IPC
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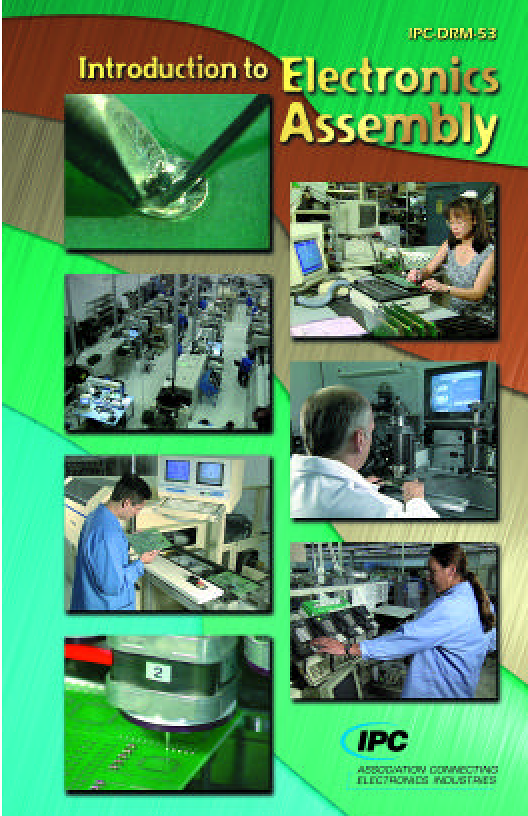

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Introduction to Electronics Assembly

A laptop and cell phone at work in the field.

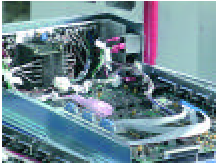
Introduction

[illegible]ook ar[illegible] [illegible]ucts a[illegible]. our homes, offices, schools, hospitals, airports, banks and stores. And year after year there are innovations - products get better and better, they're easier to use and their value increases as they do more for the same or lower cost.

An ATM machine is an electronic device we all use.

Personal computers are a perfect example. Ten years ago they were priced high and ran slow. Now they're a lot faster and cheaper.

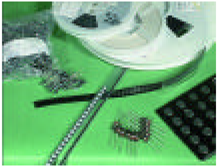
If you were to take the cover off an electronic product you'd see components and interconnections.



An inside view of a typical electronic device.

Components

Components are devices that alter the flow of electricity. The majority of electronic components are semiconductors - meaning they have properties of both conductors and insulators. A conductor is a metal/material that carries electrical signals. An insulator is any material that has a high resistance to the flow of electrical current.

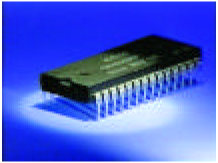


Components prior to assembly onto circuit board.

Resistors and capacitors are called passive components. That means the basic function of these components does not change when they receive a signal. Resistors slow down, or resist the flow of current to provide the proper amount. Capacitors store an electrical charge for a period of time, then discharge it over a longer or shorter period of time - depending on the requirements of the circuit.

A capacitor and resistor of the Through-hole variety.

Transistors, diodes and integrated circuits, or ICs, are called active components. That means the basic function of these components will change when they receive a signal. ICs can store information, perform calculations and move the information around. A microprocessor chip that contains millions of transistors and diodes is an example of a very sophisticated IC.

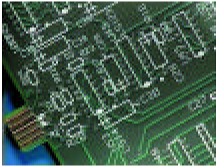


An IC in a Dual-In-Line Package.

Training References:
IPC-CD-18 Component ID Training (CD)
IPC-DRM-18 Component ID Desk Reference Manual

Interconnections

The interconnections are the pathways where electricity flows between components. These pathways are almost always printed circuit boards, or printed wiring boards. These are sometimes referred to as PCBs or PWBs. The printed boards are basically a pattern of electronic conductors that are formed on an insulating base material, or laminate.



A printed circuit board with no components.

Electronics Assembly

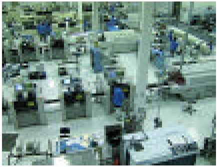
Electronics assembly is the process of attaching component leads or terminations to the lands, or conductors, on the circuit board, and then soldering them to make both mechanical and electrical connections. These circuit board assemblies are at the heart of our electronic products - allowing the products to be both complex and compact.

A circuit board assembly is inserted into a metal chassis.

Industry Overview

Electronics assembly is performed by Original Equipment Manufacturers (OEMs), and by members of the Electronics Manufacturing Services Industry, also known as EMS providers.

OEMs are companies that design and manufacture their own electronic products. Usually these companies do all or some of the electronics



A typical Electronics Assembly Facility.

assembly work themselves. For a variety of reasons, there are times when OEMs send out all or some of their design and assembly to EMS providers. EMS providers are differentiated from OEMs in that they don't produce their own products. They provide assembly and sometimes design services.

Assembly design is a complex process.

Before the assembly process can begin the components and circuit boards must be procured. Then these circuit boards and components go through specific manufacturing processes to create the soldered assemblies. After processing, the assemblies are tested. The assembler, whether OEM or EMS provider, usually performs any rework and repair that's needed. Occasionally, an EMS provider also performs the final system assembly, as well as system and reliability testing.

Component insertion is sometimes done by hand.

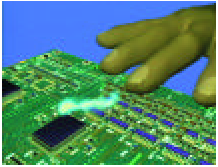
Sometimes the OEM will have assembly operations that not only perform circuit board assembly, test and system assembly for their own products, but also accept assembly work from other OEMs. That makes the company both an OEM and an EMS provider.

In recent years there has been significant growth in the EMS industry. The industry plays a dynamic role in today's information and entertainment-oriented world. It also provides many jobs and enjoys exciting career opportunities. In fact, the electronics industry as a whole employs more people than the aerospace, steel and automotive industries combined.

A training session for EMS Providers.

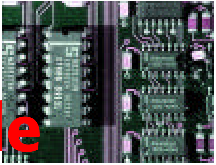
Electrostatic Discharge

One of the critical issues in electronics assembly is control of electrostatic discharge, or ESD. ESD occurs when static electricity from your body or a charged source comes in contact with and is discharged into an electronic component. This electricity can degrade or destroy the operation of many types of components. There are a wide variety of materials and techniques to eliminate the build up and discharge of static electricity.



An ESD sensitive component getting "ZAPPED" by an operator not wearing his grounding strap.

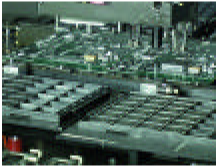
[illegible]raining [illegible]eferences:
[illegible]PC-VT-[illegible] ESD [illegible]nt[illegible])
[illegible]PC-CD-19[illegible] C[illegible]nt[illegible]l [illegible]D-[illegible]OM[illegible]
Technical References:
IPC-A-610 Acceptability of Electronic Assemblies



This board has through-hole components on the left, and smaller surface mount components on the right.

Assembly Processes

There are two primary categories of electronic components; through-hole and surface mount. Through-hole components have leads that are inserted *through* the holes in the circuit board. Surface mount components have leads or terminations that attach directly *onto* the lands on the surface of the board. A third category of components are those actually embedded in or on the surface



A component placement workstation.

of a printed wiring board. A printed wiring board (PWB) with embedded components is called a printed circuit board (PCB).

This reference manual will discuss many of the through-hole and surface mount processes involved in electronics assembly. (Embedded components in PCBs are not discussed in this document because they are part of the board fabrication process.) The overall assembly processes includes incoming inspection and preparation of circuit boards and components; automatic component insertion and placement; manual insertion of components; wave and reflow soldering; hand soldering; assembly cleaning; electrical test; rework and repair; conformal coating and final system assembly.

Training References:
IPC-VT-32 Introduction to Electronics Assembly (Video)
IPC-VT-53 Electronics Assembly Industry Overview (Video)
IPC-VT-24 Handling in Electronics Assembly (Video)

Technical References:
IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits
IPC-EIA J-STD-001 Requirements For Soldered Electrical And Electronic Assemblies

Incoming Inspection

Electronic components and circuit boards need to function as

Board inspection after the solder paste printing operation.

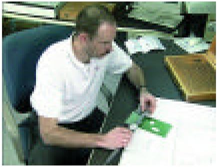
Incoming inspection of boards at the assembler.

Certified supplier checking components prior to shipment to assembler.

required. Incoming inspection is a method of verifying that order requirements have been met. This includes the correct number and type of products, the condition of the products upon receipt and the function of those products.

Many companies use a system of certified suppliers to minimize incoming inspection – sometimes called dock to stock. In this system, the supplier takes responsibility for the quality of the materials being purchased by the customer by thoroughly inspecting and testing the circuit boards and components before they are shipped. This means that when the materials arrive on the loading dock at the customer's facilities, they can be left in the packaging; the associated paperwork checked for part number and revision level; and sent to the stockroom. There is no incoming inspection or testing needed for verification of the customer.

When more detailed incoming inspection is required, there are a number of characteristics that may be checked by inspection. For example, a sample of circuit boards may be checked for proper dimensions, hole patterns and sizes, solder mask and solderability, and marking. A shipment of electronic components could be checked for count, condition, marking and solderability.



Checking board dimensions during incoming inspection.

Verifying components during incoming inspection.

Training References:
IPC-VT-57 Stockroom Materials - Storage and Distribution (Video)
IPC-CD-63 Bare Board Acceptability (CD)

Technical References:
IPC/EIA J-STD-002 Solderability Tests for Component Leads, Terminations, Lugs, Terminals and Wires
ANSI/J-STD-003 Solderability Tests for Printed Boards
IPC-6011 Generic Performance Specification for Printed Boards
IPC-6012 Qualification and Performance Specification for Rigid Printed Boards
IPC-A-600 Acceptability of Printed Boards
IPC-DRM-18 Component Identification Desk Reference Manual

Through-Hole Assembly

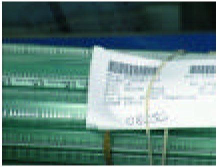
Through-hole assembly basically consists of component insertion and soldering.

Through-hole components, such as ICs, often come in dual-in-line packages, or DIPs. They usually arrive from the supplier in anti-static plastic tubes.

Small axial-lead components, such as resistors, capacitors and diodes, are usually packaged on tape and reel for automatic sequencing and insertion. Some through-hole components such as transistors are packaged in bags or boxes and may require lead forming and manual insertion.

Training References:
IPC-VT-27 Introduction to Through-Hole Assembly (Video)

Technical References:
IPC-CM-770 Component Mounting Guidelines for Printed Boards
IPC-DRM-40 Through-Hole Solder Joint Evaluation Desk Reference Manual

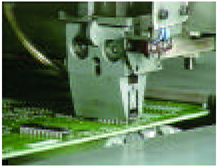


DIP components in static -proof tubes.

Axial components come packaged on tape and reels.

Automatic Insertion

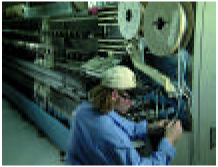
Automatic insertion machines make it possible to insert many components into the holes of a circuit board in a very short time. There are three types of automatic insertion machines - DIP inserters, axial inserters and radial inserters.



A DIP component insertion machine.

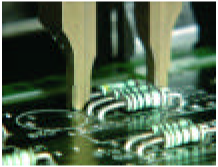
DIP inserters have universal circuit board fixtures that position the board to exact locations underneath the insertion head. The tubes containing DIP components are loaded in specific feeder locations. The components are picked up from the proper feeder, and are positioned in the insertion head. The machine is programmed so the fixture moves the board under the insertion head and the leads are inserted into the corresponding holes in the circuit board.

Axial and radial inserters operate a little differently than the DIP inserters. Axial and radial components are supplied on tape and reel. A sequencer is used to cut and retape the components in a specific order, or sequence, for automatic insertion. Sometimes the sequencer is part of the axial or radial inserter. Sometimes the sequencer is a separate machine. Once the components are sequenced, they are moved by metal feeders to the insertion head. A driver with forming fingers pre-forms the leads, and places them into the holes on the circuit board. One type of process uses tooling underneath the board to cut the leads and bend them slightly. The bend, or clinch, allows the component to be mechanically retained during subsequent operations.



Operator checking newly taped components on a sequencer.

Sequencer close up view.



Axial inserter for through-hole components.

Manual Insertion

There are two situations that require manual insertion of components. First, some components, because of their size and shape, simply do not fit in the automatic insertion machines. The second situation occurs when there are very few through-hole components required for an assembly. It becomes more cost effective to insert them by hand.

Manual insertion is used for some components.

The leads of many of these components need to be first preformed to the proper position for manual insertion. After preforming, the components are inserted into the correct holes on the board, and the leads may trimmed and clinched.

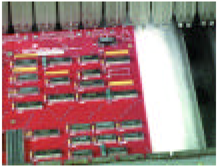
Some leads must be bent, or preformed, in order to fit in the assembly.

Training References:
IPC-VT-44 Component Preparation and Manual Insertion (Video)

Technical References:
IPC-EIA J-STD-001 Requirements For Soldered Electrical And Electronic Assemblies
IPC-A-610 Acceptability of Electronic Assemblies

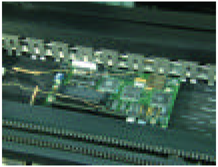
Wave Soldering

After all through-hole components have been inserted into the circuit board, the assembly is ready for the wave soldering operation. Wave soldering consists of three basic steps - fluxing, preheating and soldering. Each of these parts of a wave soldering machine are interconnected by a conveyor system.



A foam fluxer applies the flux.

Fluxing is the process of applying flux to the assembly. Flux is made up of a combination of chemicals. The purpose of the flux is to remove oxides and other contaminants from the surfaces of the metal parts to be soldered. Oxides begin to form on the component leads and through-hole lands whenever these metals come in contact with air. If these oxides, or contaminants, are not removed the solder won't form a reliable bond between the leads and through-hole lands. The two most common methods of flux application are foam and spray.



Preheating activates the flux prior to soldering.

The next part of the wave soldering process is preheating. During preheating, the entire assembly is slowly heated to a temperature that will activate the flux. This allows the flux to react with and condition the metals for the soldering operation. Preheating also reduces thermal shock when the assembly contacts molten solder in the next part. Thermal shock can cause damage to the PWB and components.

The assembly passes over a wave of molten solder.

After preheating, molten solder is delivered to the underside of the assembly in the form of a wave. As the bottom of the assembly passes over the crest of the wave, the solder is forced up through the holes in a wicking or capillary action. Wave soldering completes the electrical and mechanical connections of the components to the circuit board, and allows thousands of solder connections to be made in a very short time.

Training References:
IPC-VT-47 Wave Soldering (Video)

Technical References:
IPC-EIA J-STD-001 Requirements For Soldered Electrical And Electronic Assemblies
IPC-EIA J-STD-004 Requirements For Soldering Fluxes
IPC-EIA J-STD-006 Requirements For Electronic Grade Solder Alloys For Fluxed And Non-Fluxed Solid Solders For Electronic Soldering Applications

Hand Soldering

An assembly may also contain odd-form and temperature sensitive components such as batteries, switches, connectors, or unsealed parts that will have to be manually inserted and hand soldered after the wave soldering operation.


Operator at hand soldering workstation.

Soldering iron selection, tip size and desired heat range should be considered for the work at hand. An important factor in hand soldering is solder wire selection.

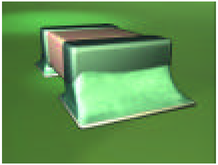
Training References:
IPC-VT-42/43 Hand Soldering
IPC-VT-49 The Seven Sins of Hand Soldering
IPC-VT-36 Hand Soldering With Low Residue Fluxes (Videos)

Technical References:
IPC-7711 Rework of Electronic Assemblies
IPC/EIA J-STD-001 Requirements for Soldered Electrical and Electronic Assemblies
IPC-A-610 Acceptability Of Electronic Assemblies


Hand soldering up close.

Surface Mount Assembly

Surface mount technology is newer than through-hole technology. Rather than being inserted through holes in the circuit board, surface mount component leads sit on lands on the surface of the board. Surface mount assembly consists of three basic processes - solder paste application, component placement and reflow soldering.


Chip component soldered to a surface mount land.

Training References:
IPC-VT-33 Introduction to Surface Mount Assembly (Video)
IPC-VT-71-75 Surface Mount Evaluation Series

Technical References:
IPC-TP-1115 Selection and Implementation Strategy for a Low-Residue, No-Clean Process
IPC-DRM-SMT Surface Mount Solder Joint Evaluation Desk Refernce Manual


Inspecting a surface mount assembly after component placement.

Solder Paste Application

Solder paste is a mixture of flux and tiny balls of solder in paste form. The application of solder paste is commonly done using a stencil printing process. Solder paste is pressed through openings in a stencil screen onto the corresponding circuit board lands with a squeegee made of hard rubber or stainless steel. The stencil openings are called apertures. They are designed to make sure the right amount of solder paste is deposited onto each land. The apertures must be in perfect alignment with the surface mount lands.


The solder paste printing process.

Training References:
IPC-VT-34 Solder Paste Printing
IPC-VT-35 Solder Paste Printing Defect Analysis and Prevention (Videos)

Technical References:
IPC-7525 Stencil Design Guidelines
IPC/EIA J-STD-005 Requirements for Soldering Pastes


Solder paste printing on a different machine.

Component Placement

Once solder paste is properly applied to the lands, the circuit board is typically moved to one or more automatic placement machines for component place ment.

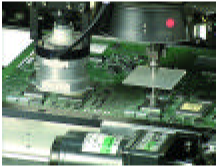
Surface mount components are usually supplied in three different ways - on tape and reel, in tubes or in matrix trays.

Surface mount chip components, such as resistors and capacitors, are usually supplied on perforated tape wound around a reel. The reel is loaded onto a feeder. The feeder is then connected to a placement machine. The high speed place ment machines for these types of components are called chip shooters. Chip shooters have rotating turrets with many nozzles. The turret rotates around to the feeder, picks up the component, orients it correctly and places it onto the solder paste coated lands at 60,000 or more components per hour.

Medium sized surface mount components are usually supplied in tubes or on tape and reel. The larger components are generally in matrix trays. Slower pick and place machines have heads that may be fitted with nozzles of different sizes. The nozzles pick up the component from the trays, tubes or reels, and accurately place them into the solder paste on the lands of the circuit board.

Inspecting components in a tray.

An operator loading a reel of components on tape onto the feeder.



The pick and place machine.

Other features of placement machines are a conveyor system to transfer circuit boards into and out of the machine; a table that keeps the board stationary using vacuum or clamping; pins or fixtures used to support the board on the table; a vision system used to verify correct board and component orientation; and a computer program which contains the description of the board to be assembled. The program also specifies the components required, their location on the board in X/Y coordinates, their orientation and the order in which they will be placed.

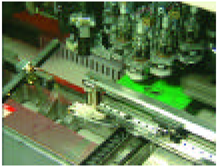
Sometimes, as with through-hole components, surface mount components are mounted by hand to a board in order to reduce costs when the quantity of boards being assembled is low.

Training References:
IPC-VT-39 Surface Mount Component Placement (Video)

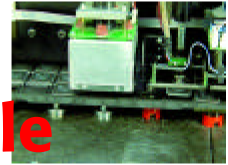
Technical References:
IPC-EIA J-STD-001 Requirements For Soldered Electrical And Electronic Assemblies
IPC-A-610 Acceptability Of Electronic Assemblies

Reflow Soldering

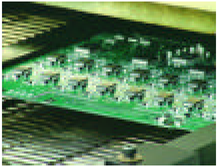
After component placement, the surface mount assemblies are ready for reflow soldering. The two most common heating methods to reflow the solder are forced convection and infrared.



A high speed chip shooter at work.



Another type of placement machine.



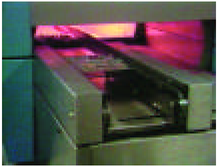
Convection ovens are used to reflow solder paste.

In convection systems, air or nitrogen is heated and blown onto the circuit board to melt or reflow the solder. Infrared uses heat panels that radiate the heat to reflow the solder. Most modern reflow soldering machines use a combination of these two heating systems.

The first area inside a reflow soldering machine is a preheat zone. Preheating allows the circuit board to be exposed to a controlled temperature rise. If all the required heat were applied immediately, the circuit board and some of the components might be damaged from heating up too quickly. The preheat operation also causes the flux in the solder paste to activate. As in wave soldering, this activation allows the oxides to be removed from the metal surfaces. If the assembly is in the preheat area too long, the flux may "burn out" and oxidation will recur before solder reflow. When this happens proper wetting may not occur.

The assembly proceeds by conveyor to the next heating zones where higher temperatures cause reflow and solder wetting to take place. The final step is a cool down zone which may or may not be augmented by cooling fans. Reflow soldering completes the surface mount assembly process.

Training References:
IPC-VT-15/16 Reflow Soldering
(Video)



Infrared ovens are also used to reflow solder paste.

A board moves through a preheat zone before solder reflow.

The end result, a surface mounted lead soldered onto a land.

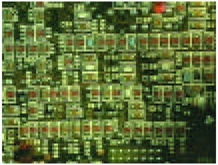
Adhesive Application

There is an additional surface mount operation that may be used for certain types of assemblies. In many of today's double sided circuit board designs, surface mount chip components are attached to the secondary, or bottom side of the board, and a combination of large surface mount components and some through-hole components are attached to the primary, or top side. This combination of surface mount and through-hole components on the same circuit board is called a mixed technology assembly.

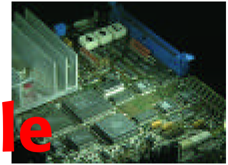
The purpose of adhesive application is to keep the surface mount components that are placed on the secondary side of the board from falling off before they're securely soldered during wave soldering.

In this case, the assembly operation would begin with the surface mount process from the primary side of the board. After solder paste printing, the larger surface mount components are placed in their proper locations on the board. This is followed by reflow soldering.

Next, the board is flipped over and adhesive is applied so that the chip components can be placed and glued onto the secondary side of the circuit board. Adhesive may be applied using an adhesive dispenser or stencil



Chip components on the secondary side of the circuit board.



Larger surface mount and some through-hole components on the primary side of the circuit board.

Adhesive dispensing process prior to component placement.

printer. The glue dots are applied between the chip component lands, rather than on the lands themselves. If the adhesive were placed on the lands, the components wouldn't be able to be reliably soldered to the lands. In other words, the adhesive would block the solder.

After adhesive application, the components are positioned using automated placement equipment. The adhesive is then cured. Curing allows the glue to achieve its full strength.

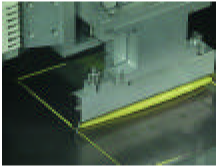
Next, the required through-hole components are inserted from the primary side of the board. The fully assembled circuit board is then passed through a wave solder machine. The solder wicks up the holes to solder the through-hole leads. The surface mount chip components glued to the bottom side of the board are also soldered at this time. This completes the mixed technology assembly process.

Training References:

IPC-VT-51 Adhesive Application for Surface Mount (Video)

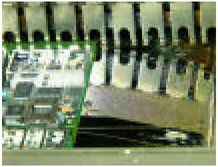
Technical References:

IPC-CA-821 General Requirements for Thermally Conductive Adhesives



Applying adhesive using the stencil printing method.

Placing chip components on top of adhesive temporarily holds them in place.



An assembly surfs the solder wave to complete the process.

Cleaning

Some companies use no-clean soldering operations that do not require any cleaning process to follow assembly and soldering. Others require a cleaning operation that removes undesirable contaminants including any flux residues that may be left over from the soldering operation. Depending on the type of flux used, cleaning may be accomplished using water or a more active cleaning agent. If certain types of flux residues are not removed, corrosion and ultimately assembly operating problems can occur.

Training References:

IPC-VT-47 Wave Soldering (Video)

IPC-VT-[illegible] Hand Soldering With Low R[illegible]idue [illegible]

Technical References:

IPC-TP-1115 Selection and Implementation Strategy for a Low-Resdiue,No-Clean Process

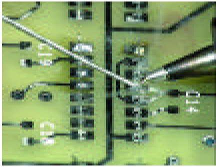
IPC-SC-60 Post Solder Solvent Cleaning Handbook

IPC-SA-61 Post-Solder Semiaqueous Cleaning Handbook

IPC-AC-62 Post-Solder Aqueous Cleaning Handbook

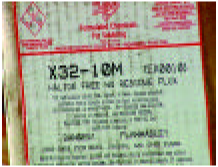
IPC-CH-65 Guidelines for Cleaning of Printed Boards and Assemblies

IPC-9201 Surface Insulation Resistance Handbook



Hand soldering with a low-residue flux.

The cleaning operation.



A No Clean flux label.

Electrical Test

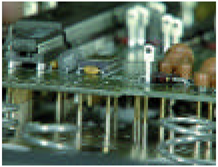
Testing usually follows in the assembly process to guarantee that assemblies work. There are two basic categories of testing that will be described here. These are in-circuit test, or ICT, and functional test.

ICT checks the assembly for unwanted open and short circuits by testing components for manufacturing defects. ICT is performed on automatic test equipment that uses a bed-of-nails fixture consisting of a series of spring loaded probes to connect the tester to specific solder connections and test points.

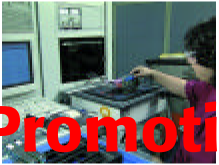
Functional test checks the operation of the entire circuit board assembly by applying power and input signals, then checking that the output signals are correct. The difference between functional test and ICT is that functional test doesn't check a specific component. It is actually testing a group of components by testing the different functions, or electronic operations designed into the assembly.

One method of functionally testing the assembly is accomplished on automatic test equipment. There is usually a special connector fixture to gain access to the circuitry on the assembly.

The assembly can also be tested on a technician's bench. Special



Close up view of bed-of-nails test probes.



Using an automated functional test machine.

A functional bench test workstation.

test electronics are designed to create an operational environment for the assembly that's similar to the finished product. For example, a modem assembly might be tested to dial up and establish a connection.

Functional test can be performed on both the circuit board assembly and on the finished product. ICT is only done on the assembly.

When an assembly fails ICT or functional test, the error message is examined and the problem can usually be identified. Sometimes troubleshooting is used to determine which component or components are failing. Once the problem is identified, the assembly can be reworked and/or repaired.

Training References:
IPC-VT-[illegible] Electrical Test in Electronics Assembly (Video)

Technical References:
IPC-7711 Rework of Electronic Assemblies
IPC-7721 Repair and Modification of Printed Boards and Electronic Assemblies

Rework and Repair

Rework involves removing and replacing defective components or correcting defective solder connections. Repair is done when the circuit board laminate, conductors or lands are damaged during the assembly or rework operations. Rework and repair methodology may

An assembly passes in-circuit test.

Troubleshooting a problem.

Reworking a bad solder joint.

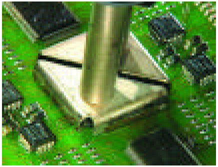
also be used to incorporate design changes for assemblies.

Rework on through-hole and many surface mount components may be done using hand tools. For through-hole components, the tools are often just a soldering iron with the proper tip installed and a vacuum extractor.

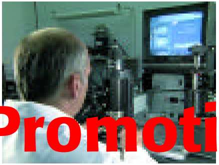
The smaller and more densely packed surface mount components have made rework and repair more difficult. To deal with this challenge, specialized hand tools have been developed to make surface mount rework more manageable. These hand tools are especially effective in low volume rework applications.

Today, there are component package styles that make it virtually impossible to perform rework operations with hand tools. A couple of examples include ultra fine pitch leaded parts and Ball Grid Arrays, or BGAs. The rework requirements for these types of components have resulted in the development of "rework stations." Rework stations are self-contained systems that provide controlled removal and replacement of these types of surface mount components. They are also effective for high volume rework applications.

Repair involves using special tools and procedures to correct damaged lands, conductors and circuit board laminate material.



A rework hand tool removes the component.



Aligning component leads to circuit board lands on a rework station.

Training References:

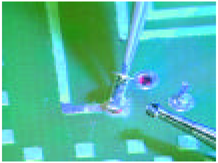
IPC-VT-97A/B Land and Conductor Repair for Electronic Assemblies
IPC-VT-97C Plated-Through Hole Repair
IPC-VT-41 Through-Hole Rework
IPC-VT-91 Intro to Surface Mount Rework
IPC-VT-92 Rework of Surface Mount Chip Components
IPC-VT-93 Gull Wing Rework
IPC-VT-94 Rework of J-Lead Components
IPC-VT-95 Surface Mount Rework Stations
IPC-VT-96 Ball Grid Array Rework
(All Videos)

Special kits may be required to accomplish some repairs.

The assembly is re-tested following the rework and/or repair operation.

Technical References:

IPC-7711 Rework of Electronic Assemblies
IPC-7721 Repair and Modification of Printed Boards & Electronic Assemblies
IPC-EIA J-STD-001 Requirements For Soldered Electrical & Electronic Assemblies
IPC-A-610 Acceptability Of Electronic Assemblies

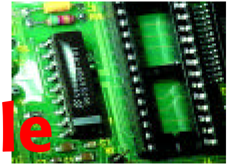


Repair in progress.

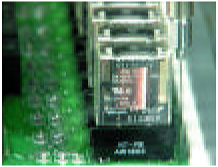
Conformal Coating

Some finished assemblies are destined for operational environments that are very harsh when compared to the environment [illegible] normal[illegible] assembly wi[illegible] e[illegible] co[illegible] er. There may be temperature extremes, humidity, corrosive atmosphere, and salt water. These environments may be encountered in applications such as automotive "under the hood", aerospace, medical and military. When this occurs, there is a need for a protective barrier between the assembly and the environment. These protective barriers are called conformal coatings. Conformal coatings have also become necessary on fine-pitch high-density circuitry to retard failures caused by electromigration.

There are a variety of conformal coatings and each one has spe-



A conformally-coated assembly.



Spraying conformal coating.

cific characteristics. Once the proper coating is selected for the intended use, it can be applied by brush, spray, dip, curtain coat, or vacuum deposition. It is important to make sure that all other process steps have been completed prior to conformal coating. Once the conformal coating has been applied, it will prevent normal in-circuit test using a bed of nails tester, and will make it much more difficult to modify the assembly in any way.

Technical References:

IPC-EIA J-STD-001 Requirements For Soldered Electrical & Electronic Assemblies

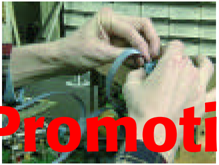
IPC-A-610 Acceptability Of Electronic Assemblies

IPC-CC-830 Qualification and Performance of Electrical Insulating Compound for Printed Board Assemblies

IPC-TR-476A Electro-Chemical Migration: Electrically Induced Failures in Printed Wiring Assemblies

Final System Assembly

Assemblies that pass ICT and functional test can be installed in the final system. This phase of the overall assembly process is called final system assembly, or box build. During box build, all of the hardware required for the finished product is installed into the equipment chassis. This includes racks, wire harnesses, power supplies, heat sinks, fans, front panel switches and displays, connectors - and the electronic assemblies.



Connecting a ribbon cable during a box build.

The assembled product is given a final functional, or system test to make sure it is operating properly. Companies often use reliability, or stress testing to weed out components that may fail after the first few hours of operation. This type of testing is sometimes part of a burn-in process and usually guarantees a higher level of reliability for the product.

Performing final test on a computerized telephone system.

A simple version of a stress test is to turn a product on and off many times, and to verify it still operates properly. A more comprehensive reliability test is to place the assemblies in a thermal chamber for a period of time. During this time, temperatures are repeatedly raised and lowered at a controlled rate. We call this type of stress testing "environmental stress screening" or ESS.

An operator loads assemblies in a thermal chamber for a burn-in reliability test.

After the assemblies are removed from the oven, they are given a functional test. Passing the test indicates the assembly should work reliably for many years under normal operating conditions. The products are then shipped to customers and distributors.

Training References:

IPC-VT-46 Mechanical Assembly (Video)

IPC-VT-17 Electrical Test in Electronics Assembly (Video)

One last functional test is done to verify assembly reliability.

The electronics assembly industry has grown rapidly during the past decade. New technologies have allowed products to become more functional, faster and more compact, as well as less expensive. Innovation and quality keep electronics assembly successful in an increasingly competitive world market.

Rapid growth of the EMS industry.

GLOSSARY

ACTIVE COMPONENT: An electronic component whose basic function is to modify an applied signal. (This includes diodes, transistors and integrated circuits that are used for the rectification, amplification, switching, etc., of analog or digital circuits in either monolithic or hybrid form.)

APERTURES: The openings in a stencil or screen that correspond to the land patterns of a circuit board. Solder paste or adhesive is pushed through these openings with a squeegee during printing.

AXIAL COMPONENTS: Through-hole components such as resistors and capacitors that have lead wire extending from the component along its longitudinal axis.

BED-OF-NAILS FIXTURE: A test fixture consisting of a frame and a holder containing a field of spring-loaded pins that make electrical contact with a planar test object.

BOX BUILD: Final assembly of a system. Includes attaching all the needed hardware, along with the circuit board assemblies into a box or chassis.

CHIP COMPONENTS: Very small surface mount resistors and capacitors.

CHIP SHOOTER: A high-speed placement machine that mounts surface mount chip components to a circuit board assembly.

CONDUCTOR: A metal, such as copper, or metallic based material, such as conductive ink or tape that carries or conducts electrical signals.

DIP (Dual In-Line Package): A basically rectangular component package that has a row of leads extending from each of the longer sides of its body that are formed at right angles to a plane that is parallel to the base of its body.

EMSI (Electronics Manufacturing Services Industry): Companies that perform electronics assembly for Original Equipment Manufacturers.

ESD (Electrostatic Discharge): Occurs when static electricity from a body or object comes in contact with and is discharged into an electronic component.

FLUX: A chemically and physically active compound that, when heated, promotes the wetting of a base metal surface by molten solder by removing minor surface oxidation and other surface films and by protecting the surfaces from reoxidation during a soldering operation.

FORCED CONVECTION: Reflow soldering using forced hot air or inert gas (nitrogen) as the primary source of heat.

FUNCTIONAL TEST: A test that analyzes the unit under test as a complete functional entity by applying inputs and sensing outputs.

HARDWARE: The components that go into the final system during box build. Includes circuit board assemblies, card racks, power supplies, wire harnesses, heat sinks. fans, switches, connectors - and the materials used to mount them.

IN-CIRCUIT TEST: The application of test signals directly to a device's input terminals and sensing the results directly from the device's output terminals.

INFRARED REFLOW: Reflow soldering using infrared heating as the primary source of energy.

INSULATOR: A material with a high resistance to the flow of electrical current.

INTEGRATED CIRCUIT: A combination of inseparable associated circuit elements that are formed in place and interconnected on or within a single base material to perform a microcircuit function.

LAMINATE: The base material of a circuit board upon which a conductive pattern is formed.

LANDS: The portion of conductive pattern on a circuit board designed for the connection and/or attachment of components.

LEAD: A length of insulated or uninsulated metallic conductor that is used for electrical interconnections.

LOW RESIDUE FLUX: Flux that uses different kinds of chemicals than in traditional fluxes. This type of flux becomes inert in the reflow process and can be left on an assembly after soldering without causing deterioration.

MICROPROCESSOR CHIP: A sophisticated integrated circuit that performs almost all of the high speed functions in a computer.

MIXED TECHNOLOGY ASSEMBLY: An assembly that has both surface mount and through-hole components.

NO-CLEAN: A soldering process that uses low residue fluxes so the assembly will not need to be cleaned after soldering.

OPEN CIRCUIT: A fault that occurs when two electrically connected points become separated.

OEM (Original Equipment Manufacturer): A company that designs and manufactures its own electronic products.

OXIDES: The contamination that forms on component leads and circuit board lands whenever these metals come in contact with the oxygen in the air.

PASSIVE COMPONENT: A discrete electronic device whose basic function does not change while it processes an applied signal. (Includes components such as resistors and capacitors.)

PATHWAY: A single conductive path in a conductor pattern.

PREFORMING LEADS: Bending the leads of a component to fit into the holes in a circuit board.

PREHEATING: The raising of the temperature of a material(s) above the ambient temperature in order to reduce the thermal shock and to influence the dwell time during subsequent elevated temperature processing.

PRIMARY SIDE: The side of an assembly that usually contains the most complex or the most number of components.

PCB (Printed Circuit Board): A printed wiring board that provides point-to-point connections in a predetermined arrangement on a common base and that has embedded components.

PWB (Printed Wiring Board): A printed board that provides point-to-point connections in a predetermined arrangement on a common base and does not have any embedded components.

RADIAL COMPONENTS: Components that have two or more leads extending from the same face of the component, as opposed to axial components which have them coming out opposite sides.

REFLOW SOLDERING: The joining of surfaces that have been tinned and/or have solder between them, placing them together, heating them until the solder flows, and allowing the surface and the solder to cool in the joined position.

REPAIR: The act of restoring the functional capability of a defective article in a manner that precludes compliance of the article with original drawings or specifications.

RESISTANCE: The restriction of the flow of electricity.

REWORK: The act of reprocessing non-complying articles, through the use of original or alternate equivalent processing, in a manner that assures compliance of the article with applicable drawings or specifications.

SECONDARY SIDE: The side on an assembly that is opposite the primary side (it is usually the same as the "solder-source side" on through-hole mounting technology).

SEQUENCER: A machine that cuts and retapes axial or radial components in a specific order for automatic insertion.

SOLDER: An alloy that melts at lower temperatures than any of the base metals and is used to join or seal metals with higher melting points.

SOLDERABILITY: The ability of a metal to be wetted by molten solder.

SOLDER PASTE: Finely divided particles of solder, with additives to promote wetting and to control viscosity, tackiness, slumping, drying rate, etc., that are suspended in a cream flux.

STENCIL PRINTING: The act of pressing solder paste through openings in a a stencil or screen onto corresponding lands on a circuit board. The pressing is done with a squeegee.

STRESS TESTING: Exposing an assembly to controlled extreme operating conditions to ensure reliability before shipping the product.

SURFACE MOUNT: A technology that uses components having leads or terminations that attach directly onto lands on the surface of the PWB.

THROUGH-HOLE: A technology that uses components having leads that are inserted through holes in the PWB.

WAVE SOLDERING: A process wherein an assembled printed board is brought in contact with the surface of a continuously flowing and circulating fountain of solder.

WETTING: The formation of a relatively uniform, smooth, unbroken and adherent film of solder to a basis metal.

WICKING: The capillary movement of solder between metal surfaces, such as strands of a wire.

Technical References: IPC-T-50 Terms and Definitions for Interconnecting and Packaging Electronic Circuits
IPC-DRM-18 Component Identification Desk Reference Manual