Semi-rigid Coax</td><td>Not less than Manufacturer’s stated minimum bend radius, see 13.10.1</td></tr>
<tr><td>Harness assembly</td><td>Minimum bend radius of any individual wire/cable within the harness.</td></tr>
</table>
Note 1: OD is the outer diameter of the wire or cable, including insulation.
Note 2: Coaxial Fixed Cable Coaxial cable that is secured to prevent movement; not expected to have the cable repeatedly flexed during operation of the equipment.
Note 3: Coaxial Flexible Cable Coaxial cable that is or may be flexed during operation of the equipment.

Defect
• Bend radius does not meet the requirements of Table 14–1 of this addendum.</td></tr>
</table>

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
15.1	**Braided** Metal braid shielding can either be woven directly over a core or obtained in prefabricated form and installed by sliding it over the wire bundle. All breakouts **shall** be properly secured prior to applying the braid. IPC/WHMA-A-620A Figure 15–1 shows using tape to provide the breakouts. Lacing or cable ties may also be used (see Section 14 (Securing)). To prevent potential damage, e.g., cold flow or shorting to the underlying wire, a separator such as the tape shown in IPC/WHMA-A-620A Figure 15–2 **shall** be applied over the wire bundle. Directly applied braid **shall** be back braided to lock the weave. Prewoven braids **shall** be secured at the ends. When using cable straps or spot ties, fold the braid over itself, secure, and cover the end with heat shrink tubing or tape. Prewoven metallic braid **shall** be cleaned to remove contamination prior to installation over the harness. Temporary holding devices, e.g., spot ties, plastics straps and lacing, **shall** be removed from wire bundles prior to braid application. Approved flat tapes may be left under braid if the tape has a low profile.
15.1.1	**Braided – Direct Applied** **Defect** • Braid strands bunched (excess overlap). • Braid coverage does not meet drawing requirements. • Wire or shield braid visible through top braid. • Braiding overlap less than 13 mm [0.5 in] at breakouts and branches. • Braid has loops. • Ends not secured, frayed or unraveling. • Tears and/or cuts of braiding. • End strands not trimmed. • Damage exceeds the shield braid damage limits of 13.1 in this addendum.
15.1.2	**Braided – Prewoven** **Defect** • Braid coverage does not meet drawing requirements. • Ends not secured. • Tears and/or cuts of braiding. • Overlap is less than 1 bundle diameter where multiple braids meet. • Ends frayed or unraveling. • Loose ends protruding from potting or shrink sleeving. • Braid ballooned or bunched. • Damage exceeds the shield braid damage limits of 13.1 of this addendum.
15.2	**Shield Termination** Insulation of the inner wire(s) **shall** be protected from damage that can be caused by the soldered ends of the shield braid. Shield terminations **shall** be staggered within specified design limits to minimize wire bundle diameter buildup in the shield termination area.
15.2.1.1	**Shield Termination – Shield Jumper Wire – Attached Lead** Shield should terminate as close as possible to inner conductor termination point. For critical applications, engineering documentation should provide maximum limits on the gap between the conductor termination point and the shield termination point. Terminations made with self-sealing heat shrinkable devices are exempt from the cleaning requirements. Heat shrinkable solder devices, including those supplied with an integral shield wire, may be changed 1 size up or down to achieve correct fit when size is not called out on the engineering drawing.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
15.2.1.1.1	**Shield Termination – Shield Jumper Wire – Attached Lead – Solder/Heat Shrinkable Solder Device** A thermal indicator (if provided) is an aid for deciding when to stop heating. Its presence or absence in the installed part is not reason for rejection of the installation. **Note:** To enable viewing of strands and solder fillets, some of the illustrations in this section were made with the sleeving removed. **Defect** • Shield wire is not aligned with the stripped portion of the shield. • Solder fillet is less than 75% of the stripped length of the shield jumper wire (IPC/WHMA-A-620A Figure 15–16). • Meltable sealing ring precludes formation of acceptable solder connection (not shown). • Shield wire extends beyond stripped surface of shield preventing wire from contacting shield (IPC/WHMA-A-620A Figure 15–15, A). • Shield wire has pierced the insulation sleeving (IPC/WHMA-A-620A Figure 15–15, B). • Solder joint is insufficient (IPC/WHMA-A-620A Figure 15–16). • Shield strand, (IPC/WHMA-A-620A Figure 15–17, A), is protruding from end of insulation sleeving. • Shield strand, (IPC/WHMA-A-620A Figure 15–17, B), has pierced the insulation sleeving. • Insufficient solder flow, contour of solder preform is discernible. • Plastic sleeve burned/charred. • Discoloration of sleeving obscures the solder connection. • Heat shrinkable solder device/protective sleeving is not properly positioned on the shield and bare shield is exposed. • Sleeve is not formed tightly onto the lead and the cable.
15.2.1.2	**Shield Termination – Shield Jumper Wire – Shield Braid** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
15.2.1.3	**Shield Termination – Shield Jumper Wire – Daisy Chain** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
15.2.1.4 [new]	**Shield Termination – Shield Jumper Wire – Common Ground Point** Requirements for shield jumper wires spliced to a common point ground **shall** be the same as the splice requirements documented in 8.1 or 8.2 for the type of splice called out, e.g., lap.
15.2.2	**Shield Termination – No Shield Jumper Wire** When the braid is not terminated the braid **shall** be either (1) trimmed flush-to 3 mm [0.12 in] at the end of the outer jacket and covered with heat shrink tubing or (2) folded back over the outer jacket and covered with heat shrink tubing. **Defect** • Stripped shield length exceeds 3 mm [0.12 in]. • Sleeving overlap is less than 1 wire or bundle diameter, whichever is greater, in each direction. • Sleeve or wire insulation is burned or charred. • Any split in sleeving. • Sleeving is loose. • Sleeving pierced by wire strand (not shown).

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
15.3.1	**Shield Termination – Connector – Shrink, Banding Clamp, and Crimp** **Defect (Shrink, Banding Clamp, and Crimp)** • Gaps are present in weave pattern (IPC/WHMA-A-620A Figure 15–36). • Damage exceeds the shield braid damage limits of 13.1 in this addendum. • Shield extends beyond backshell crimp area (IPC/WHMA-A-620A Figure 15–39 (A)). **Defect (Crimp Ring)** • Shield strands not contained within crimp ring have not been trimmed (IPC/WHMA-A-620A Figure 15–39 (C)). • Crimp ring extends greater than 10% of the crimp ring length beyond backshell (IPC/WHMA-A-620A Figure 15–37 (A)). • Crimp ring is under-crimped resulting in movement of the ring or shield. **Defect (Shrink Ring)** • Shield is not visible between shrinkable ring and backshell (IPC/WHMA-A-620A Figure 15–38). • Shrinkable ring is not shrunk, movement of the ring and shield is evident. (Ring has retained its original color.) **Defect (Banding Clamp)** • Sharp edges are present in the band cut off area (IPC/WHMA-A-620A Figure 15–39 (B)). • Banding clamp is not wrapped around backshell 2 times.
15.3.2	**Shield Termination – Connector – Shield Jumper Wire Attachment** **Defect** • Shield jumper wire is not within the envelope dimension of the connector (where possible). • Terminal lug is not properly torqued to the grounding point. • Shield jumper wire is taut causing stress on the solder or crimp connections.
15.4.1	**Shield Termination – Splicing – Solder** **Defect** • Tack solder has not flowed to inner shields (IPC/WHMA-A-620A Figure 15–48, arrows). • Shield overlap is less than 1 times the diameter of the large (combined) wire bundle (not shown). • Solder flow in the shield overlap area is excessive with no flexibility. • Shield weave pattern is disturbed beyond the allowable limits defined in clause 15.1.1 or 15.1.2. • Shield overlap is greater than 3 wire bundle diameters.
15.7	**Shrink Tubing – Conductive Lined** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
16.1.2	**Braid – Prewoven** **Defect** • Ends frayed or unraveling. • Pulled loops. • Braid ballooned or bunched. • Ends not secured. • Damage to braiding, i.e., tears, cuts, melting. • Overlap is less than 1 bundle diameter where multiple braids meet.
16.3	**Spiral Plastic Wrap** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
17	**Finished Assembly Installation** A finished assembly is a harness, cable or wire(s) that may be covered or uncovered. See 19.4.1 for post-installation testing requirements.
17.2	**Hardware Installation** This section illustrates several types of mounting hardware. Process documentation will specify configuration of the hardware (drawings, prints, parts list, build procedures). Deviations **shall** require User approval prior to use. There **shall** be a documented process for torquing of threaded fasteners, including, but not limited to, standard torque values (when not specified in engineering documentation), requirements, procedures, quality assurance provisions, and tool control. Visual inspection is performed in order to verify the following conditions: a. Correct parts and hardware. b. Correct sequence of assembly. c. Correct security and tightness of parts and hardware. d. In-process torque verification, i.e., witness. e. No discernible damage. f. Correct orientation of parts and hardware. g. Existence and correct application of materials to the fastener system. The amount of torque applied establishes the preload in the fastener and the joint clamping force. Incorrect preload may result in static or fatigue failure of the fastener, joint slip, or separation. Threaded fasteners **shall** be torqued to the value specified on the drawing. If the torque value is not specified on the drawing, threaded fasteners **shall** be torqued to a defined standard torque value. The application of this torque value **shall not** cause the violation of the requirements in this specification. The torque applied at final assembly **shall** include: the torque required to overcome the kinetic friction between the mating bearing faces and between the mating threads and the torque required to overcome the self-locking feature, i.e., prevailing torque, if any, plus the torque required to apply the required axial load to the fastener system, i.e., specified torque. Each threaded fastener used in a design **shall** have a torque value and should have a torque tolerance specified on the engineering drawing, e.g., 8 in-lbs ± 6%. The torque tool accuracy **shall** be equal to or less than the tolerance, if defined. (Note that the tolerance is only used in the context of limiting the tool use to those tools that can meet the specified torque.) When a locking mechanism is used with a threaded fastener, the engineering drawing **shall** state that the prevailing torque **shall** be added to the specified torque value. Threaded fasteners which have been over-torqued **shall** be removed and discarded. **Tooling and Equipment** Tool standards equivalent to those below may be used. Torque tools (mechanical hand) **shall** conform to ASME B107.14, ASME B107.28 or ISO6789, as applicable. Torque tools (rotary) **shall** be tested and have their accuracies stated in accordance with ISO5393. Torque tools and measuring equipment **shall** be calibrated at regular intervals based on the type of tool and records of the tool's calibration. Calibration **shall** be in accordance with section 1.9 of this document. Periodic torque tool verification (if required) **shall** be performed to documented procedures. Process control for torquing of threaded fasteners **shall** be established, documented, and followed. Torque tools **shall** be selected and used in accordance with the Manufacturer's recommendations, i.e., tolerance, accuracy, and range of the tool. Torque tool settings/values **shall** be adjusted to compensate for additions to the torque tool, e.g., extensions, adapters, etc.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

A-620A Reference	Space Applications Requirement (as changed by this Addendum)
	Materials Applied to the Fastener System Compounds applied to fasteners (thread-locker, torque identification/witness/anti-tampering stripes, corrosion protection, sealants, adhesives, staking, lubricant, etc.) **shall** be identified on the drawing and **shall** be applied and cured in accordance with documented procedures, and the requirements of Section 1.21 of this document. Threaded fasteners that have been retained by the use of thread locking compounds **shall** be cleaned and inspected before reuse. Fasteners requiring torque stripe (witness/anti-tampering stripe) **shall** have the stripe in accordance with the following requirements. The stripe **shall**: • Be continuous. • Extend from the top of the fastener onto the adjacent substrate (at minimum). • Be aligned with the center line of the fastener. Fasteners requiring staking **shall** be retained by the appropriate approved adhesive, with a minimum of 50% circular coverage (either one continuous bead for 50% of the circumference, or two beads with at least 25% each of the circumference) **Visual Inspection** The following **shall** be the visual criteria for threaded fastener hardware installation, in addition to the other visual criteria in section 17: **Defect** • Hardware is not seated. Gaps exist between hardware and mating surfaces. • Proper hardware installation sequence, i.e., torque pattern not applied. • Fasteners are damaged (worn, burrs, frayed edges, cross-threading, mutilation). • Flathead screws protrude above the mounting surface.
17.2.3	**Wires** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
17.2.4	**High Voltage Applications** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.
17.3.3	**Service Loops** A service loop sufficient to allow 1 field repair **shall** be incorporated only when indicated on approved engineering documentation. **Defect** • Insufficient wire length if required by drawing.
17.4 [New]	**Lock Wires** When lock wires are required, they **shall** be installed in accordance with the engineering documentation (work instructions). In the absence of criteria in the engineering documentation, the following requirements are applicable: • The double twist method of lock-wiring **shall** be used. • Devices **shall not** be loosened to align lock-wire holes. • Lock wire **shall not** be reused. • Lock wire **shall not** be stretched, nicked, or kinked. • The lock wire **shall not** have a slack loop that enables the wire to move up over the device being secured. • The lock wire **shall** be installed such that the wire is put in tension if the device tends to loosen. • The twisted portion of the pigtail **shall** begin within three wire diameters of the hole being lock-wired. • The wire pigtail **shall** be long enough to be bent into a loop but **shall not** be longer than 25 mm [0.98 in]. • The wire pigtail **shall** be bent into a loop or otherwise positioned to prevent sharp ends.
18	**Solderless Wrap** Process and acceptance criteria **shall** be agreed upon between the Manufacturer and User prior to use.

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

<table>
<tr><th>A-620A Reference</th><th>Space Applications Requirement (as changed by this Addendum)</th></tr>
<tr><td>19.4.1</td><td>
Electrical Test – Selection Table 19–1 of this addendum gives an overview of the electrical tests that are required by default when agreement has not otherwise been made between the Manufacturer and the User. The “Requirements” column identifies whether a test is required for all assemblies (Required) or when the test must be specified by the User (As Specified).

Post installation testing shall be performed to assure that individual wire conditions have not been degraded by installation operations. The post installation test requirements shall be those identified in this clause. The tests shall be performed after installing the cables or harness in place, but before mating connectors.

The required tests shall be conducted in this order:

1. Continuity
2. Shorts
3. DWV
4. IR

Records of all acceptance testing shall be complete and shall be traceable to the cable or harness assembly being tested.

Adapter cables, breakout boxes, and/or connector savers shall be used to conduct any and all electrical tests on interconnecting cable and harness assemblies.

Hand probes shall not be used directly in the cable or harness connectors.

At a minimum, the electrical acceptance tests on potted-type connectors shall be performed immediately before the potting operation and after final assembly.

Table 19–1 Electrical Test Requirements
<table>
<tr><th>Paragraph</th><th>Test</th><th>Requirements</th></tr>
<tr><td>19.5.1</td><td>Continuity Test Parameters</td><td>Required</td></tr>
<tr><td>19.5.2</td><td>Shorts</td><td>Required</td></tr>
<tr><td>19.5.3</td><td>Dielectric Withstanding Voltage (DWV) Test Parameters</td><td>Required</td></tr>
<tr><td>19.5.4</td><td>Insulation Resistance (IR) Test Parameters</td><td>Required</td></tr>
<tr><td>19.5.5</td><td>Voltage Standing Wave Ratio (VSWR) Test Parameters</td><td>As Specified</td></tr>
<tr><td>19.5.6</td><td>Insertion Loss Test Parameters</td><td>As Specified</td></tr>
<tr><td>19.5.7</td><td>Reflection Coefficient Test</td><td>As Specified</td></tr>
<tr><td>19.5.8</td><td>Other Electrical Tests – User Defined</td><td>As Specified</td></tr>
</table>
</td></tr>
<tr><td>19.5.2</td><td>
Electrical Test – Methods – Shorts Testing for shorts is a low voltage test used to detect unintended connections.

When a limit is specified and included in the ‘‘Other Defined Value’’ column of Table 19–3 of this addendum, the shorts test shall verify that the measurement is not below that limit. In the absence of specific agreed on test requirements between Manufacturer and User or an agreement by the User to accept the Manufacturer’s documented test requirements, the requirements of Table 19–3 of this addendum shall apply.

Table 19–3 Shorts Test (low voltage isolation) Minimum Requirements
<table>
<tr><th>Parameter</th><th>Requirement</th><th>Other Defined Value</th></tr>
<tr><td>Min Resistance</td><td rowspan="3">Tester Default</td><td>____ Ohms</td></tr>
<tr><td>Max Current</td><td>____ mA</td></tr>
<tr><td>Max Voltage[1]</td><td>Volts</td></tr>
</table>
Note 1: A maximum voltage and or current should be specified when components within an assembly may be damaged by these tests.
</td></tr>
</table>

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

<table>
<tr><th>A-620A Reference</th><th>Space Applications Requirement (as changed by this Addendum)</th></tr>
<tr><td>19.5.3</td><td>
Dielectric Withstanding Voltage Test (DWV) The dielectric withstanding voltage test is a high voltage test, either AC or DC, used to validate that the components can operate safely at their rated voltage and withstand momentary spikes in voltage due to switching, surges or other causes. It assures that insulating materials and spacing in the component part are adequate. When a component part is faulty in these respects, application of the test voltage will result in either disruptive discharge (arc-over) or deterioration (dielectric breakdown).
The test potential shall be applied between the following:
(1) each conductor and all other conductors in the cable or harness assembly
(2) each conductor and connector shell
(3) each conductor and shield
(4) shields that are not electrically common
(5) shields and connector shell/ground, except when shields are connected to ground
The assembly fails when the measured current exceeds the specified value or the test equipment detects an electrical discharge.
AC tests are usually chosen over DC tests when an assembly is used in applications operating at voltages over 90VAC or where performance under AC stresses is a concern. AC test frequency is 60 Hz unless otherwise specified. When a total leakage current above 2 mA is expected, the test limits should be defined in terms of real current.
Cable or harness assemblies with a large capacitance, e.g., long runs generally over six feet, a long cable, or a harness incorporating shielding should be tested using the DC potential option to avoid erroneous indications of failure.
When limits other than those defined in Table 19–4 of this addendum are specified by the User, the DWV test shall be performed using those limits. In the absence of specifically agreed upon test requirements between Manufacturer and User, or an agreement by the User to accept the Manufacturer’s documented test requirements, Table 19–4 of this addendum shall apply.
Table 19–4 Dielectric Withstanding Voltage Test (DWV) Requirements
<table>
<tr><th>Parameter</th><th>Requirement</th></tr>
<tr><td>Voltage Level[1]</td><td>1500VDC +/-75 VDC or equivalent peak AC voltage</td></tr>
<tr><td>Maximum Leakage Current</td><td>1 mA</td></tr>
<tr><td>Dwell time[1]</td><td>5 to 60 seconds</td></tr>
</table>
Note 1: See 19.1
</td></tr>
<tr><td>19.5.4</td><td>
Electrical Test – Methods – Insulation Resistance (IR) The insulation resistance test is a high voltage test used to verify the resistance offered by the insulating materials. Failure occurs when the measured resistance value is lower than the specified value or the test equipment detects an electrical discharge.
For the IR test, the duration of the test may be reduced to the time required for steady state current to be established. If a DC test potential is used for the dielectric withstanding voltage test, the insulation resistance may be measured simultaneously.
If both DWV and IR tests are performed independently, the IR test shall be conducted after the DWV.
The test potential shall be applied between the following:
(1) each conductor and all other conductors in the cable or harness assembly
(2) each conductor and connector shell
(3) each conductor and shield
(4) shields that are not electrically common
(5) shields and connector shell/ground, except when shields are connected to ground
</td></tr>
</table>

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

<table>
<tr><th>A-620A Reference</th><th>Space Applications Requirement (as changed by this Addendum)</th></tr>
<tr><td></td><td>When limits other than those defined in Table 19–5 of this addendum are specified by the User, the IR test shall be performed using those limits. In the absence of specifically agreed upon test requirements between Manufacturer and User, or an agreement by the User to accept the Manufacturer’s documented test requirements, Table 19–5 of this addendum shall apply.

Table 19–5 Insulation Resistance (IR) Test Minimum Requirements
<table>
<tr><th>Parameter</th><th>Requirement</th></tr>
<tr><td>Voltage Level[1]</td><td>500 VDC +/- 50 VDC or tester default</td></tr>
<tr><td rowspan="2">Minimum Insulation Resistance[2]</td><td>Any cable other than coaxial ≥ 100M ohms</td></tr>
<tr><td>Coaxial/twinaxial/triaxial cable of any length ≥ 500 Megohms</td></tr>
<tr><td>Max Dwell Time</td><td>10 Seconds</td></tr>
</table>
Note 1: See 19.1
Note 2: IR levels specified are applicable at less than 80% relative humidity. When relative humidity exceeds 80%, derating should be addressed between Manufacturer and User.</td></tr>
<tr><td>19.5.5</td><td>Electrical Test – Methods – Voltage Standing Wave Ratio (VSWR) The voltage standing wave ratio test is used to evaluate reflective energy in high frequency cables. The result is a ratio of the reflected power to the input power. This test is not required unless specified by the User. When VSWR testing is required, the parameters and acceptance criteria, e.g., frequency range and ratio of reflected power to input power, shall be agreed upon between the Manufacturer and User.</td></tr>
<tr><td>19.5.6</td><td>Electrical Test – Methods – Insertion Loss The insertion loss test is a measurement of signal loss across a high frequency cable at specified frequencies or over a frequency range. This test is not required unless specified by the User. When insertion loss testing is required, the parameters and acceptance criteria, e.g., maximum insertion loss in a defined frequency range, shall be agreed upon between the Manufacturer and User.</td></tr>
<tr><td>19.5.7</td><td>Electrical Test – Methods – Reflection Coefficient The reflection coefficient test is a method used to evaluate reflective energy in high frequency cables. The result is the ratio of the reflected wave to the incident wave. This test is not required unless specified by the User. When reflection coefficient testing is required, the parameters and acceptance criteria, e.g., maximum reflection coefficient loss in a defined frequency range, shall be agreed upon between the Manufacturer and User.</td></tr>
<tr><td>19.5.8</td><td>Other Electrical Tests – User Defined The User or performance requirements may necessitate additional electrical testing. If such additional testing is specified, these tests shall be performed. Test parameters and acceptance criteria shall be agreed upon between the Manufacturer and User.</td></tr>
<tr><td>19.6.1</td><td>Mechanical Test – Selection In the absence of specific agreed on test requirements between Manufacturer and User, or an agreement by the User to accept the Manufacturer’s documented test requirements, the requirements of Table 19–9 of this addendum shall apply to 100% of assemblies.

If the Manufacturer has a documented process control program in place (see 1.3 and 1.8), supported by objective evidence, for maintaining crimp tooling and validating crimped connections, that program may be used in lieu of 19.7.2 when approved by the User prior to use. However, crimp tools shall not be used for longer than 30 days between verification testing.

Contacts used for tensile testing shall be from the same lot number as those that will be used in the assembly.

Table 19–9 Mechanical Test Requirements
<table>
<tr><th>Paragraph</th><th>Test</th><th>Requirement</th></tr>
<tr><td>19.7.1</td><td>Crimp Height Testing</td><td>Optional</td></tr>
<tr><td>19.7.2</td><td>Pull Force/Tensile Testing</td><td>Required</td></tr>
<tr><td>19.7.3</td><td>Crimp Force Monitoring</td><td>As Specified</td></tr>
<tr><td>19.7.5</td><td>Contact Retention Verification</td><td>Required
Either 19.7.5.1 or 19.7.5.2</td></tr>
<tr><td>19.7.6</td><td>RF Connector Shield Pull Test</td><td>As specified</td></tr>
<tr><td>19.7.7</td><td>RF Connector Shield Torsion Test</td><td>As specified</td></tr>
<tr><td>19.7.8</td><td>Other Mechanical Tests – User Defined</td><td>As specified</td></tr>
</table></td></tr>
</table>

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

<table>
<tr><th>A-620A Reference</th><th>Space Applications Requirement (as changed by this Addendum)</th></tr>
<tr><td>19.7.1</td><td>
Crimp Height Testing (Dimensional Analysis) Crimp height testing verifies that the terminal crimp height is within the terminal manufacturer's specifications. Each crimp terminal and conductor combination will have unique crimp height criteria. If the Manufacturer and User agree to use this optional test, in the absence of specifically agreed upon test requirements between Manufacturer and User or an agreement by the User to accept the Manufacturer's documented test requirements, crimp height testing shall be performed to the parameters specified in Table 19–10 of this addendum.

Table 19–10 Crimp Height Testing
<table>
<tr><th>Parameter</th><th>Requirement</th></tr>
<tr><td>Max Flash Height</td><td>0.5x material stock thickness</td></tr>
<tr><td>True Crimp Height</td><td>Use terminal supplier's specification[1]</td></tr>
<tr><td>Width
(non-circular crimp, i.e., Lugs)</td><td>Use terminal supplier's specification[1]</td></tr>
</table>
Note 1: If the User or Manufacturer has objective evidence indicating that the terminal supplier's specification is not sufficient, other values may be agreed upon between Manufacturer and User.

It is critical that crimp height measurements are taken correctly. Crimp height measurement tools have a flat blade on one side and a pointed contact on the other. The purpose of the pointed contact is to avoid the flash that may form on some terminals during the crimping process. Excessive flash may be a sign that the crimp anvils are worn. See IPC/WHMA-A-620A Figure 19–1.
</td></tr>
<tr><td>19.7.2</td><td>
Mechanical Test – Methods – Pull Force (Tensile) Testing These criteria apply to crimp terminations (contacts and lugs), splices, and crimp rings.

Longitudinal force is applied to evaluate the mechanical integrity of the crimped connection. If the contact has a wire insulation support it shall be rendered mechanically ineffective by either manually opening the insulation crimp or by making an extra-long strip so that the uninsulated wire extends beyond the insulation crimp.

Pull force testing shall be performed and the results shall be recorded, including:

1. Unique identification of the crimp tool, e.g., serial number, asset number, etc.

2. Unique identification of the pull tester (or force gauge if used as a separate part of a tensile testing system).

3. Calibration date of the pull tester or force gauge.

4. Date of pull test.

5. Force at failure (break).

6. Unique identification of contact/lug.

7. Gauge of wire.

8. Crimper position/setting (when applicable).

Samples used for pull testing shall not be used for deliverable product.

When a testing interval is not defined in the contract, tensile testing shall be performed at the beginning and end of each shift or crimping operation for each contact/conductor combination. The total number of samples for each contact/conductor combination test shall be three. (Periodic testing is not required when tooling is not in use but shall be performed when placed back in service.)

The pull rate shall be ≤25 mm [1 in]/minute and shall be held constant throughout the pull.

Where specific values for pull force have not been agreed upon between the User and the Manufacturer, the minimum tensile values shall meet or exceed the values in IPC/WHMA-A-620A Table 19–12.

For crimped multiple wire applications of varying sizes, pull tests shall be performed on the smallest wire in the crimp.

Pull and break testing shall be used unless other pull force test methods are agreed upon between Manufacturer and User. Examples of destructive pull force test methods are:

• Pull and break – Increasing longitudinal force is applied to the connection until either the terminal and wire separate or the wire breaks.

• Pull and return – the terminal is pulled to a specified force. Once the specified force is achieved the force is removed.

• Pull and hold – the terminal is pulled to a specified force and held for a specified period of time then the force is decreased to zero.

• Pull, hold and break – the terminal is pulled to a specified force and held for a specified period of time then the terminal is pulled until either the terminal is separated from the wire or the wire breaks.

IPC/WHMA-A-620A Table 19–12 provides pull-force acceptance values for crimps on stranded copper wire. Where crimp force values are not established, the tensile strength of the crimp connection shall be no less than 60 percent of the tensile strength of the wire.
</td></tr>
</table>

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

<table>
<tr><th>A-620A Reference</th><th>Space Applications Requirement (as changed by this Addendum)</th></tr>
<tr><td>19.7.2.1</td><td>Mechanical Test – Methods – Pull Force Testing – Without Documented Process Control Not applicable. Use 19.7.2.</td></tr>
<tr><td>19.7.5</td><td>Mechanical Test – Contact Retention Verification Contact retention (seating/locking) shall be verified with a non-destructive process appropriate to the connector in use. Each contact in all connectors using retention clips or tines shall be push or pull tested 100 percent for seating. Each contact shall be limited to one push (or pull) test per contact insertion. Verification shall be accomplished prior to addition of any restraining devices.</td></tr>
<tr><td>19.7.5.1 [New]</td><td>Contact Retention Verification – Push Testing In applications in which the engaging (mating) ends of the pin or socket contacts are accessible, contact retention testing to the requirements of Table 19–13 of this addendum shall be performed by push testing. Push testing shall utilize a tool that minimizes the possibility of accidental contact bending and applies a controlled pressure to the contact before releasing the force within the specified value. A typical tool design is shown in Figure 19–1 of this addendum. Socket testing probes shall be under-sized compared to mating-pin diameters and shall not cause a mating cycle to take place.

In the event of a failure of the contact retention test, perform a visual inspection of the contact and connector. Clean the contact and connector if there is evidence of debris. Reseat the contact. If the test fails a second time, document and disposition as a defect.

Table 19–13 Push Test Contact Retention Test Force[1]
<table>
<tr><th>Contact Size</th><th>Newtons [Pounds]</th></tr>
<tr><td>22</td><td>18 to 27 [4 to 6]</td></tr>
<tr><td>20</td><td>22 to 31 [5 to 7]</td></tr>
<tr><td>16</td><td>36 to 45 [8 to 10]</td></tr>
<tr><td>12</td><td>45 to 53 [10 to 12]</td></tr>
</table>
Note 1: These values are established for connectors constructed with metal contact retaining tines/clips. Retention value criteria for connectors constructed using composite or other non-metal contact retaining tines/clips shall be agreed upon between the Manufacturer and the User prior to use.

Exceptions to retention verification are:
• Pre-wired molded connectors.
• Molded or potted connectors after the molding/potting has been applied (but must be performed prior to applying molding/potting)
• Solder cup connectors.
• Connector contacts are soldered into position.

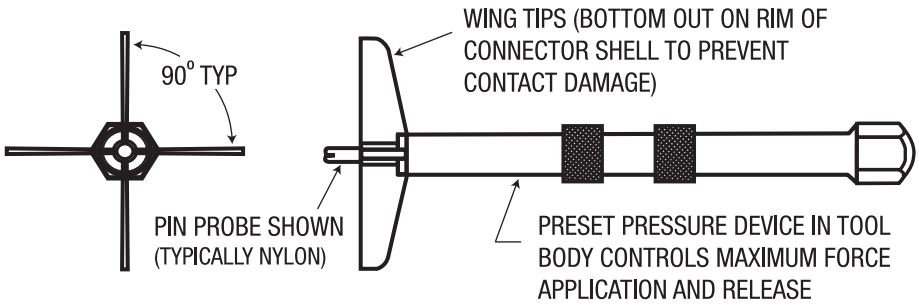
 

Figure 19–1 Typical Contact Retention Push Test Tool</td></tr>
</table>

Table 1 IPC/WHMA-A-620AS Space Applications Requirements (cont.)

<table>
<tr><th>A-620A Reference</th><th>Space Applications Requirement (as changed by this Addendum)</th></tr>
<tr><td>19.7.5.2 [New]</td><td>
Contact Retention Verification – Pull Testing Pull force contact retention testing to the requirements of Table 19–14 of this addendum shall be performed only on devices in which the contact engaging (mating) ends are not accessible. Pull force testing shall be performed by pulling on the wire terminated in the contact as illustrated in Figure 19–2 of this addendum. When the wire breakout to the terminal junction is less than 13 cm [5.118 in] in length, ties and clamps may be removed but only to the point where the wires leave the main bundle. Pull the wire perpendicular to the wire exit face of the connector device. Wires shall not be pulled to a force in excess of 80 percent of the minimum pull force (tensile test) value specified in IPC/WHMA-A-620A Table 19–12 to preclude damage to the wire/contact crimp joint.

Table 19–14 Pull Test Contact Retention Test Force[1]
<table>
<tr><th>Contact Size</th><th>Newtons [Pounds] [2]</th></tr>
<tr><td>22</td><td>13 to 22 [3 to 5]</td></tr>
<tr><td>20</td><td>13 to 22 [3 to 5]</td></tr>
<tr><td>16</td><td>18 to 31 [4 to 7]</td></tr>
<tr><td>12</td><td>18 to 31 [4 to 7]</td></tr>
</table>
Note 1: These values are established for connectors constructed with metal contact retaining tines/clips. Retention value criteria for connectors constructed using composite or other non-metal contact retaining tines/clips shall be agreed upon between the Manufacturer and the User prior to use.
Note 2: If wire smaller than AWG 24 is used, an alternate verification method shall be agreed upon between Manufacturer and the User prior to use.

In the event of a failure of the contact retention test, perform a visual inspection of the contact and connector. Clean the contact and connector if there is evidence of debris. Reseat the contact. If the test fails a second time, document and disposition as a defect.

Exceptions to retention verification are:

Pre-wired molded connectors.
Molded or potted connectors after the molding/potting has been applied (but must be performed prior to applying molding/potting).
Solder cup connectors.
Connector contacts are soldered into position.

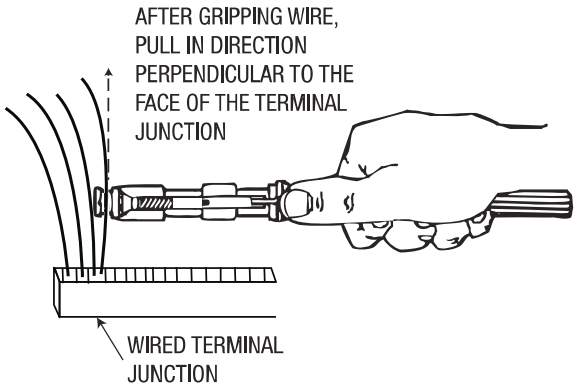


Figure 19–2 Typical Contact Retention Pull Test Tool
</td></tr>
<tr><td>19.7.6</td><td>
RF Connector Shield Pull Test Axial force is applied to evaluate the mechanical integrity of the shield connection. This test is not required unless specifically agreed upon between the Manufacturer and User.

Pull and break testing shall be used unless other pull force test methods are agreed upon between Manufacturer and User.

If RF Connector Shield Pull Force Testing is specified, the pull rate and minimum pull force value shall be agreed upon between the Manufacturer and User.
</td></tr>
<tr><td>19.7.8</td><td>
Other Mechanical Tests – User Defined The User or performance requirements may necessitate additional mechanical testing. If such additional testing is specified, then these tests shall be performed. Test parameters and acceptance criteria shall be agreed upon between the Manufacturer and User.
</td></tr>
</table>

Standard Improvement Form

IPC/WHMA-A-620AS

The purpose of this form is to provide the Technical Committee of IPC with input from the industry regarding usage of the subject standard.

Individuals or companies are invited to submit comments to IPC. All comments will be collected and dispersed to the appropriate committee(s).

If you can provide input, please complete this form and return to:

IPC
3000 Lakeside Drive, Suite 309S
Bannockburn, IL 60015-1249
Fax: 847 615.7105
E-mail: answers@ipc.org
www.ipc.org/standards-comment

1. I recommend changes to the following:

___ Requirement, paragraph number _____

___ Test Method number _____, paragraph number _____

The referenced paragraph number has proven to be:

___ Unclear ___ Too Rigid ___ In Error

___ Other _____

2. Recommendations for correction:

3. Other suggestions for document improvement:

Submitted by:

Name Telephone

Company E-mail

Address

City/State/Zip Date

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