

IPC/WHMA-A-620D-S

2020 - August

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

Supersedes IPC/WHMA-A-620C-S
March 2018

An international standard developed by IPC



BUILD ELECTRONICS BETTER

Copyright IPC
Provided by IHS Markit under license with IPC, Copyright IPC International,
No reproduction or networking permitted without license from IHS

Licensee=Hong Kong Polytechnic University/9976803100, User=FERIK SON, Anna Pernil
Not for Resale, 11/23/2020 10:54:47 MST

Documents
Document Sharing Hub

The Principles of Standardization

In May 1995 the IPC's Technical Activities Executive Committee (TAEC) adopted Principles of Standardization as a guiding principle of IPC's standardization efforts.

Standards Should:

- Show relationship to Design for Manufacturability (DFM) and Design for the Environment (DFE)
- Minimize time to market
- Contain simple (simplified) language
- Just include spec information
- Focus on end product performance
- Include a feedback system on use and problems for future improvement

Standards Should Not:

- Inhibit innovation
- Increase time-to-market
- Keep people out
- Increase cycle time
- Tell you how to make something
- Contain anything that cannot be defended with data

Notice

IPC Standards and Publications are designed to serve the public interest through eliminating misunderstandings between manufacturers and purchasers, facilitating interchangeability and improvement of products, and assisting the purchaser in selecting and obtaining with minimum delay the proper product for his particular need. Existence of such Standards and Publications shall not in any respect preclude any member or nonmember of IPC from manufacturing or selling products not conforming to such Standards and Publication, nor shall the existence of such Standards and Publications preclude their voluntary use by those other than IPC members, whether the standard is to be used either domestically or internationally.

Recommended Standards and Publications are adopted by IPC without regard to whether their adoption may involve patents on articles, materials, or processes. By such action, IPC does not assume any liability to any patent owner, nor do they assume any obligation whatever to parties adopting the Recommended Standard or Publication. Users are also wholly responsible for protecting themselves against all claims of liabilities for patent infringement.

IPC Position Statement on Specification Revision Change

It is the position of IPC's Technical Activities Executive Committee that the use and implementation of IPC publications is voluntary and is part of a relationship entered into by customer and supplier. When an IPC publication is updated and a new revision is published, it is the opinion of the TAEC that the use of the new revision as part of an existing relationship is not automatic unless required by the contract. The TAEC recommends the use of the latest revision. Adopted October 6, 1998

Why is there a charge for this document?

Your purchase of this document contributes to the ongoing development of new and updated industry standards and publications. Standards allow manufacturers, customers, and suppliers to understand one another better. Standards allow manufacturers greater efficiencies when they can set up their processes to meet industry standards, allowing them to offer their customers lower costs.

IPC spends hundreds of thousands of dollars annually to support IPC's volunteers in the standards and publications development process. There are many rounds of drafts sent out for review and the committees spend hundreds of hours in review and development. IPC's staff attends and participates in committee activities, typesets and circulates document drafts, and follows all necessary procedures to qualify for ANSI approval.

IPC's membership dues have been kept low to allow as many companies as possible to participate. Therefore, the standards and publications revenue is necessary to complement dues revenue. The price schedule offers a 50% discount to IPC members. If your company buys IPC standards and publications, why not take advantage of this and the many other benefits of IPC membership as well? For more information on membership in IPC, please visit www.ipc.org or call 847/597-2809.

Thank you for your continued support.

©Copyright 2020. IPC International, Bannockburn, Illinois, USA. All rights reserved under both international and Pan-American copyright conventions. Any copying, scanning or other reproduction of these materials without the prior written consent of the copyright holder is strictly prohibited and constitutes infringement under the Copyright Law of the United States.

Copyright IPC
Provided by IHS Markit under license with IPC, Copyright IPC International,
No reproduction or networking permitted without license from IHS

Licensee=Hong Kong Polytechnic University/9976803100, User=FERIK SON, Anna Pernil
Not for Resale, 11/23/2020 10:54:47 MST



IPC/WHMA-A-620D-S

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

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

Supersedes:

IPC/WHMA-A-620C-S -
March 2018
IPC/WHMA-A-620B-S -
June 2013
IPC/WHMA-A-620AS
with Amendment 1 -
June 2012

Users of this publication are encouraged to participate in the development of future revisions.

Contact:

IPC
3000 Lakeside Drive, Suite 105N
Bannockburn, Illinois
60015-1249
Tel 847 615.7100
Fax 847 615.7105

<https://www.ipc.org/standards/IPC-A-620D-S-2020>

This Page Intentionally Left Blank

Acknowledgment

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

Product Assurance Committee	IPC/WHMA-A-620 Space and Military Electronic Assemblies Addendum Task Group	Technical Liaison of the IPC Board of Directors
Chair Robert Cooke NASA Johnson Space Center	Chair Garry McGuire NASA Marshall Space Flight Center	Bob Neves Microtek Laboratories
Vice Chair Debbie Wade Advanced Rework Technology - A.R.T.	Vice Chair George Millman Raytheon Missile Systems Christina Trussell Blue Origin, LLC	
IPC/WHMA-A-620 Space and Military Electronic Assemblies Addendum Task Group		
Kathy Johnston	Vesna Delic, Carlisle Interconnect Technologies	Howard Feldmesser, Johns Hopkins University
Evan Levy	Sean Keating, Clonfert Solutions Ltd	Gerald Adams, KBRwyle
Arye Grushka, A. A. Training Consulting and Trade A.G. Ltd.	Caroline Ehlinger, Collins Aerospace	Sue Powers-Hartman, Killdeer Mountain Manufacturing, Inc.
Constantino Gonzalez, ACME Training & Consulting	Bonnie Pape, Collins Aerospace	Shelley Holt, L3Harris Communications
Debbie Wade, Advanced Rework Technology - A.R.T.	David Rafson, Collins Aerospace	Theodore Laser, L3Harris Communications
Michael Wierleski, Aerojet Rocketdyne	Symon Franklin, Custom Interconnect Ltd	Rebekah Kovarik, Lockheed Martin
Brandy Tharp, AeroTEC Inc.	Michael Timney, Daniels Manufacturing Corporation	Rachel Rienstra, Lockheed Martin Corporation
Fernando Perez Gracia, Airbus Defence & Space	Monica Tucker, Dynetics, Inc.	Kyle Johnson, Lockheed Martin Missiles & Fire Control
Stefan Hanigk, Ariane Group GmbH	Yaakov Zissman, Elta Systems Ltd.	Vijay Kumar, Lockheed Martin Missiles & Fire Control
Bob Potysman, ATRON Group LLC	Leo Lambert, EPTAC Corporation	Owen Reid, Lockheed Martin Missiles & Fire Control
Greg Hurst, BAE Systems	Helena Pasquito, EPTAC Corporation	Pamela Petcosky, Lockheed Martin Mission Systems & Training
Agnieszka Ozarowski, BAE Systems	B.J. Franco, Honeywell Aerospace	David Mitchell, Lockheed Martin Rotary & Mission Systems
Darrell Sensing, BAE Systems	John Mastorides, Honeywell Aerospace	Paul Kirpes, Los Alamos National Laboratory
Thomas Carle, Ball Aerospace & Technologies Corp.	Christina Rutherford, Honeywell Aerospace	Matt Garrett, Microsemi
Jonathon Vermillion, Ball Aerospace & Technologies Corp.	Hector Valladares, Honeywell Aerospace	William Pfingston, Miraco, Inc.
Gerald Bogert, Bechtel Plant Machinery, Inc.	Keith Walker, Honeywell Aerospace	Daniel Foster, Missile Defense Agency (MDA)
Dorothy Cornell, Blackfox Training Institute	Richard Rumas, Honeywell Canada	Bill Kasprzak, Moog Inc.
Samuel Sorto, Blue Origin, LLC	Milea Kammer, Honeywell International	Chris Fitzgerald, NASA Goddard Space Flight Center
Christina Trussell, Blue Origin, LLC	Jeremy Lakoskey, Honeywell International	Rigo Garcia, NASA Goddard Space Flight Center
Ryan Trussell, Blue Origin, LLC	Ife Hsu, Intel Corporation	Bhanu Sood, NASA Goddard Space Flight Center
Eric Harenburg, Boeing Company	Toshiyasu Takei, Japan Unix Co., Ltd.	
Dawn Cabales, Carlisle Interconnect Technologies	Minh Do, Jet Propulsion Laboratory	
Tawsha Cabales, Carlisle Interconnect Technologies	Reza Ghaffarian, Jet Propulsion Laboratory	
	Alan Young, Jet Propulsion Laboratory	
	Rick Bruguera, Johns Hopkins University	

Robert Cooke, NASA Johnson Space Center	Mahendra Gandhi, Northrop Grumman Space Systems	Liu Suzhong, Shenzhen Hengzhiyuan Technology Corporation Ltd
James Blanche, NASA Marshall Space Flight Center	Randy McNutt, Northrop Grumman Aerospace Systems	Neil Johnson, Solve Direct Electronics
Charles Gamble, NASA Marshall Space Flight Center	Callie Olague, Northrop Grumman Systems Corporation	Benjamin Pieprgrass, Southwest Research Institute
Adam Gowan, NASA Marshall Space Flight Center	Patrick Phillips, Northrop Grumman Innovation Systems	Robert Fornefeld, STI Electronics, Inc.
Ron Hodge, NASA Marshall Space Flight Center	Angela Pennington, NuWaves Engineering	Frank Honyotski, STI Electronics, Inc.
Garry McGuire, NASA Marshall Space Flight Center	Russell Kido, Practical Components Inc.	Patricia Scott, STI Electronics, Inc.
Zackary Fava, NAVAIR	Lance Brack, Raytheon Missile Systems	Tracy Clancy Vecchioli, Technical Training Center
Michael Hughes, Naval Air Warfare Center Weapons Division	George Millman, Raytheon Missile Systems	James Parke, The Aerospace Corporation
William May, Naval Surface Warfare Ctr	Paula Jackson, Raytheon UK	Gaston Hidalgo, Toyota Motor North America
Joseph Sherfick, Naval Surface Warfare Ctr	Gary Latta, SAIC	Paul Zutter, U.S. Army Aviation & Missile Command
Eriberto Silva, Northrop Grumman	Johnson (Songtao) Zhao, ShenZhen Easyway Science & Technology Co. Ltd.	Zhiman Chen, Zhuzhou CRRC Times Electric Co., LTD.

Space and Military Applications Hardware Addendum to IPC/WHMA-A-620D, Requirements and Acceptance for Cable and Wire Harness Assemblies

Table of Contents

The following topics are addressed in this Addendum.

- 0.1 Scope
 - 0.1.1 Purpose
 - 0.1.2 Precedence
 - 0.1.3 Existing or Previously Approved Designs
 - 0.1.4 Use of this Addendum
 - 0.1.5 Lead (Pb)-Free Tin
 - 0.1.6 Red Plague (Cuprous Oxide Corrosion)
 - 0.1.7 White Plague (Fluorine Attack)

The following reference numbers are to IPC/WHMA-A-620D Clauses that are modified or added in this Addendum.

1.1	Scope
1.2	Purpose
1.3	Classification
1.5.1.2.1	Disposition
1.6	Process Control
1.10	Personnel Proficiency
1.12.2.1	Lighting
1.12.2.2	Magnification Aids
1.16	Materials and Processes
3.1	Stripping
3.2	Strand Damage and End Cuts
4.1.1.1	Material, Components and Equipment – Materials – Solder
4.1.1.2	Material, Components and Equipment – Materials – Flux
4.1.2	Material, Components and Equipment – Gold Removal
4.2.1	Cleanliness – Presoldering
4.2.2	Cleanliness – Postsoldering
4.3.2.2	Solder Connection – Soldering Anomalies – Partially Visible or Hidden Solder Connections
4.4	Wire/Lead Preparation, Tinning
4.8	Terminals
4.8.1.2	Terminals – Turrets and Straight Pins – Solder
4.8.2.2	Terminals – Bifurcated – Lead/Wire Placement – Bottom and Top Route
4.8.2.4	Terminals – Bifurcated – Solder

4.8.4.2	Terminals – Pierced/Perforated/Punched – Solder
4.8.5.2	Terminals – Hook – Solder
4.8.6.2	Terminals – Cup – Solder
5	Crimp Terminations (Contacts and Lugs)
5.1	Stamped and Formed – Open Barrel
5.1.1	Stamped and Formed – Open Barrel – Insulation Support
5.1.1.1	Stamped and Formed – Open Barrel – Insulation Support – Inspection Window
5.1.1.2	Stamped and Formed – Open Barrel – Insulation Support Crimp
5.1.2	Stamped and Formed – Open Barrel – Insulation Clearance if No Support Crimp
5.1.3	Stamped and Formed – Open Barrel – Conductor Crimp
5.1.4	Stamped and Formed – Open Barrel – Crimp Bellmouth
5.1.5	Stamped and Formed – Open Barrel – Conductor Brush
5.1.6	Stamped and Formed – Open Barrel – Carrier Cutoff Tab
5.1.7	Stamped and Formed – Open Barrel – Individual Wire Seal
5.2.1	Stamped and Formed – Closed Barrel – Insulation Clearance
5.2.2	Stamped and Formed – Closed Barrel – Insulation Support Crimp
5.2.3	Stamped and Formed – Closed Barrel – Conductor Crimp and Bellmouth
5.3	Machined Contacts
5.3.1	Machined Contacts – Insulation Clearance
6	Insulation Displacement Connection (IDC)
7 (All)	Ultrasonic Welding
8.1	Soldered Splices
8.1.1	Soldered Splices – Mesh
8.1.2	Soldered Splices – Wrap
8.1.3	Soldered Splices – Hook
8.1.4.1	Soldered Splices – Lap – Two or More Conductors
8.1.4.2	Soldered Splices – Lap – Insulation Opening (Window)
8.2.1	Crimped Splices – Barrel
8.2.2	Crimped Splices – Double Sided
8.3	Ultrasonic Weld Splices
9.1.1	Hardware Mounting – Jackpost – Height

9.2.1	Strain Relief – Clamp Fit
9.4.2	Connector Damage – Limits – Hard Face – Mating Surface
9.4.3	Connector Damage – Limits – Soft Face – Mating Surface or Rear Seal Area
9.4.4	Connector Damage – Contacts
9.4.4.1 [New]	Connector Damage – Contacts – Exposed Sockets, Protected Pins, e.g., MIL-DTL-83513 Micro D
9.4.5 [New]	Connector Damage – Seals/Gaskets
9.5	Installation of Contacts and Sealing Plugs into Connectors
10	Over-Molding/Potting
12	Marking/Labeling
12.4	Location and Orientation
12.6.2	Marker Sleeve – Tubular
12.8	Tie Wrap Markers
13	Coaxial and Biaxial Cable Assemblies
13.1	Stripping
13.7.2	Coaxial Connector – Terminal Cover – Press Fit
14.1	Tie Wrap/Lacing Application
14.2.1	Breakouts – Individual Wires
14.3.2	Routing – Bend Radius
15.1	Braided
15.1.1	Braided – Direct Applied
15.1.2	Braided – Prewoven
15.2	Shield Termination
15.2.1.1	Shield Termination – Shield Jumper Wire – Attached Lead
15.2.1.1.1	Shield Termination – Shield Jumper Wire – Attached Lead – Solder
15.2.1.2	Shield Termination – Shield Jumper Wire – Shield Braid
15.2.1.3	Shield termination – Shield Jumper Wire – Daisy Chain
15.3.1	Shield Termination – Connector – Shrink

15.3.2	Shield Termination – Connector – Crimp
15.3.3	Shield Termination – Connector – Shield Jumper Wire Attachment
15.4.1	Shield Termination – Splicing Prewoven – Soldered
15.7	Shrink Tubing – Conductive Lined
16.1.2	Braid – Prewoven
16.3	Spiral Plastic Wrap (Spiral Wrap Sleeving)
17	Finished Assembly Installation
17.1	General
17.2	Hardware Installation
17.2.2	Hardware Installation – Threaded Fasteners – Wires
17.3.3	Wire/Harness Installation – Service Loops
18 (All)	Solderless Wrap
19.4	Electrical Test
19.4.1	Electrical Test – Selection
19.5.2	Electrical Test Methods – Shorts
19.5.3	Electrical Test Methods – Dielectric Withstanding Voltage (DWV)
19.5.4	Electrical Test Methods – Insulation Resistance (IR)
19.6.1	Mechanical Test – Selection
19.7.1	Mechanical Test Methods – Crimp Height (Dimensional Analysis)
19.7.2	Mechanical Test Methods – Pull Force (Tensile)
19.7.2.1	Mechanical Test Methods – Pull Force – Without Documented Process Control
19.7.5	Mechanical Test Methods – Contact Retention Verification
19.7.5.1 [New]	Mechanical Test Methods – Contact Retention Verification – Push Testing
19.7.5.2 [New]	Mechanical Test Methods – Contact Retention Verification – Pull Testing
19.7.6	Mechanical Test Methods – RF Connector Shield Pull Force (Tensile)
Appendix A	Terms and Definitions

0.1 Scope This Addendum provides modified and additional requirements over those published in IPC/WHMA-A-620D to ensure the performance of cable and wire harness assemblies that must survive the vibration and thermal excursions encountered getting to and operating in the military and space environments.

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

0.1.1 Purpose When required by the contract or engineering documentation, this Addendum supplements or replaces specifically identified requirements of IPC/WHMA-A-620D.

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 reference documents cited herein, this Addendum takes precedence. (See IPC/WHMA-A-620D 1.7.)

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

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

Where criteria are not supplemented by this Addendum, the Class 3 requirements of IPC/WHMA-A-620D **shall** apply. If an IPC/WHMA-A-620D 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., Acceptable conditions are not listed. If a feature is not listed as a defect, it **shall** be considered acceptable. Acceptable conditions (except where changed by this Addendum) and Figures are provided in IPC/WHMA-A-620D.

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-620D that are not listed in this Addendum are to be used as-published.

When a paragraph refers to an entire chapter, for example the first paragraph in 15.1 of this Addendum, it is the user of the standard's responsibility to determine which clauses from that chapter are used from IPC/WHMA-A-620D and which clauses are covered by this Addendum.

0.1.5 Lead (Pb)-Free Tin For this document, the definition of lead (Pb)-free tin is tin containing less than 3% Pb by weight as an alloying constituent. See Table 1 of this Addendum 4.1.1.1.

The use of components, assemblies, packaging technology, mechanical hardware, and materials identified as having external surfaces (platings, metallization, etc.) of Pb-free tin or assembled with Pb-free tin solder alloys **shall** be prohibited unless documented and controlled through a User-approved Pb-Free Control Plan (LFCP). Solder alloy Sn96.3Ag3.7 is exempt from this requirement for a LFCP.

0.1.6 Red Plague (Cuprous Oxide Corrosion) Red Plague (cuprous oxide corrosion) can develop in silver-coated soft or annealed copper wire when a galvanic cell forms between the copper base metal and the silver coating in the presence of moisture (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.

The use of silver-coated copper wire and cable **shall** require the implementation of a User-approved Red Plague Control Plan (RPCP). See IPC-WP-113 for technical guidance and a generic RPCP template.

0.1.7 White Plague (Fluorine Attack) During the manufacturing of fluoropolymer-insulated electrical wires and cables made with tin-coated, silver-coated, or nickel-coated copper or copper alloy conductors, the extrusion of fluorocarbon resin to form the insulation jacket occurs at a temperature high enough that oxidative degradation of the polymer may occur, possibly resulting in the evolution or outgassing of a number of materials, including carbonyl fluoride (COF_2), an extremely reactive compound. This outgassing from the insulation is both internal, e.g., to the wire strand/cable bundle, and external, e.g., to the surrounding environment. In the presence of trace atmospheric moisture, e.g., humidity, the carbonyl-difluoride hydrolyzes to generate carbon dioxide (CO_2) and hydrogen fluoride (HF). The hydrogen fluoride (HF) will then hydrate to

form concentrated hydrofluoric acid (HF aq), an extremely corrosive agent that attacks metal and metal oxides, including, but not limited to, conductors, contacts, connector shells, etc.

The use of fluoropolymer-insulated copper wire and cable may require the implementation of a User-approved White Plague Control Plan (WPCP). See IPC-WP-114 for technical guidance and a generic WPCP template.

Table 1 IPC/WHMA-A-620D Space and Military Applications Requirements

A-620D Reference	Space and Military Applications Requirements (as changed by this Addendum)
1.1	Scope This standard prescribes practices and requirements for the manufacture of cable, wire and harness assemblies. This standard does not provide criteria for cross-section or X-ray evaluation. Exception: Non-Destructive Evaluation (NDE) shall be required when an item is subject to the requirements of 1.6 of this Addendum. If a conflict occurs between the English and translated versions of this document, the English version will take precedence. IPC/WHMA-A-620 can be used as a stand-alone document for purchasing products, however it does not specify frequency of in-process inspection or frequency of end product inspection. No limit is placed on the number of process indicators or the number of allowable repair/rework of defects. Such information should be developed with a statistical process control plan (see IPC-9191). The illustrations in this document portray specific points noted in the title of each section. A brief description follows each illustration. The development committee recognizes that different parts of the industry have different definitions for some terms used herein. For the purposes of this document, the terms cable and wire harness are used interchangeably.
1.2	Purpose This standard describes materials, methods, tests and acceptability criteria for producing crimped, mechanically secured, or soldered interconnections and the related assembly activities associated with cable and harness assemblies. The intent of this document is to rely on process control methodology to ensure consistent quality levels during the manufacture of products. Any method that produces an assembly conforming to the acceptability requirements described in this standard may be used. Standards may be updated at any time using revisions or amendments. The use of an amendment or newer revision is not automatically required. The revision in effect shall be as specified by the User. Note: This clause is unchanged from IPC/WHMA-A-620D. It is included here to clarify that the Purpose of the Space Addendum does not replace nor alter Purpose of IPC/WHMA-A-620D.
1.3	Classification If an IPC/WHMA-A-620D clause is not addressed by this Addendum, the Class 3 requirement in IPC/WHMA-A-620D shall apply.
1.5.1.2.1	Disposition 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. Note: Disposition requirements should be identified in the contract.
1.6	Process Control A documented process control system shall be developed and implemented. Process control tools such as IPC-9191, EIA-557-1 or other user-approved system may be used as guidelines for implementing process control. The documented process control system shall define process control and corrective action limits. This may or may not be a “statistical process control” system (see 1.6.1 of IPC/WHMA-A-620D). The use of “statistical process control” (SPC) is optional and should be based on factors such as design stability, lot size, production quantities, and the needs of the company. 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. Visual inspection may be supplemented by the measurement of characteristics appropriate to the product being assembled, e.g., go/no-go gauges, pull force measurements, torque measurement. Partially visible or hidden features shall meet the following conditions: - The visible portion, if any, of the feature is acceptable. - Process controls are maintained in a manner assuring repeatability of assembly techniques. - For Solder Joint Connections – The design does not restrict solder flow to any connection element. See 4.3.2.2. For partially visible or hidden features that do not meet the above conditions, non-destructive evaluation (NDE) shall be used. The NDE method shall be approved by the User prior to use. Process control methodologies shall be used in the planning, implementation and evaluation of the manufacturing processes used to produce cables and wire harness assemblies. The philosophy, implementation strategies, tools and techniques may be applied in different sequences depending on the specific company, operation, or variable under consideration to relate process control and capability to end product requirements. When a decision or requirement is to use a documented process control system, failure to implement process corrective action and/or the use of continually ineffective corrective actions shall be grounds for disapproval of the process and associated documentation.

Table 1 IPC/WHMA-A-620D Space and Military Applications Requirements (cont.)

A-620D Reference	Space and Military Applications Requirements (as changed by this Addendum)																													
1.10	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 IPC/WHMA-A-620D and this Addendum, and/or results of periodic reviews of proficiency. Training shall be in accordance with the IPC/WHMA-A-620-Space Addendum Training and Certification Program or a supplier developed program that shall be made available for review and approval upon request by the User. All training shall be traceable to a Master IPC Trainer (MIT).																													
1.12.2.1	Lighting Illumination at the surface of workstations should be at least 1000 Lux (approximately 93 foot candles). Supplemental lighting may be necessary to assist in visual inspection. The light source shall provide shadowless illumination of the area being viewed unless directional or oblique lighting is specifically required. Note: In selecting a light source, the color temperature of the light is an important consideration. Light ranges from 3000 - 5000 K enable users to distinguish various metal and plating features and contaminants with increased clarity.																													
1.12.2.2	Magnification Aids Magnification power for assembly inspection shall be at least the minimum inspection power specified in IPC/WHMA-A-620D-S Tables 1-1 and 1-2. Other magnification powers within the inspection range may be used. The magnification power requirement is based on the gauge of the wire being inspected. For assemblies with mixed wire sizes, the greater magnification may be used for the entire assembly. If the presence of a defect cannot be determined at the inspection power, the item is acceptable. The referee magnification power is intended for use only after a defect has been determined but is not completely identifiable at the inspection power. Magnification aids shall be capable of rendering true colors, proportional dimensions, and adequate resolution at the chosen magnification to perform the specified inspection. The tolerance for magnification aids is ± 15% of the selected magnification power. Magnification aids should be maintained and calibrated as appropriate (see IPC-OI-645). IPC/WHMA-A-620D-S Table 1-1 Magnification Aid Applications – Wire and Wire Connections¹ <table><tr><th rowspan="2">Wire Size AWG Diameter mm [inch]</th><th colspan="2">Magnification Power</th></tr><tr><th>Inspection Range</th><th>Maximum Referee</th></tr><tr><td>Larger than 14 AWG >1.63 mm [0.064 in]</td><td>N/A</td><td>1.75X</td></tr><tr><td>14 to 22 AWG 1.63 to 0.64 mm [0.064 to 0.025 in]</td><td>1.5X – 3X</td><td>4X</td></tr><tr><td><22 to 28 AWG <0.64 to 0.32 mm [<0.025 to 0.013 in]</td><td>3X –7.5X</td><td>10X</td></tr><tr><td>Smaller than 28 AWG <0.32 mm [<0.013 in]</td><td>10X</td><td>20X</td></tr></table> Note 1: Referee magnification power is intended to be used only to verify a product rejected at the inspection magnification. For assemblies with mixed wire sizes, the greater magnification may be (but is not required to be) used for the entire assembly. IPC/WHMA-A-620D-S Table 1-2 Magnification Aid Applications – Other <table><tr><td>Solder joint cleanliness (with or without cleaning processes)</td><td>4X - 10X</td></tr><tr><td>Solder joint cleanliness (no-clean processes)</td><td>Magnification not required, Note 1</td></tr><tr><td>Encapsulation, Staking</td><td>Magnification not required, Notes 1, 2</td></tr><tr><td>Component</td><td>Magnification not required, Notes 1, 2</td></tr><tr><td>Marking</td><td>Magnification not required, Note 2</td></tr><tr><td>Assembly</td><td>No magnification required, Note 1</td></tr></table> Note 1: Visual inspection may require the use of magnification, e.g., for very small features, to determine contamination affects form, fit, or function. Note 2: If magnification is used it is limited to 4X maximum.	Wire Size AWG Diameter mm [inch]	Magnification Power		Inspection Range	Maximum Referee	Larger than 14 AWG >1.63 mm [0.064 in]	N/A	1.75X	14 to 22 AWG 1.63 to 0.64 mm [0.064 to 0.025 in]	1.5X – 3X	4X	<22 to 28 AWG <0.64 to 0.32 mm [<0.025 to 0.013 in]	3X –7.5X	10X	Smaller than 28 AWG <0.32 mm [<0.013 in]	10X	20X	Solder joint cleanliness (with or without cleaning processes)	4X - 10X	Solder joint cleanliness (no-clean processes)	Magnification not required, Note 1	Encapsulation, Staking	Magnification not required, Notes 1, 2	Component	Magnification not required, Notes 1, 2	Marking	Magnification not required, Note 2	Assembly	No magnification required, Note 1
Wire Size AWG Diameter mm [inch]	Magnification Power																													
	Inspection Range	Maximum Referee																												
Larger than 14 AWG >1.63 mm [0.064 in]	N/A	1.75X																												
14 to 22 AWG 1.63 to 0.64 mm [0.064 to 0.025 in]	1.5X – 3X	4X																												
<22 to 28 AWG <0.64 to 0.32 mm [<0.025 to 0.013 in]	3X –7.5X	10X																												
Smaller than 28 AWG <0.32 mm [<0.013 in]	10X	20X																												
Solder joint cleanliness (with or without cleaning processes)	4X - 10X																													
Solder joint cleanliness (no-clean processes)	Magnification not required, Note 1																													
Encapsulation, Staking	Magnification not required, Notes 1, 2																													
Component	Magnification not required, Notes 1, 2																													
Marking	Magnification not required, Note 2																													
Assembly	No magnification required, Note 1																													