General Information and Common Procedures

1 General

1.1 Scope This document covers procedures for repairing and reworking printed board assemblies. It is an aggregate of information collected, integrated and assembled by the Repairability Subcommittee (7-34) of the Product Assurance Committee of the IPC. This revision includes expanded coverage for lead free processes, and additional inspection guidelines for operations such as repair that may not have other published criteria.

This document does not limit the maximum number of rework, modification or repair actions to a Printed Circuit Assembly.

1.2 Purpose This document prescribes the procedural requirements, tools, materials and methods to be used in the modification, rework, repair, overhaul or restoration of electronic products. Although this document is based in large part on the Product Class definitions used in IPC documents such as J-STD-001 or IPC-A-610, this document should be considered applicable to any type of electronic equipment. When invoked by contract as the controlling document for the modification, rework, repair, overhaul or restoration of products, the requirements flowdown apply.

IPC has identified the most common equipment and process in order to make a specific repair or rework. It is possible that alternate equipment and processes can be used to make the same repair. If alternate equipment is used, it is up to the user to determine that the resultant assembly is good and undamaged.

1.2.1 Definition of Requirements This document is intended to be used as a guide and there are no specific requirements or criteria unless separately and specifically called out in a user's contractual or other documentation. When statements such as "must," "should" or "need to be" are used, they are stressing an important point. If these strong recommendations are not followed the end result may not be satisfactory and additional damage could be caused.

1.3 Background Today's electronic assemblies are more complex and smaller than ever before. Despite this, they can be successfully modified, reworked or repaired if the proper techniques are followed. This manual is designed to help users repair, rework and modify electronic assemblies with minimum impact on end use function or reliability. The procedures in this document have been obtained from assemblers, printed board manufacturers and users who recognize the need for documenting commonly used rework, repair and modification techniques. These techniques have, in general, been proven to be acceptable for the class of product indicated through testing and extended field functionality. Procedures contained herein were submitted for inclusion by commercial and military organizations too numerous to list individually. The Repairability Subcommittee has, where appropriate, revised procedures to reflect improvements.

1.4 Terms and Definitions Definitions marked with an * are from IPC-T-50 and apply to the use of this document.

PCA – Printed Circuit Assembly

**Rework* – the act of reprocessing noncomplying articles, through the use of original or equivalent processing, in a manner that assures full compliance of the article with applicable drawings or specifications.

**Modification* – the revision of the functional capability of a product in order to satisfy new acceptance criteria. Modifications are usually required to incorporate design changes which can be controlled by drawings, change orders, etc. Modifications should only be performed when specifically authorized and described in detail on controlled documentation.

**Repair* – the act of restoring the functional capability of a defective article in a manner that does not assure compliance of the article with applicable drawings or specifications.

1.4.1 Class of Product The user of the product is responsible for identifying the Class of Product. The procedure selected for action to be taken (modification, rework, repair, overhaul etc.) must be consistent with the Class identified by the user. The three Classes of Product are:

Class 1 – General Electronic Products
Includes products for applications where the major requirement is the function of the completed assembly.

Class 2 – Dedicated Service Electronic Products
Includes products where continued performance and extended life is required, and for which uninterrupted service is desired but not critical. Typically, the end use environment would not cause failures.

Class 3 – High Performance Electronic Products
Includes products where continued performance or performance-on-demand is critical. Equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment must function where required, such as life support and other critical systems.

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1.2 Purpose This document prescribes the procedural requirements, tools, materials and methods to be used in the rework, repair, modification, overhaul or restoration of electronic products. Although this document is based in large part on the Product Class definitions used in IPC documents such as J-STD-001 or IPC-A-610, this document should be considered applicable to any type of electronic equipment. When invoked by contract as the controlling document for the rework, repair, modification, overhaul or restoration of products, the requirements flowdown apply.

IPC has identified the most common equipment and process in order to perform a specific repair or rework. It is possible that alternate equipment and processes can be used to make the same repair/rework. If alternate equipment or processes are used, it is up to the user to ensure the equipment/processes do not damage the assembly and meet the intent of Section 1.5.1.1 (Levels of Conformance) for the alternate equipment/processes utilized.

1.2.1 Definition of Requirements This document is intended to be used as a guide and there are no specific requirements or criteria unless separately and specifically called out in a user's contractual or other documentation. When statements such as "must," "should" or "need to be" are used, they are stressing an important point. If these strong recommendations are not followed, the end result may not be satisfactory and additional damage could be caused.

Arrows in the rework procedures are either up or down describing the type of rework procedure being conducted. An up arrow means removal and a down arrow means installing.

1.3 Background Today's electronic assemblies are more complex and smaller than ever before. Despite this, they can be successfully reworked, repaired or modified if the proper techniques are followed. This manual is designed to help users rework, repair and/or modify electronic assemblies with minimum impact on end use functionality or reliability. The procedures in this document have been obtained from assemblers, printed board manufacturers and users who recognize the need for documenting commonly used rework, repair and modification techniques. These techniques have, in general, been proven to be acceptable for the class of product indicated through testing and extended field functionality. Procedures contained herein were submitted for inclusion by commercial and military organizations too numerous to list individually. The Repairability Subcommittee has, where appropriate, revised procedures to reflect improvements.

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Repair – the act of restoring the functional capability of a defective article in a manner that does not assure compliance of the article with applicable drawings or specifications.

Tack Solder – A solder connection commonly used to temporarily align and retain a multilead component in place on a PCB during the soldering of the other leads. A tack solder connection typically requires additional reflow to form the final solder connection.

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Class 1 – General Electronic Products
Includes products suitable for applications where the major requirement is the function of the completed assembly.

1.4.2 Board Types There are a variety of printed board types that the procedures in this document apply to. When selecting the appropriate modification, rework or repair procedure the printed board type being worked should be considered. Select a procedure that applies to the printed board type as listed on the procedure. Printed board types include the following:

R. Rigid Printed Boards and Assemblies – A printed board or assembly using rigid base materials only. These may be single-sided, double-sided or multilayered, and may be constructed from base laminate material that spans all approved commercial grades of laminate and includes glass fabric reinforced epoxy and polyimide resin laminates.

F. Flexible Printed Boards and Assemblies – A printed board or assembly using flexible or a combination of rigid and flexible materials only. May be partially provided with electrically nonfunctional stiffeners and/or cover lay. These may be single-sided, double-sided or multilayered.

W. Discrete Wiring Boards and Assemblies – A printed board or assembly using a discrete wiring technique to obtain electrical interconnections.

C. Ceramic Boards and Assemblies – A printed board or assembly using ceramic as the base material with interconnections separated by dielectric. The board layers are usually formed by alternate printing or depositing of interconnections and dielectric. The assemblies are either surface mount or die attach. Usually multilayered, these may be single-sided or double-sided.

1.4.3 Skill Level To assist in determining the skill level needed for each procedure a Skill Level indicator is included in each process. The Skill Level recommended should be used as a guide only. Skill levels will vary widely from technician to technician and from company to company. These recommendations come from industry experience and are not necessarily backed up with substantive testing. Skills are separated into three categories.

I. Intermediate – Technician with skills in basic soldering and component rework but inexperienced in general repair/rework procedures.

A. Advanced – Technician with soldering and component rework skills and exposure to most repair/rework procedures but lacking extensive experience.

E. Expert – Technician with advanced soldering and component rework skills and extensive experience in most repair/rework procedures.

1.5 Applicability, Controls and Acceptability Although the terms modification, rework and repair may seem very similar, applicability of such procedures may not be the same due to conditions and objectives involved. Procedures and guidelines of this document may be used during manufacturing of products or to products that have failed after being placed in use.

In general, rework or repair controls during manufacturing are different from the controls applied to products that fail after being placed in service.

When a defect or functional problem is discovered during the assembly process, a decision has to be made whether to rework or repair the product, use it as is, or discard it. This decision is typically made by a Material Review Board (MRB) as discussed in various assembly standards.

When a product fails after it has been placed in service, the term ‘‘repair’’ is commonly applied to actions that restore operation. Unlike the manufacturing process, there is no Material Review Board to disposition the failed assembly. How that decision is made is beyond the scope of this document.

Whether by an MRB or another process, if a decision has been made to perform a corrective action, and that action involves removing and replacing a failed component, the rework procedures in Part 2 - 7711 will be applicable. If a repair or modification action is needed, the procedures in Part 3 - 7721 will provide guidance.

1.5.1 Level of Conformance Level of Conformance provides the means for selecting an appropriate level of conformance to the original electrical, mechanical, physical, environmental and visual product requirements. Each procedure lists a Level of Conformance that the product will attain when successfully completed. The Level of Conformance rating for each procedure is based on the skill of the technician. The ratings are based on long term industry experience and are not necessarily backed up with testing data.

1.5.1.1 Levels of Conformance

L. Lowest Level – Significant variance with the physical character of the original and may vary with many of the electrical, functional, environmental and serviceability factors.

M. Medium Level – Some variance with the physical character of the original and most likely varies with some of the functional, environmental and serviceability factors.

H. Highest Level – Most closely duplicates the physical characteristics of the original and most probably complies with all the functional, environmental and serviceability factors.

Class 3 Products must use procedures rated Highest level unless it can be demonstrated that a lower level procedure will not adversely affect the product’s functional characteristics. Class 2 and 1 Products should use procedures rated

Class 2 – Dedicated Service Electronic Products
Includes products where continued performance and extended life is required, and for which uninterrupted service is desired but not critical. Typically, the end use environment would not cause failures.

Class 3 – High Performance/Harsh Environment Electronic Products
Includes products where continued high performance or performance-on-demand is critical, equipment downtime cannot be tolerated, end-use environment may be uncommonly harsh, and the equipment must function when required, such as life support and other critical systems.

1.4.2 Board Types There are a variety of printed board types that the procedures in this document apply to. When selecting the appropriate rework, repair or modification procedure, the printed board type being worked should be considered. Select a procedure that applies to the printed board type as listed on the procedure. Printed board types include the following:

R. *Rigid Printed Boards and Assemblies* – A printed board or assembly using rigid base materials only. These may be single-sided, double-sided or multilayered, and may be constructed from base laminate material that spans all approved commercial grades of laminate and includes glass fabric reinforced epoxy and polyimide resin laminates.

F. *Flexible Printed Boards and Assemblies* – A printed board or assembly using flexible or a combination of rigid and flexible materials, which may utilize electrically nonfunctional stiffeners and/or cover layers. These may be single-sided, double-sided or multilayered.

W. *Discrete Wiring Boards and Assemblies* – A printed board or assembly using a discrete wiring technique to obtain electrical interconnections.

C. *Ceramic Boards and Assemblies* – A printed board or assembly using ceramic as the base material with interconnections separated by dielectric. The board layers are usually formed by alternate printing or depositing of interconnections and dielectric. The assemblies are either surface mount or die attach. Usually multilayered, these may be single-sided or double-sided.

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I. *Intermediate* – Technician with skills in basic soldering and component rework but inexperienced in general repair/rework procedures.

A. *Advanced* – Technician with soldering and component rework skills and exposure to most repair/rework procedures but lacking extensive experience.

E. *Expert* – Technician with advanced soldering and component rework skills and extensive experience in most repair/rework procedures.

1.5 Applicability, Controls and Acceptability Although the terms rework, repair and modification may seem very similar, applicability of such procedures may not be the same due to conditions and objectives involved. Procedures and guidelines of this document may be used during manufacturing of products or to products that have been delivered and/or failed in use.

In general, rework, repair or modification controls during manufacturing are different from the controls applied to products that fail after being placed in service and should be considered when dispositioning hardware.

When a defect or functional problem is discovered during the assembly process, a decision has to be made whether to rework or repair the product, use it as is, or discard it. Other than rework, this decision is typically the responsibility of a Material Review Board (MRB) as discussed in various assembly standards.

When a product fails after it has been placed in service, the term ‘‘repair’’ is commonly applied to actions taken in the service environment that restore operational use. Unlike the manufacturing process, there is no Material Review Board to disposition the failed assembly. How that decision is made is beyond the scope of this document.

When a disposition decision has been made that involves removing and replacing a failed component, the rework procedures in Part 2 - 7711 would be applicable. If a repair or modification is needed, the procedures in Part 3 - 7721 would be applicable.

1.5.1 Level of Conformance The Level of Conformance ratings provide the means for selecting a procedure with an appropriate level of conformance to the original electrical, mechanical, physical, environmental and visual product requirements. Each procedure lists a Level of Conformance that the product should attain when successfully completed. The Level of Conformance rating for each procedure is based on the skill of the technician, and is based on long term industry experience and are not necessarily backed up with testing data.

Highest level for assured safety and dependability but Medium and Low Level procedures can be used if it has been determined that they are suitable for the specific product's functional characteristics.

Procedures in this manual are given a ''Level of Conformance'' rating which is described in Table 1.

Table 1 Level of Conformance

Functional Consideration	Level of Conformance		
	L	M	H
Electrical - Resistance	No	Verify	Yes
Electrical - Inductance	No	Verify	Yes
Electrical - Capacitance	No	Verify	Yes
Electrical - Cross Talk	No	Verify	Yes
Electrical - High Speed Frequency	No	Verify	Yes
Environmental - Shock	No	Verify	Yes
Environmental - Vibration	No	Verify	Yes
Environmental - Humidity	Verify	Verify	Yes
Environmental - Temperature	Yes	Yes	Yes
Environmental - Altitude	Verify	Verify	Verify
Environmental - Bacteria	Verify	Verify	Yes
Environmental - Fungus	Verify	Verify	Yes
Serviceability - Future Repair or Mod.	No	Yes	Yes

No — Procedure may not comply with functional consideration.
Verify — Procedure should comply with functional consideration but should be tested to verify.
Yes — Procedure will normally comply with functional consideration.

In principle any modification, rework or repair action taken on a product should reestablish the products original character, ''Make it like it was.'' Physical changes, obvious or otherwise, can adversely affect the products performance or capability factors.

1.5.2 Compliance Products that have been subjected to rework need to comply with the functional requirements for the product and any other attributes that may be required by the customer. In the absence of other defined acceptability criteria it is appropriate to apply the acceptance criteria of IPC-A-610 to rework actions.

Modification and repair, by their nature, do not have industry established requirements and acceptance criteria. These will need to be determined on a case by case basis. Products that have been subjected to modification need to comply with the requirements of the engineering data package that defines the modification.

Repair or modification may result in, or include, minor changes in visual appearance that do not degrade the form, fit, or function of the assembly.

1.6 Training The quality and reliability of modified or repaired printed boards and assemblies is highly dependent upon the skill and competence of the person performing these tasks. The implementation of proper methods by unqualified personnel can result in a substandard end product. Consequently, achieving successful results with the methods described herein is predicated on the use of properly trained personnel whose skills have been tested and certified to be of a sufficient level of competence.

1. *Soldering Skills* – Many companies have considered assembly personnel who are competent in soldering techniques to be sufficiently trained for rework/repair activities. This has often proven to be erroneous, since proper soldering is only one of the skills required. Also, in order to attain comparable results, there are many instances where component rework requires techniques that are different than those used to originally solder the component.
2. *Personnel Selection* – The proper selection of trainees will contribute significantly toward the success in developing capable repair personnel. Personnel with above average soldering abilities and sound reasoning capabilities often make ideal trainees. However, personnel who have no soldering skills, but possess a good level of eye acuity, manual dexterity, and sound reasoning capability, can be successfully trained.
3. *Professional Training* – Companies should establish and maintain procedures for identifying the training needs and provide for the training of all personnel performing the activities affecting product quality. Personnel performing specific assigned tasks shall be qualified on the basis of appropriate education, training and experience. Maintaining records of training is appropriate and may be specifically required to meet ISO or other quality certification criteria.

Training for personnel and instructors is commercially available and can be completed by an outside organization specializing in the applicable discipline. Modification/rework/repair training employs concepts, techniques, procedures and a vocabulary that distinguishes it from basic soldering training. Effective training requires the development of high levels of comprehension and reasoning within the trainee. This necessitates expansive teaching methods and detailed demonstration under close instructor supervision, to help assure the development of proficiency within each trainee.

Training to establish a desired level of proficiency can usually be achieved after three to ten days of training, depending on the content of the training program, the complexity of the end product, and the proficiency of the trainee. Testing and certification can be provided for each trainee, as the situation warrants.

1.5.1.1 Levels of Conformance

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Class 3 Products must use procedures rated Highest level unless it can be demonstrated that a lower level procedure will not adversely affect the product's functional characteristics. Class 2 and 1 Products should use procedures rated Highest level for assured safety and dependability but Medium and Low Level procedures can be used if it has been determined that they are suitable for the specific product's functional characteristics. Procedures in this manual are given a "Level of Conformance" rating which is described in Table 1.

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Environmental - Altitude	Verify	Verify	Verify
Environmental - Bacteria	Verify	Verify	Yes
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Serviceability - Future Repair or Mod.	No	Yes	Yes

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