



Workmanship Standards



1.0 PURPOSE

The purpose of this document is to achieve uniformity in the quality and appearance of each product produced by ADTRAN and ADTRAN suppliers and subcontractors. This is accomplished by providing general requirements of quality acceptance for those who design, manufacture, and inspect the products. It is the intent of ADTRAN that all work be done to meet the preferred criteria in this manual. Work that is judged minimally acceptable indicates that process improvements are required.

2.0 SCOPE (Document Hierarchy)

ADTRAN has adopted IPC-A-610 Class 2 as the primary workmanship standard for all electronic assemblies. The purpose of this ADTRAN specific workmanship standards manual is to clarify or modify the requirements that ADTRAN has deemed unique or more critical than that which is stated in IPC 610. Therefore, the requirements listed in the ADTRAN Q50 Workmanship Standard supersedes the like requirement described in IPC 610. For the purpose of judging adequacy of workmanship, the following documents, in the order listed, will be used:

1. ADTRAN Engineering documentation (drawings, bills of materials, specifications, and Engineering Change Orders).
2. ADTRAN Q50 Workmanship Standards
3. IPC - A - 610 [Acceptability of Electronic Assemblies](#)
4. IPC/WHMA-A-620 Requirements and Acceptance for Cable and Wire Harness Assemblies

3.0 RESPONSIBILITY

Recommended additions, corrections and deletions should be forwarded to the Quality Assurance Department. The Quality Assurance Department will conduct periodic review of this document.

This document is provided as an aid for quality workmanship verification and is to be used by trained personnel. Dimensions given are not absolute, but provided as guidelines.

4.0 REWORK, REPAIR, & MODIFICATION

4.1 Trace (Conductor) Repair

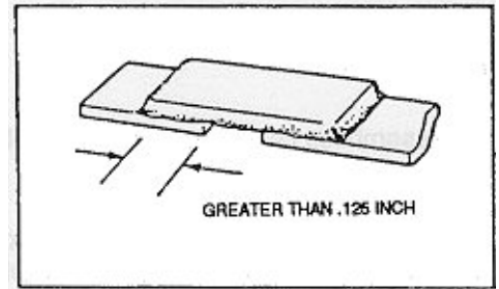
The choice of repair method for broken tracks generally depends on conditions such as size of fracture (gap), shape of trace (straight or curved), spacing between tracks, width of broken trace and whether PCB is double, single-sided or multi-layer. Care must be taken in ensuring that widths and spacings are not reduced below allowable limits. The number of trace repairs shall be limited to two per track on no more than five tracks per board (counting both sides).

4.1.1 Breaks, Foil Repair

This repair method is recommended if trace width is greater than 0.02 inch. Where the width of the trace is less than 0.02 inch, foil strips become difficult to handle, therefore, tinned copper wire may be used.

Acceptable

1. Replacement foil is from 80% of width to the same width as existing trace.
2. Overlap is a minimum of 0.12 inch on both ends of fracture.
3. Replacement foil is straight, parallel to, and centered on track.
4. Good solder fillet all around.



4.1.2 Breaks, Wire Repair: Surface Jumper Method

This method is recommended where the track width is less than 0.02 inch and only applies to populated printed circuit board assemblies.

The diameter of the wire used shall be approximately 85% of the track width. Table 4.1.2 is a cross reference of track widths and wire sizes (AWG) that can be used.

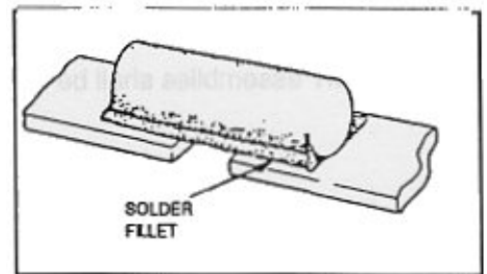
High temperature solder shall be used during the repair. This is to prevent possible damage to the repair during any additional assembly processes. A recommended high temperature solder is a 10%/ 90% tin/lead formulation where reflow temperature is approximately 500 degrees F.

Inch	Millimeter	AWG	Diameter (Millimeters)
0.005	0.13	38	0.10
0.010	0.25	32	0.20
0.015	0.40	28	0.32
0.020	0.51	26	0.40

Table 4.1.2

Acceptable

1. Solid tinned wire has a minimum diameter of 80% and a maximum diameter of 85% of the track width.
2. Overlap on both ends of gap (fracture) is a minimum of 0.12 inch.
3. Wire is straight and parallel to the track.
4. Solder has completely wet the joint with a continuous fillet between the wire and track over the entire solderable length.
5. Wire does not encroach onto component mounting pads or lands.
6. Wire does not violate minimum spacing requirements.
7. Repair is sufficiently covered with HUMISEAL or equivalent insulated coating, conforming to BELLCORE TR-NWT-000078, Section 13.2.

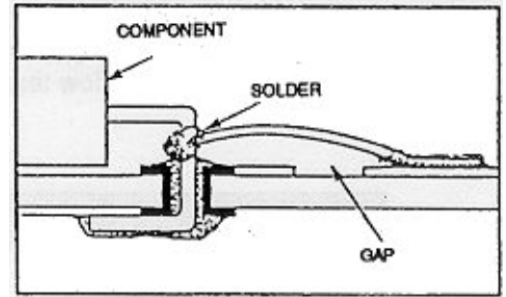


4.1.3 Breaks, Wire Repair: Surface-to-Lead Method

This method is not applicable to IC leads.

Acceptable

1. Jumper wire is mechanically wrapped around component lead (3/4 to 1 turn).
2. Other end of wire is at least 0.25 inch past the break and is located on the center line of the track.
3. Good solder wetting around wire wrap.
4. Good wetting and solder fillet over entire solderable length of wire.
5. Wire wrap is as far as possible from component body (minimum 2-Wire diameters).

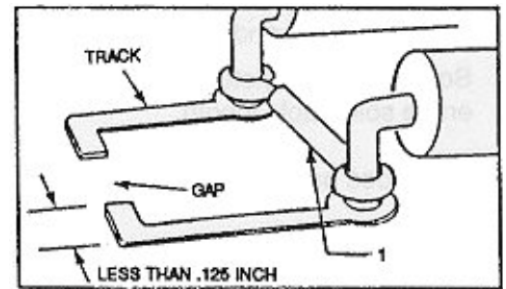


4.1.4 Breaks, Wire Repair: Lead-to-Lead Method

This method is recommended when a 0.12 inch overlap is not possible. This method is not applicable to IC leads.

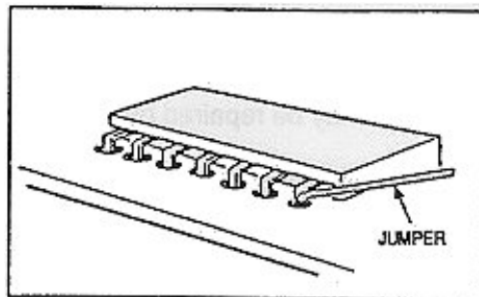
Acceptable

1. Tinned copper insulated wire is looped (wrapped around) and soldered to component lead (solder fillet not shown).
2. Repair is direct with no slack, flat to board and wire wrap around lead is from 270 degrees to 360 degrees (3/4 to 1 turn).
3. Remnants of damaged track have been removed and the remaining ends do not lift off the board surface.



4.1.5 Breaks, Wire Repair: SMT

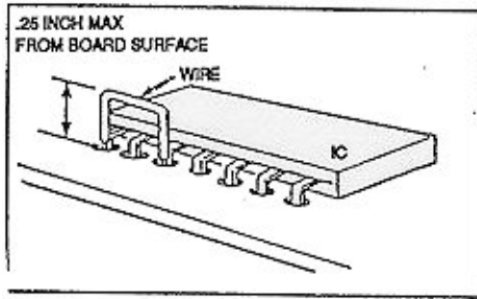
Wire repair on SMT assemblies shall be as specified and approved by ADTRAN Process Engineering.



Breaks, Wire Repair: Applicable to IC Leads

When a jumper wire is required to run from an IC leg, Kynar, Lumex or equivalent insulated wire shall be used, preferably 26 to 30 gauge, and wire shall be inserted into the same hole as the IC leg.

When short links are required between IC legs, the height of these links shall not exceed 0.25 inch.



4.2 Trace (Conductor) Cutting

When trace must be cut, a minimum of 0.03 inch shall be removed or one conductor width, whichever is greater.

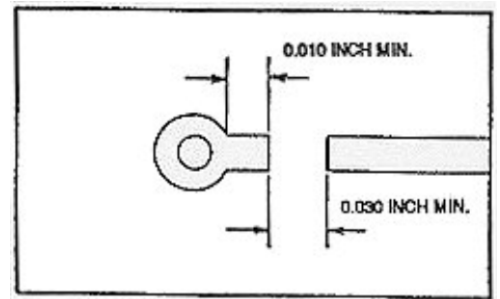
Tracks shall not be cut within 0.01 inch of terminal areas or circuit junctions.

No component shall be mounted over trace cuts.

A sealant such as Humiseal shall cover the cut area. Reference: IPC-R-700 #4.2.8.

Acceptable

1. Area where track is removed is free of any traces of conductor.
2. Cuts are straight and at right angles.
3. Gap is a minimum of 0.03 inch wide and is at least 0.01 inch from terminal pad.
4. The ends of the cut are secure to the board surface.



4.3 PAD (Land) Defects

Surface defects

Surface defects such as scratches, nicks, solder indentations, exposed copper on pads with no component, etc., may be repaired by a Reflow Solder method.

Through Connection Repair

Remounting pads on plated-through holes shall not be permitted.

4.4 Cleaning

Contaminants, process residue and other foreign materials introduced during repair/rework shall be removed when excessive amounts are deposited in isolated areas.

Acceptable (minimum)

ADTRAN Process Engineering-approved wire solder fluxes used for hand reworked/repared solder joints.

Unacceptable

Activated rosin core wire solder and fluxes shall not be used.



5.0 HARDWARE

5.1 Torque Requirements

Torque values specified in Table 5.1 represent the best balance between torque and tension unless otherwise stated on the Engineering drawing.

Thread Size	Aluminum Nominal (in-lb)	Low Carbon Steel Nominal (in-lb)	Stainless Steel Nominal (in-lb)	Nylon Nominal (in-lb)	Brass Nominal (in-lb)
2-56	1.5	1.7	2.0	0.1	1.3
4-40	3.1	3.6	4.3	0.3	2.8
6-32	5.8	6.6	8.1	0.5	5.1
8-32	10.7	12.1	14.8	0.9	9.3
10-24	15.4	17.6	21.4	1.3	13.5
10-32	17.6	20.1	24.4	1.5	15.5
1/4-20	36.9	42.0	51.1	3.1	32.4
1/4-28	42.2	48.1	58.5	3.6	37.0
5/16-18	76.0	86.5	105.3	6.4	66.7
5/16-24	84.1	95.8	116.5	7.1	73.8
3/8-16	134.9	153.6	186.8	11.4	118.3
3/8-24	152.9	174.0	211.6	12.9	134.0
7/16-14	215.9	245.8	298.9	18.3	189.3
7/16-20	241.1	274.5	333.8	20.4	211.4
1/2-13	329.4	375.0	456.1	27.9	288.8
1/2-20	371.2	422.6	513.9	31.4	325.5

TABLE 5.1 BOLT TIGHTENING TORQUE SPECIFICATIONS

5.1.1 Definition of Tight

Because of the many variables affecting tightening, tight is defined as meaning the fastener cannot be appreciably tightened further without damage to the threads or material.

5.1.2 Faceplate Fastening

All 4-40 self-tapping hardware used to fasten PCBs to faceplates shall be installed with a hex driver to a torque of up to 10 in-lb unless otherwise specified. 4-5 in-lb is recommended for plastic faceplates. 10 in-lb is recommended for metal faceplates. Phillips or slot drivers are prohibited to eliminate any potential burring during installation.

5.2 Damaged Fasteners.

Burred or marred fasteners are not acceptable. Fasteners must not be damaged to the extent that removal would be difficult. Visible hardware on completed assemblies shall be free from this type of defect.

Preferred:

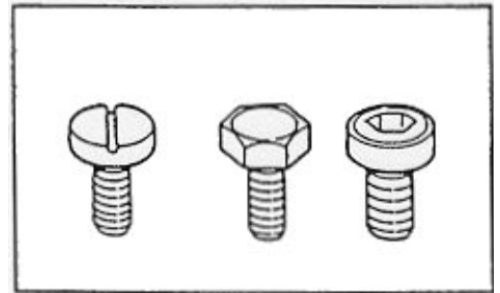
No burrs, rounded corners or edges, or damage.

Acceptable (minimum):

1. Slight fractures not extending halfway to recess and not affecting usability.
2. Slight hairlines.
3. Slight tool or pin marks.
4. Burrs less than 0.015 inch in length.

Unacceptable:

1. Burrs greater than 0.015 inch in length (B).
2. Rounded drive edges.
3. Large open fractures extending halfway or more to the recess making removal difficult.
4. Open, angular fractures on edges of head.
5. Slivers or loose flakes on top of head greater than 0.015 inch in length.



5.3 Roll Pins

Preferred:

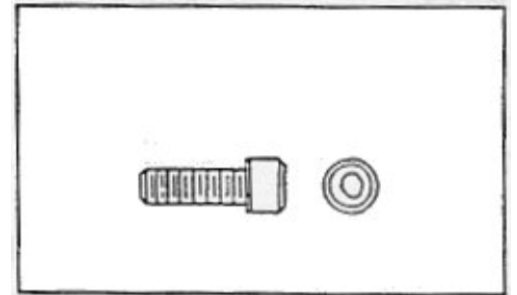
Roll pin flush on both sides.

Acceptable (minimum):

Roll pin protruding less than 0.015 inch on either side.

Unacceptable:

Roll pin protruding greater than 0.015 inch on either side.



5.4 Screw-Retaining Compound (Loctite)

Compound is applied to screw threads prior to insertion and not to the nut after hardware has been assembled.

Various grades, distinguished by different colors, are used to meet various torque requirements. Compound must be approved by ADTRAN Process Engineering.

6.0 COSMETIC REQUIREMENTS

6.1 Surface Classification

Three classes of cosmetic grading will be used to identify the level of cosmetic characteristics of a part. These classes distinguish between the requirements for surfaces normally viewed by a product's end user and those of lesser importance that are seldom viewed.

Class A: External surface which is in plain view of the customer during normal use, (panel fronts, faceplates, chassis fronts, etc.).

Class B: External surface which is not in plain view of the customer during normal use, but may be visible to the customer during installation or maintenance, (chassis sides, top, or bottom, faceplate edges, etc.).

Class C: Surfaces seldom, if ever, seen by the customer, (inside of chassis, inside battery boxes, back of faceplates, back of chassis etc.).

6.2 Inspection Criteria

6.2.1 Class A

Distance from Eye: 18 to 24 inches away using unaided eyes.

Viewing Time: 10 seconds maximum.

Type of Light: 85 minimum Foot Candles Cool White Florescent.

Viewing Angle: 45-90degrees. With part manipulation allowed.

6.2.2 Class B

Distance from Eye: 24 to 36 inches away using unaided eyes.

Viewing Time: 5 maximum seconds.

Type of Light: 85 minimum Foot Candles Cool White Florescent.

Viewing Angle: 45-90 degrees. No part manipulation allowed. Viewing must be done at a constant viewing angle.

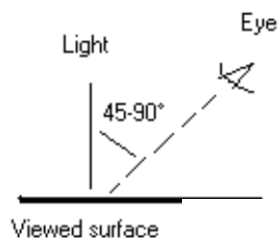
6.2.3 Class C

Distance from Eye: 48 to 60 inches away using unaided eyes.

Viewing Time: 5 maximum seconds.

Type of Light: 85 Foot Candles Cool White Florescent.

Viewing Angle: 90 degrees. No part manipulation allowed. Viewing must be done at a constant viewing angle.





6.3 Fabricated Metal

6.3.1 Class A

Preferred:

No nicks, dents, scratches or any other surface blemish.

Acceptable (Minimum):

Plating may have minimal discoloration.

Scratch - Qty 1 @ 0.015" Wide x 0.10" Long per 50 Square Inches (example: 5" x 10" area),

Scratch - Qty 2 @ 0.015" Wide x 0.10" Long or combination of up to 0.20" long per 100 Square Inches,

Scratch - Qty 3 @ 0.015" Wide x 0.10" Long or combination of up to 0.030" long per 300 Square Inches or greater

Unacceptable:

Smears, runs, non-uniform glossiness and coverage, fingerprints, corrosion, scratches through the plating, excessive grease/oils, grit, dust or other foreign matter that may affect the decorative, adhesion and protective surface finish.

6.3.2 Class B

Acceptable (Minimum):

Scratch - Qty 1 @ 0.015" Wide x 0.25" Long per 50 Square Inches.

Scratch - Qty 2 @ 0.015" Wide x 0.250" Long or combination of up to 0.50" per 100 Square Inches.

Scratch - Qty 3 @ 0.015" Wide x 0.25" Long or combination of up to 0.75" per 300 Square Inches or greater.

Runs or Smears 1x per 50 square inches and multiple increments thereof, i.e. 2x @100 sq. in, 3x @150 etc.

Minimal non-uniform glossiness, and discoloration.

Unacceptable:

Fingerprints, corrosion, scratches through the plating, excessive grease/oils, grit, dust or other foreign matter that may affect the decorative, adhesion and protective surface finish.

6.3.3 Class C

Acceptable (Minimum):

Scratch - Qty 3 @ 0.015" Wide x 0.50" Long or combination of up to 1.50" per 50 Square Inches.

Scratch - Qty 4 @ 0.015" Wide x 0.50" Long or combination of up to 2.00" per 100 Square Inches.

Scratch - Qty 5 @ 0.015" Wide x 0.50" Long or combination of up to 2.50" per 300 Square Inches or greater.

Minimal non-uniform glossiness, coverage, and discoloration.

Unacceptable: Scratches through plating, corrosion, excessive grease/oils, grit, dust or other foreign matter that may affect adhesion and protective surface finish.



6.4 Painted Fabricated Material/Parts

Note: ADTRAN Mechanical Engineering dept. approves paint color and gloss (see paint specifications). Texture will be measured using paint chips (min and max).

Note: All material/parts shall pass tape test using 3M Scotch Tape # C-4210 invisible tape.

6.4.1 Class A

Preferred:

No nicks, dents, scratches or any other surface blemish. Shall be wrinkle and bubble free.

Acceptable (Minimum):

No scratches allowed on areas less than 100 Square Inches.

Scratch - Qty 1 @ 0.015" Wide x 0.10" Long per area greater than 100 Square Inches.

Unacceptable:

Smears, runs, non-uniform glossiness, texture and coverage, finger-prints, corrosion, orange peel, excessive grease/oils, wrinkles, grit, dust or other foreign matter that may affect the decorative, adhesion and protective surface finish.

6.4.2 Class B

Preferred:

Shall be wrinkle and bubble free.

Acceptable (Minimum):

Scratch - Qty 1 @ 0.015" Wide x 0.30" Long per 50 Square Inches.

Scratch - Qty 2 @ 0.015" Wide x 0.30" Long or combination of up to 0.60" per 100 Square Inches.

Scratch - Qty 3 @ 0.015" Wide x 0.30" Long or combination of up to 0.90" per 300 Square Inches and greater.

Unacceptable:

Smears, runs, non-uniform glossiness, texture and coverage, finger-prints, corrosion, orange peel, excessive grease/oils, wrinkles, grit, dust or other foreign matter that may affect the decorative, adhesion and protective surface finish.

6.4.3 Class C

Acceptable (Minimum):

Scratch - Qty 2 @ 0.015" Wide x 0.50" Long or combination of up to 1.00" per 100 Square Inches.

Scratch - Qty 4 @ 0.015" Wide x 0.50" Long or combination of up to 2.00 "per 100 Square Inches and greater.

Runs or Smears 1x per 50 square inches and multiple increments thereof, i.e. 2x @100 sq. in, 3x @150 etc.

Minimal non-uniform glossiness, coverage, and discoloration.

Unacceptable: Corrosion, excessive grease/oils, grit, dust or other foreign matter that may affect the adhesion and protective surface finish.



6.5 Silkscreen, Pad Print, and Labels:

Characters on stamped, engraved, silkscreened, printed or typed labels, nameplates, faceplates, or any other customer-visible surfaces shall be legible in all cases.

6.5.1 Appearance

Preferred:

1. Characters are clean, legible, aligned, and evenly spaced.
2. Labels and decals are not torn, scratched, bent, or chipped.

Acceptable (Minimum):

Lines of a number or letter may be broken (or the ink thin over a portion of the character) providing the character is legible and cannot be confused with another number or character.

Unacceptable:

Characters are smeared, broken, or missing causing text to be illegible.

6.5.2 Positioning

Preferred:

Customer-visible labels, decals, or nameplates orientated to read from left to right or bottom to top with reference to normal operating position of the equipment.

Acceptable (Minimum):

1. Labels, decals, nameplates or stamps should be applied in a consistent location and orientation.
2. Customer-visible labels, decals, or nameplates shall be mounted squarely and shall not have a skew of more than 1/32 (0.020) inch per linear inch relative to the edge of the surface being applied.

Unacceptable:

Skew greater than 1/32 (0.020) inch per linear inch relative to the edge of the surface being applied.

6.5.3 Fastening

Preferred

Adhesive labels, nameplates or logos shall be flush with the mounting surface. Nameplates or logos mounted with hardware shall be properly secured to avoid the possibility of rattling or movement.

Unacceptable:

Lifting (poor adhesion), Wrinkling, Turned-up edges, Voids (caused by contamination or trapped air between decal and the surface of panel or chassis, or my improper mounting), Skewed



6.6 Plastic Parts (both surface and entire part):

Note: First Articles may be used as go/no go examples.

Preferred:

No nicks, dents, scratches or any other surface blemish.

Acceptable (minimum):

Scratches: 1x @ 0.10" long max

Sinks: 0.003" max

Pits: 2 per total surface area

Discoloration: use limit sample

Gate Blush: use limit sample

Flow/Knit/Weld lines: 2 @ 0.25" each

Flash: 0.02"

Cracking: None

Warping: See part drawing

Short shot: None

Haze: None

Drag/pull marks: use limit sample

Texture Variation: None. see part drawing for texture type. Texture to be consistent and uniform coverage

Unacceptable:

Nicks, dents, scratches, or any other surface blemish that exceeds minimum acceptable requirements under appropriate viewing conditions

6.7 Cosmetic Definitions:

Bleed out: Substance that runs out of seams. Color can vary from dark brown to gray white.

Blister: Enclosed raised spot on a surface.

Burn Deposits: Rough discolored plating on edges or, in/on corners.

Burr: Thin slivers of base material at the junction of a cut edge.

Chips or Voids: Areas of a surface that have been broken or chipped, or are missing coating.

Corrosion: Surface impurities or oxidation (Rust).

Drag/pull marks: Scratches or wiping mark from part dragging against mold when part is ejected from mold.

Discoloration: Unintended inconsistency or change in color from the approved standard color chip.

Fisheye: Cratering caused by organic contamination.

Flash: Thin protrusion of material at the parting line or junction of mold.

Flow mark: Visible mark resulting from solidification of two material flow fronts. Also known as Knit or weld lines.

Foreign Material: Dirt, lint, or other particles trapped in the finish.

Gate blush: Discolored area near mold gate.

Haze: Cloudiness on a transparent part.

Machine Marks: Visible lines caused during the punching and forming of sheet metal. Lines are straight and uniform.

Non adhesion: Plated, painted, pad print, silkscreen or label material is separating from base material.

Non uniform coverage: Area that has insufficient or excessive coating.

Orange Peel: Rippled appearance of material surface. Looks like orange peel in texture.



Oxidation: Rust.

Runs: Excessive coating forming drips or stains.

Pit: Small crater or void on surface.

Sink: Shallow depression on surface resulting from internal shrinkage during molding.

Short shot: Insufficient fill of material during molding.

Spot Welds: Indentations or rough areas from spot welding that exceeds the drawing or specification requirements.

Tape test: Apply a typical 3M Scotch Tape # C-4210 invisible tape over lettering or paint to be tested, and with normal pressure press the tape in place. Then tear off the tape in a continuous motion at a 90 degree angle to surface being tested. There shall be no evidence of ink or paint on tape.

Tool Marks: Creases or other indentations from tooling during the manufacturing process.

Void: Unfilled space where paint, plating or lettering should have been.

Warpage: Dimensional distortion of a part.

Water marks: Stains caused by excessive water not being blown off the part before drying sets in.

Weld Porosity: Pinholes in welds.



APPROVAL AUTHORITY:

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Randy Crim	Gerry Kelley

FORMS: N/A

REFERENCE DOCUMENT: IPC-A-610 Acceptability of Electronic Assemblies
IPC/WHMA-A-620 Requirements and Acceptance for Cable and Wire Harness Assemblies.

REVISION HISTORY

Revision	Author	Date	Change Description
A	Unknown	6/26/92	Initial Release
B	Unknown	3/24/02	Adopted IPC-A-610 and created HTML document format
C	W. Powell	11/30/04	General update. Adopted IPC/WHMA-A-620 for Cable and Wire Harness requirements. Converted document to pdf format.