HANDBOOK ON
HANDLING & STORAGE OF
ELECTRONIC CARDS OF ELECTRIC
LOCOMOTIVES

TARGET GROUP: ELECTRICAL MAINTENANCE STAFF (TRS, TrD, GS)
CAMTECH/ E/ 14-15/Electronic Cards/ 1.0
October, 2014

Indian Railways
Centre for Advanced Maintenance Technology

महाराजपुर, ग्वालियर — 474 005
Maharajpur, GWALIOR - 474 005
QUALITY POLICY

“To develop safe, modern and cost effective Railway Technology complying with Statutory and Regulatory requirements, through excellence in Research, Designs and Standards and Continual improvements in Quality Management System to cater to growing demand of passenger and freight traffic on the railways”.
FOREWORD

Electronic cards are being used vastly in electric locomotives and other control technology over Indian Railways.

These cards play vital role in the safe functioning of the system. Proper handling and storage are the key requirement in the maintenance of these cards.

CAMTECH has prepared this handbook on “Handling & Storage of Electronic Cards of Electric Locomotives” to create awareness among the maintenance personnel.

I hope this handbook will prove to be useful for the staff working in electric loco sheds/ workshops as well as other dealing with electronic cards.

CAMTECH, Gwalior
Date : 21st October, 2014

A.R. Tupe
Executive Director
PREFACE

With the advancement of electronic technology in conventional and 3 phase electric locomotives, printed circuit boards are widely used. To ensure safe and reliable operation of locomotive it is essential to upkeep these cards in healthy condition. These cards consist a large percentage of ICs which are very sensitive to many factor and often get defective when PCBs are mishandled.

This handbook on “Handling & Storage of Electronic Cards of Electric Locomotives” has been prepared by CAMTECH to discriminate the knowledge among the field people.

In this handbook a brief history of PCBs, special issues, electrostatic discharge and their bad effects are covered. The requirement of antistatic work station, proper assembly environment, e-waste management and ESD gadgets are also covered along with useful standards.

It is clarified that this handbook does not supersede any existing provisions laid down by Railway Board, RDSO or Railways. This hand book is for guidance only and it is not a statutory document.

I am sincerely thankful to all field personnel who helped us in preparing this handbook.

Technological up-gradation & learning is a continuous process. Please feel free to write to us for any addition/ modification in this handbook. We shall highly appreciate your contribution in this direction.

CAMTECH, Gwalior
Date: 21st October 2014
Director / Electrical

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The correction slips to be issued in future for this handbook will be numbered as follows:

CAMTECH/E/14-15/Electronic Cards/1.0/ C.S. # XX date---

Where “XX” is the serial number of the concerned correction slip (starting from 01 onwards).

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1. INTRODUCTION

Electronic card being used vastly in electric locomotives and other control technology over Indian Railways.

Electronic circuits in industry are normally manufactured through the use of PCBs (Printed Circuit Boards). The boards are made from glass reinforced plastic with copper tracks in the place of wires. Components are fixed in position by drilling holes through the board, locating the components and then soldering them in place. The copper tracks link the components together forming a circuit.

Circuit board is a card made specifically for attaching electronic components.

The "card" is made of a material that does not conduct electricity, like fiber glass or plastic. Usually electro less copper is etched inside the board (between the layers of plastic). Electronic parts are then attached to this base using a conductive material (metal). The circuits etched into the board allow electricity to travel from one component to another, so the parts can work together.
2. HISTORY

1. Printed circuit boards came from electrical connection systems that were used in the 1850s. Originally metal strips or rods were used to connect large electric components mounted on wooden bases.

2. The metal strips were replaced by wires connected to screw terminals, and wooden bases were replaced by metal frames. Smaller designs allowed spacing components more closely, for increasingly complex circuits in 1925.

3. Charles Ducas of the United States submitted a patent application for a method of creating an electrical path directly on an insulated surface by printing through a stencil with electrically conductive inks. This method gave birth to the name "printed wiring" or "printed circuit."

4. In 1943, Paul Eisler of the United Kingdom patented a method of etching the conductive pattern, or circuits, on a layer of copper foil bonded to a glass-reinforced, non-conductive base.

5. Eisler's technique was noticed by the US military and they started to use it in their new weapons in World War II. His idea did not come into commercial use until the 1950s when the transistor was introduced.

6. Plated through-hole technology and its use in multi-layer PCBs were patented by the U.S. firm Hazeltine in 1961.

7. The resulting increase in the complexity and detailed paths started a new era in PCB design. Integrated circuit chips were introduced in the 1970s.
8. Today the Printed Circuit Board can have up to 50 layers in some applications.

9. Surface mount technology was developed in the 1960s and became widely used in the late 1980s.

3. MODERN DESIGN PCB

Modern practice is less labor-intensive since computers can automatically perform many of the layout steps. The general progression for a commercial printed circuit board design would include:

1. Schematic capture through an electronic design automation tool.

2. Card dimensions and template are decided based on required circuitry and case of the PCB. Determine the fixed components and heat sinks if required.

3. Deciding stack layers of the PCB 1 to 12 layers or more depending on design complexity. Ground plane and power plane are decided. Signal planes where signals are routed are in top layer as well as internal layers.

4. Line impedance determination using dielectric layer thickness, routing copper thickness and trace-width. Trace separation also taken into account in case of differential signals. Microstrip, stripline or dual stripline can be used to route signals.

5. Placement of the components. Thermal considerations and geometry are taken into account. Via (electronics) and lands are marked.
Routing the signal traces for optimal electromagnetic interferences performance high frequency signals are routed in internal layers between power or ground planes as power planes behave as ground for AC.

In the design of the PCB artwork, a power plane is the counterpart to the ground plane and behaves as an AC signal ground, while providing DC voltage for powering circuits mounted on the PCB. In electronic design automation (EDA) design tools, power planes (and ground planes) are usually drawn automatically as a negative layer, with clearances or connections to the plane created automatically.

PCB copper electroplating line in the process of pattern plating copper as shown below.

After the board has been populated it may be tested in a variety of ways:
- While the power is off, visual inspection, automated optical inspection. PCB component placement, soldering, and inspection are commonly used to maintain quality control in this stage of PCB manufacturing/attending.
- While the power is off, analysis, power off testing.
- While the power is on, in circuit test, where physical measurements (for example, voltage) can be done.
- While the power is on, functional test, just checking if the PCB does what it had been designed to do.
- Check the PCB visually and video magnifier can be used for dry soldering, track overheating at any other defect.

In boundary scan testing, test circuits integrated into various ICs on the board. The architecture provides a means to test interconnection between integrated circuits on a board without using physical test probes.

When boards fail the test, technicians may desolder and replace failed components, a task known as rework. For any rework conformal coating removing is essential. The conformal coating procedure is described latter. After successful testing of PCB, Born in test carried out & all test parameters are monitored.
4.0 PCBs AND SPECIAL ISSUES

The printed circuit boards hold microchips (Integrated circuits) and other components. A large percentage of Integrated Circuits used these days, especially CMOS are very sensitive to many factors and often get defective when PCBs are mishandled. So PCBs need special handling. Some of the special issues with regard to PCBs are as follows:

4.1 CMOS

CMOS (Complementary Metal Oxide Semiconductor) is the most common type of MOSFET (Metal-Oxide Semiconductor Field-Effect Transistor) today and are extensively used in PCBs. The high impedance of the FET gate makes it rather vulnerable to electrostatic damage. In general, MOS devices are sensitive to voltage spikes and static-electricity discharges. The level of static electricity on human body is high enough to destroy the inputs of a CMOS device if its pins are touched with fingers.

4.2 Electrical Overstress (EOS)

Electrical overstress damage can be caused by generation of unwanted energy; such as spikes, occurring within soldering irons, solder extractors, testing instruments and other electrically operated equipment. The equipment must be designed to prevent unwanted electrical discharges i.e, these instruments should be ESD (electrostatic discharge) safe.
4.3 Conformal Coating

Conformal coatings are transparent materials applied in thin layers (typically a few mils or a fraction of a mm) onto printed circuit boards. They provide environmental and mechanical protection to significantly extend the life of the components and circuitry. Conformal coatings protect electronic printed circuit boards from moisture and contaminants, preventing short circuits and corrosion of conductors and solder joints. They also minimize dendritic growth and the electro migration of metal between conductors. In addition, the use of conformal coatings protects circuits and components from abrasion and solvents.

5. FUNDAMENTALS & TERMINOLOGY OF ESD

Every material has the ability to take on an electrostatic charge. The charge of the object is called static electricity and figuratively, it means that there is some charge just sitting on the item and waiting for an opportunity to move. The amount of static electricity created depends upon the material, the area of contact, the speed of separation and the relative humidity. Higher relative humidity creates less charge. If two conductive objects with different potential levels or polarity come close together or in contact with each other, the charge rapidly moves from one object to the other.

VOLTAGE UP TO 35000 V

GENERATED VOLTAGE IN HUMAN BODY
The terms associated with static electricity are defined as:

**Coulombs**: Static electricity is measured in Coulombs. The charge of 1 Coulomb on an object is determined by the product of the capacitance of 1 Farad and a potential of 1 Volt on the object.

\[
1 \text{ Coulomb} = 1 \text{ Farad} \times 1 \text{ Volt}.
\]
\[
1 \text{ C} = 1 \text{ F} \times 1 \text{ V}; \quad 1\text{C} = 1\text{As} \quad \text{where}
\]
\[
A=\text{amperes}
\]
\[
s = \text{seconds}.
\]

With the induction of the electron Volt, which is the energy taken by an electron for passing the potential difference of 1 Volt we have:

\[
1\text{eV} = 1.602 \times 10^{-19} \text{ C} \times 1\text{V}
\]
\[
= 1.602 \times 10^{-19} \text{ As} \times 1\text{V}
\]
\[
= 1.602 \times 10^{-19} \text{ Ws}
\]
\[
= 1.602 \times 10^{-19} \text{ J (Joule)}
\]

Furthermore the potential difference between two points in an electric field is defined as the amount of work done in moving a unit positive charge from one point to another point, which means the

Potential difference = Work done divided by quantity of charge transferred

\[
1 \text{ Volt} = 1 \text{ Joule/ 1 Coulomb} = \text{AsV/As} = 1 \text{ Volt}
\]

Electrostatic voltage generated by various operations depending on the relative humidity.
<table>
<thead>
<tr>
<th>Operation</th>
<th>Voltage within a Relative Humidity of</th>
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<tbody>
<tr>
<td></td>
<td>10 – 20 %</td>
</tr>
<tr>
<td>Walking on synthetic carpet</td>
<td>35000 V</td>
</tr>
<tr>
<td>Pulling tape from a PCB</td>
<td>12000 V</td>
</tr>
<tr>
<td>Cleaning tape from a PCB</td>
<td>12000 V</td>
</tr>
<tr>
<td>Freon circuit spray</td>
<td>15000 V</td>
</tr>
<tr>
<td>Poly bag picked up from bench</td>
<td>20000 V</td>
</tr>
<tr>
<td>Sitting on a foam cushion</td>
<td>18000 V</td>
</tr>
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Various component types to ESD sensitivity (Measured in Volt)

<table>
<thead>
<tr>
<th>Device type</th>
<th>ESD sensitivity (V)</th>
</tr>
</thead>
<tbody>
<tr>
<td>VMOS</td>
<td>30V – 1800 V</td>
</tr>
<tr>
<td>MOSFET</td>
<td>100 V – 200 V</td>
</tr>
<tr>
<td>EPROM</td>
<td>100 V – 2500 V</td>
</tr>
<tr>
<td>CMOS</td>
<td>250 V – 3000 V</td>
</tr>
<tr>
<td>TTL</td>
<td>300 V – 2500 V</td>
</tr>
<tr>
<td>Film Resistor</td>
<td>300 V – 3000 V</td>
</tr>
<tr>
<td>SCR</td>
<td>680 V – 1000 V</td>
</tr>
</tbody>
</table>
6. ANTI STATIC WORKSTATION

Anti static workstations are normally placed in an ESD (Electro static Discharge) safe work area. Workstations comprise the following key ESD control elements:

- a static dissipative work surface,
- a means of grounding personnel (usually a wrist and heel grounder & ESD chair)
- a common grounding connection,
- an ESD protective mat,
- an appropriate signage and labelling

ESD Association standard ANSIEOS/ ESD 6.1 – Grounding recommends the following two-step procedure for grounding ESD protective equipment:

a. Ground all components of the work area (work surface, people, equipment, etc.) to the same electrical ground (common point ground) so they have the same electrical potential. This ESD common point ground should be marked by the use of the symbol as shown.

b. Static Voltage Checker

It is used to check human body voltage & to ground static charge present on human body. It must be used before working on electronic cards.

GROUND YOUR STATIC CHARGE
To protect electronics components from breakdown, following steps to be followed to ground static charge of the body.

i. Turn the device on.

ii. Gently touch the “Touch to Test” plate on the meter.

iii. Watch the LCD, depending on humidity & types of shoes/ slippers, indication between 0-1999 volts of static charge may be displayed.

iv. Touch the ground on the meter to discharge the body voltage to ground.

v. Again touch the “Touch the test” plate on the meter reading must be 000 volts on the LCD.

vi. Turn the device off.

vii. After grounding body charge only start working on electronic cards/ equipments

c. Connect the common point ground to the equipment ground (electrical ground connection). This is the preferred ground connection because all electrical equipment at the workstation is already connected to this ground connecting the ESD control materials or equipment to the equipment ground brings all components of the workstation to the same electrical potential.

6.1 A Proper Assembly Environment

A proper assembly environment can be ensured by taking the following steps:

- Define the specific electrostatic protect areas in which sensitive parts are handled. Typical areas requiring ESD protection are receiving inspection area, store, assembly line, test/ inspection area, packaging (dispatch), R&D/ Field service repair and clean rooms.
• Create a “Dust free environment”. This should be similar to clean room conditions of class 10,000 where no more than 3,500,000 particles larger than 0.5 \( \mu m \) exist.

• Control relative humidity approx. 60%.

• Use air ionizers.

• Packaging susceptible devices

• Use static dissipative floors and static dissipative work surfaces

• Label ESD-sensitive devices

• Use ESD protective material like mats, chairs, writs straps, heel grounder, garments, packaging and other items that provide ESD protection.

• Use ESD safe soldering irons, solder extractor.

**In addition**

• Remove all the unnecessary items from the assembly room.

• Eliminate all materials generating and holding static charges.

• Ensure a clean working table.

• Deploy trained manpower wearing cotton clothes, wrist straps as well as heel straps and avoiding activities generating charges.

• ESD lab must be cleaned, no eating smoking etc. should be allowed.

• ESD lab must be free from static charge generating material such as plastic nylon-fabrics, vinyl, Styrofoam etc.
Wrist Strap

Wrist Strap used by people seated at their workstations is very effective for ESD control. The wrist strap is worn snugly against bare skin. It should be attached securely to the common point ground with a current limiting resistor of 1MΩ (0.25 Watt with a working voltage rating of 250 volts) and some form of quick connect/disconnect arrangement. The current limiting resistor provides a slow but controlled drain of any charge to limit the current level and prevent damage when the charge is drained to ground.

Shoe grounders or Heel straps

They are designed to connect the body through the socks to a conductive floor or mat. Shoe grounders are very effective for stand–up operations and preclude the use of a long cord from the wrist strap. While seating, shoe grounders are not so effective because people may raise their feet when seated and lose contact with the conductive floor.

6.2 Hand-tools for ESD Work Station

- Solder iron
- Cleaning material
- Cored solder
- Pliers (bent, nose and straight)
- Wire stripper
- Lead forming tools
• Toolbox
• Fume absorber
• Solder iron station including holder
• Set of soldering iron bits
• Flux; sponge; soldering braid
• Tweezers
• Wire cutter
• Screwdriver set;
• Board holder and
• Cleaning solvent and brush
• Anti-static brush
• Spanner set
• Ionised air blower
• Compressed air gun

7. DEALING WITH PCBs

There are three major functional areas, which are vital while dealing with PCBs.

➢ Packaging
➢ Transport
➢ Storage

7.1 Packaging

• Most of the assembled PCBs are static sensitive, and therefore must be placed in antistatic bag and box. It should be moisture free.

• When packaging these boards, the user must be grounded (earthed).
• Improper packaging techniques might transmit an accumulated static charge through the board, damaging or destroying components.

• Even bare boards are sometimes static sensitive. Traces have become so fine that it's quite possible to blow an etch off the board (or change its characteristics) with a static charge.

7.2 Transportation

Transportation of cards in loco to shed laboratory, between different areas, and back should be done in ESD free (Anti Static / Conductive) bags, boxes and containers.

7.3 Storage Methods

• Storage of PCBs should be at appropriate places, which are clean and protected from moisture and dust.

• The PCBs should be individually packed in antistatic bags.

• Silica gel bags can be used in the boxes to protect the PCBs from moisture.

• Stacking of circuit boards and assemblies should be avoided to prevent physical damage.
Special racks and trays shall be provided for storing different types of boards such as ready to use, under repair, beyond repair etc. with designated colour coding. Following criteria may be applied:

- GREEN – Ready to use
- YELLOW – Under repair
- RED – Beyond repair

ETC.

There are three types of ESD protective enclosure materials including:

- Static Shielding - Prevents static electricity from passing through the package.
- Antistatic cushion - Provides antistatic cushioning for electronic assemblies.
- Static Dissipative - An "over-package" that has enough conductivity to dissipate any static build-up.

8.0 HANDLING

Circuit board assemblies must always be handled at properly designated work areas. Designated work areas must ensure safety from ESD. Areas of main concern include:

- Proper grounding methods.
- Static dissipation of work surfaces (e.g. work table).
- Wrist strap with grounding wire.
- Static dissipation of floor surfaces.
- Operation of compressed air guns.
• Conductive shoes grounding the human body.
• Antistatic work suit for person.

The above concerns should be checked periodically for continued safety.

Designated work areas must be kept free of static generating materials such as Styrofoam, vinyl, plastic, fabrics etc.

Whenever handling a circuit board assembly the operator must be properly grounded by one of the following:

• Wearing a wrist strap connected to earth ground.
• Wearing heel grounders and have feet on a static dissipative floor surface.
• Before you touch any electronic parts, plant your feet.
• If you do move your feet, plant them again and re-ground yourself before you touch any electronic parts.

• Circuit board assemblies should be handled by the edges. Do not touch the circuits or components.
Components should be handled by the edges when possible. Do not touch the component leads. Use ESD globes.
• Antistatic bag/packet normally used for packaging for PCB’s is having nonconductive inside surface & highly conductive outer surface. Therefore, in no instance PCB should be kept on antistatic packet after removing the card from the packet.

9. DUST ACCUMULATION & ITS EFFECTS ON PCB

Though the PCBs are normally inside sealed enclosures, it has been observed that, after few months of service in the field, a layer of dust deposits on the PCB. Air filters provided at the input side of the cooling air flow path are normally not fully effective in preventing fine dust particles and other chemical matter present in the environment. So fine dust and other chemical matter in the environment is drawn in and builds up inside the rack. This build-up can cause severe problems if left unchecked. The effects of dust build-up are summarised below:
9.1 Temperature Rise

Some of the components in a PCB can generate large amount of heat that must be dissipated to enable the component to function normally. The build-up of dust acts as a heat insulator, which prevents the system from cooling properly. With inadequate heat dissipation, the operating temperature of components may rise to unacceptable levels.

Excessive temperature may lead to intermittent system problems and erratic operation /malfunctioning of the component. Excessive heat also adds to the thermal stress problem caused by wider temperature changes between power-on and power-off states, shortening the life of system components. If the temperature rise is very high, the component can fail while working.

9.2 Tracking

The dust also might contain chemicals that conduct electricity. These chemicals can cause minor current shorts and create electrical signal paths where none should exist. The chemicals also cause rapid corrosion of cable connectors, socket-installed components, and areas where boards plug into slots.

10. ATTENDING OF PCBs

PCBs are now extensively used in Electric Locomotives/ EMUs of Indian Railways. When PCB fails, it has to be handled for replacement with a good one. They need periodical cleaning for optimal performance. In this connection, RDSO has already issued a Technical Circular no. ELRS/TC/0091 in February 2006 which addresses different issues on handling and cleaning of PCBs.
10.1 Cleaning Methods

While cleaning the PCBs remember the following don’t’s:

♦ Never clean IC Sockets
♦ Do not clean the PCBs with water or any other solvent.
♦ Do not move the cabling in the PCBs for cleaning.
♦ Do not keep the PCB on conductive surface after hot air blowing (If not Ionised hot air blower being used) as the static charge generated on PCB would get conducting path to damage the microchip.
♦ Avoid touching any conductive part of PCB.
♦ Use antistatic Brush carefully and lightly, if required, otherwise mechanical damage may occur.
♦ While cleaning use mouth mask.

(a) Dust Cleaning with Anti-static brush

To remove dust or other light debris from a PCB, it is advisable to simply brush the substance with a dry (clean) anti-static brush. Once the dirt is loose, the brush can be used to directly whisk the dust away, or a compressed clean air source can be used to blow the board clean.
It is not advisable to use an operating vacuum cleaner to try to remove dirt from a circuit board unless it is a specially designed vacuum cleaner for electronics work. (A household vacuum cleaner can generate thousands of volts of static electricity at the head of the hose, which can cause damage to some electronics.) Dry hot air can create severe problem of electrostatic charge as lower the relative humidity, higher the electrostatic voltage (A relative humidity of 50 to 60% is best to prevent electrostatic voltage). Therefore, cleaning of PCB may be avoided in dry season. Best method of using Ionised air blower to neutralised static charges of non conductive material.

(b) **Cleaning directions for Fibre optic connectors**

In order to remove dust/dirt from fibre optic connectors use adhesives tapes (special adhesive tapes that do not leaves sticky residues after removal) by touching the connector tip to the sticky surface of the tape.

In case of severe soiling, use alcohol as a solvent. Dry the connector with clean compressed air. If the fibre optic connectors are removed from transmitters or receivers, they should always be used with captive end caps.
10.2 **Handling of Fibre Optic Connections:**

1. The Fibre optic end terminations are of extremely high quality and even a speck of dust or smudge on it can spoil the connection. Therefore, open end connections must be closed with protective cap when not in use. Never scratch or even touch the fibre optic surface.

2. Connection of the fibre optic cables should not be pulled as this can damage the cable and the connector itself. The mechanical force must be limited to less than 25 N. It should be held at its connectors while removing from

3. The minimum bending radius of the fibre optic cable should be 50 mm.

10.3 **Instructions for Removing Conformal Coating**

- Switch ON the Workstation (Table) power supply.
- Switch ON the Conformal Coating Remover “MCR-21”.
- Check the “Blast Material” level inside, it can be checked by opening rear side window the material should be filled up to the indicator marked and not above it.
- Set the pressure on the MCR-21. It should be set to 5 bars.
• Open the glass cover and put the PCB board inside.
• Switch ON the “Blast ON” hold the nozzle and point it to the place from where the coating is to be removed.
• Press the “Foot Switch” to control the blast material flow.
• Once the coating is removed, switch OFF the Blast, now only compressed air sill come out of the nozzle, which can be used to clean the excess material on the PCB.
• To check the board, open the glass cover.
• To send back the material inside the MCR-21 use the vacuum suction gun placed on the right side of the MCR-21 unit.
• The material will be collected inside the bag.
• The material can be re-used again after cleaning.

Other method can also be used for conformal coating removing like
i. Solvent method,
ii. Peeling method,
iii. Thermal method,
iv. Grinding/ scrapping method,
v. Micro blasting method
10.4 Instructions for Applying Conformal Coating

Steps to apply conformal coating are described as below:

- Clean the PCB surface from dirt, wax, grease & all similar contaminants.
- Mask the areas of PCB where coating is not required.
- Shake the spray container/can vigorously before using. Repeat shaking frequently during use.
- Move the spray can upside down at a distance of 10-15 cm from PCB, spray evenly by pressing nozzle.
11. HEALTH AND SAFETY ASPECTS

- Don’t eat anything on the soldering worktable. The solder wire may contain Lead, which is poisonous, if taken internally.

- Some of the Lead from the solder can transfer onto the hands and then onto any food that one eats. Wash hands properly after soldering.

- Use a rag or a brush to clean your workstation from any dirt, grease, solder splatter, etc. Do not clean up the workstation by wiping with the open hand, it may hurt your hand.

- The fumes given off during the hand soldering process do not contain Lead, since Lead does not vaporise at the relatively low temperatures involved in hand soldering. However, some people are allergic to the flux fumes that are released during soldering. Fume extractors shall be used to remove the fumes.

- Molten solder can easily burn the skin and can cause serious eye-damages.

- Keep the iron in an open holder when not being used as the soldering bit may burn skin and material.

- Always use the wet sponge to clean the tip.

- Never flick the soldering iron.

- Protective clothing, if provided or needed, should be worn.

- Try to avoid dropping the iron but if it happens, don’t try to catch it. You always get the hot end.

- The mains power must be earthed to the line earth and shall be checked periodically for any damage in order to avoid shock hazards.
12. **DO’S and DON’TS**

12.1 **Do’s**
- Minimise handling.
- Keep parts in original packing until ready for use.
- Discharge static charge from the body before handling or touching electronic devices.
- Touch the ESD protective packing before touching inside device.
- Keep a dust free work area.
- Use ESD chairs in workstations.
- Use ESD globes.

12.2 **Don’ts**
- Touch the PCB/device/component by bare hand.
- Slide electro static device over any surface.
- Put masking tape on programmable ICS.
- Store or carry sensitive components of assemblies in plastic bags.
- Store sensitive components in thermocol / plastic foam.
- Handle electrostatic devices in “non ESD controlled” environment.
- Bend fiber optic cable.
Don’t touch conductive part of PCB without ESD controlled gloves

Right way to handle PCB

Don’t handle PCB without ESD controlled box

Right way to handle PCB

Don’t clean PCB with cloth

Right way to clean PCB with Anti static brush
Don’t hold PCB on conductive part

Don’t use common chair in work station

Always use anti static chair

Don’t sharp bend fibre optic cable

Right way to hold PCB with edge

Right way to bend fibre optic cable upto 50mm radius.
DISPLAY SAFETY BOARD IN ELECTRONIC LAB/WORK STATION

- Static can undo your best work
- Visitors carry static charges too!
- Any excuse for static-caused damage is groundless
- Unboxed or unbagged is unprotected

Static is everybody's business. Stand on the mat. Store & carry in static shielding bags or containers.
13. PRESENT APPROACH TO PCB SCRAP DISPOSAL

The PCB scrap is generated at various sources such as PCB manufacturers, OEMs (Original Equipment Manufacturers), individuals, corporate and equipment dismantlers. The scrap from these sources can be directly sent for recycling, recovery operations or for land fill. On an average, about 85 per cent of all the PCB scrap board waste is subject to land fill and only 15 per cent is currently subjected to any form of recycling.

Scrap PCBs can be categorised into three grades depending upon the inherent precious metal content. These are:

*Low grade scrap material:* This comprises power supply units and television boards having ferrite transformers, large aluminium heat sink assemblies and laminate off cuts.

*Medium grade scrap material:* This contains precious metal content, generally from pin and edge connectors used in high reliability equipment.

*High grade scrap material:* This comprises high precious metal content boards, gold containing integrated circuits, discrete components, opto-electronic devices, gold and palladium pin boards etc.

These grading materials help to determine the economics of applying recovery operations. However, it is possible to re-grade the material from low to medium category through selective manual disassembly of high percentage mass ferrous and aluminium components.

Recycling involves the disassembly of scrap PCBs followed by sorting, grading and shredding operations.
Iron and aluminium metals are removed from the final ground product by using magnetic and eddy current separation. The output from the recycler is either sent for land-fill or to a smelter. However, only those boards which contain sufficient gold or precious metal contents are subject to smelting, otherwise all non-precious metal bearing board scrap is consigned to land-fill. About one percent of the scrap is subject to specialized recycling operations solely for the purpose of precious metal recovery.

**Pollutants in e-Waste**

Pollutants or toxins in e-waste are typically concentrated in circuit boards, batteries, plastics and LCDs. Pollutants and their occurrence in waste electrical and electronic equipment are:

<table>
<thead>
<tr>
<th>Pollutants</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arsenic</td>
<td>Semiconductors, diodes, microwaves, LEDs (Light-emitting diodes), solar cells</td>
</tr>
<tr>
<td>Barium</td>
<td>Electron tubes, filler for plastic and rubber, lubricant additives.</td>
</tr>
<tr>
<td>Brominated flame-proofing agent</td>
<td>Casing, circuit boards (plastic), cables and PVC cables.</td>
</tr>
<tr>
<td>Cadmium</td>
<td>Batteries, pigments, solder, alloys, circuit boards, computer batteries, monitor cathode ray tubes (CRTs)</td>
</tr>
<tr>
<td>Chrome</td>
<td>Dyes/ pigments, switches, solar</td>
</tr>
<tr>
<td>Element</td>
<td>Uses</td>
</tr>
<tr>
<td>-----------</td>
<td>----------------------------------------------------------------------</td>
</tr>
<tr>
<td>Cobalt</td>
<td>Insulators</td>
</tr>
<tr>
<td>Copper</td>
<td>Conducted in cables, copper ribbons, coils, circuitry, pigments</td>
</tr>
<tr>
<td>Lead</td>
<td>Lead rechargeable batteries, solar, transistor, lithium batteries, PVC (polyvinyl chloride) stabilizers, lasers, LEDs, thermoelectric elements, circuit boards.</td>
</tr>
<tr>
<td>Liquid crystal</td>
<td>Displays</td>
</tr>
<tr>
<td>Lithium</td>
<td>Mobile telephones, photographic equipment, video equipment (batteries)</td>
</tr>
<tr>
<td>Mercury</td>
<td>Components in copper machines and steam irons; batteries in clocks and pocket calculators, switches, LCDs</td>
</tr>
<tr>
<td>Nickel</td>
<td>Alloys, batteries, relays, semiconductors, pigments</td>
</tr>
<tr>
<td>PCBs (polychlorinated biphenyls)</td>
<td>Transformers, capacitors, softening agents for paint, glue, plastic</td>
</tr>
<tr>
<td>Selenium</td>
<td>Photoelectric cells, pigments, photocopiers, fax machines.</td>
</tr>
<tr>
<td>Silver</td>
<td>Capacitors, switches (contacts), batteries, resistors</td>
</tr>
<tr>
<td>Zinc</td>
<td>Steel, brass, alloys, disposable and rechargeable batteries, luminous substances.</td>
</tr>
</tbody>
</table>
A better way of e-Waste Management:

It is Health Hazards for all life forms available on planet earth supporting proper health of our environment, which is ultimate goal on the planet earth. Following methods can be adopted for tackling e-waste and their management:

1. Waste Management of Technology at the very onset of development and manufacturing a piece of new electrical and electronic item.

2. Defining ‘User Codal Life’ of each electrical and electronic items.

3. Disallowing a new model of a product with a small or medium improvement in the previous model.

4. A time bound gap between introduction of new model and old model in the market should be made as part of regulation.

5. Encouraging repairing of a product instead of ‘Use and Through’ methodology.

6. Disposing e-waste not at one place but spreading over wide area on the planet earth to avoid health hazards to human health and environment. This I called ‘e-Product for All and e- Waste for All’.

7. If disposal is the last resort to do, one should discourage all disposal methods except ‘Deep Land Filling’ i.e. ‘Burying e-Waste at the Deepest Level Available at that Land’. Such method of disposal has environmental support looking at the way our land forms over millions of years.

8. Encouraging entrepreneurs to use various components of e-waste to manufacture a new product and government should give special subsidy to such manufacturing units.
For more details on e-waste management following may be referred:

- E-WASTE IN INDIA, Research Unit (LARRDIS), Rajya Sabha Secretariat, New Delhi, June 2011

14. USEFUL STANDARDS

**IPC-ESD-20 20:** Association Standard for the Development of an ESD Control Program: Covers the requirements necessary to design, establish, implement and maintain an Electrostatic Discharge (ESD) control program; offers guidance to protect and handle ESD sensitive times, based on the historical experience of both military and commercial organization.

**IPC-TA-722:** Technology Assessment Handbook on Soldering: Contains 45 articles on all aspects of soldering covering general soldering, soldering materials, manual soldering, mass soldering, wave soldering, re-flow, vapour phase and infra-red soldering.

**IPC/EIA J-STD-004:** Requirement for soldering fluxes includes amendment 1: Covers requirements for qualification and classification of rosin, resin, organic and inorganic fluxes according to the activity level and halide content of the fluxes; also addresses solder fluxes, flux-
containing material and low residue fluxes for no-clean process.

**IPC/EIA J-STD-005:** Requirement for soldering pastes amendment 1: List requirements for qualification and characterisation of solder paste; also include test methods and criteria for metal content, viscosity, slump, solder ball, tack and wetting of solder pastes.

**IPC-TR-460A:** Trouble shooting Checklist for wave soldering printed wiring boards: Provides a checklist of causes/ recommended corrective action for wave soldering.

**IPC-CH-65A:** Guidelines for cleaning of printed boards and assemblies: A roadmap for current and emerging cleaning issues in the electronics industry includes description and discussion of various cleaning methods; explain the relationship between materials, processes and contaminants in fabrication and assembly operations.

**IPC-SC-60A:** Post-solder solvent cleaning handbook: Addresses the use of solvent cleaning technology in automated and manual soldering operations; discusses properties of solvents, residues, considerations on process control and environmental issues.

**IPC-9201:** Surface insulation Resistance Handbook: Covers the terminology, theories, test procedures and test vehicles of surface insulation resistance (SIR) or temperature-humidity (TH) testing: includes failure modes and troubleshooting.

**IPC-S-816:** SMT Process guideline and checklist: This troubleshooting guide lists all types of processing problem
and solutions for surface mount assembly; covers bridging, skips, misalignment, placement, etc.

**IPC-CM-770D:** Component Mounting Guidelines for Printed Boards: Provides effective guidelines in the preparation of components for printed circuit board assembly and reviews pertinent design criteria, impacts and issues; contains techniques for assembly (both manual and machines including SMT and flip chip) and consideration of, and impact upon, subsequent soldering, cleaning, and coating processes.

**IPC-PE-740A:** Troubleshooting for printed board manufacture and assembly: Contains case histories of problems and corrective action in the design, manufacture, assembly and testing of printed circuit products.

**IPC-D-317A:** Design Guidelines for Electronic Packaging Utilizing High speed Techniques: Provides guidelines for the design of high speed circuitry including mechanical and electrical consideration and performance testing.

**IPC-TM-650:** Test Methods Manual: Contains over 150 industry approved test techniques and procedures for chemical, mechanical, electrical and environmental tests on all forms of printed circuit boards and connectors.

**IPC-PCB-EVAL-CH:** Printed Circuit Board Defect Evaluation Chart: Identifies board defects as revealed by micro-sectioning such as nail heading plating, cracks, epoxy smear, negative etch-back, plating voids, insufficient plating thickness, de-lamination, plating folds.
## 15. ITEMS REQUIRED FOR ELECTRONICS LAB

<table>
<thead>
<tr>
<th>Sr.</th>
<th>Description of Item</th>
<th>Application</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Digital phosphor Oscilloscope, Tektronics make, 350MHz, 3G/Hz sampling rate Model no-TDS5034B OR EQUIVALENT</td>
<td>For WRE gate drive card, SR gate unit Calibration.</td>
</tr>
<tr>
<td>2.</td>
<td>3 MHz Function generator cum frequency counter, TTI Make, Model no TG320, frequency counter 120MHz OR EQUIVALENT</td>
<td>to Measure Crystal frequency, to check WRE Gate drive card.</td>
</tr>
<tr>
<td>3.</td>
<td>True RMS Multi-meter, Fluke make, Model no. 87V OR EQUIVALENT</td>
<td>For various measurements</td>
</tr>
<tr>
<td>4.</td>
<td>Current Measurement Probe, Tektronics make, Model no P6021 OR EQUIVALENT</td>
<td>for WRE gate drive card, SR gate unit, current Calibration</td>
</tr>
<tr>
<td>5.</td>
<td>High voltage DC regulated power supply, Input voltage 230 V AC, output 0 to 128 V DC, output current 0 to 15 Amp, Make APLAB Model no L-12815 OR EQUIVALENT</td>
<td>For load testing of KUA915, KUB921, KUC153 power supply</td>
</tr>
<tr>
<td>6.</td>
<td>High voltage power supply 30 to 650 volt DC, 2 Amp, APLAB Make OR EQUIVALENT</td>
<td>For calibration of BUR DC Link Voltage sensor.</td>
</tr>
<tr>
<td>Sr.</td>
<td>Description of Item</td>
<td>Application</td>
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<tr>
<td>7.</td>
<td>DC Regulated power supply, 0 to 120 volt DC, 2Amp, Make APLAB, Model no. L 1282 OR EQUIVALENT</td>
<td>For WRE Test purpose.</td>
</tr>
<tr>
<td>8.</td>
<td>Human body voltage checker (For Checking body voltage)</td>
<td>ESD Measurement While entering in Lab.</td>
</tr>
<tr>
<td>9.</td>
<td>LED 850/1300 mm Source Model no. FLS-300, Wave length 850nm &amp; 1300nm, typical range 840-880 &amp; 1270-1345 nm, Maximum spectral width (FWHM) 585nm (850) &amp; 150nm (1300nm). stability 1 hr +-.05db .Make -EXFO OR EQUIVALENT</td>
<td>For dBm measurement of Transmitter of LWL, UFB660, SR Gate unit, WRE Gate card &amp; dB Measurement of FOB Cable on loco</td>
</tr>
<tr>
<td>10.</td>
<td>Optic Power meter. Model no. FPM-300, Power range +3 to -60 dBm, calibration wavelength 850/1300/1310/1550. Accuracy +/-0.25dbm. resolution +/-0.01 db, Display 4 digit LCD, Make- EXFO OR EQUIVALENT</td>
<td>For dBm measurement of Transmitter of LWL, UFB660, SR Gate unit, WRE Gate card &amp; dB Measurement of FOB Cable on loco</td>
</tr>
<tr>
<td>11.</td>
<td>Signal simulator for SAP Board (Make Slazer, Nasik road) OR EQUIVALENT</td>
<td>For calibration of SAP Card</td>
</tr>
<tr>
<td>Sr.</td>
<td>Description of Item</td>
<td>Application</td>
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</tr>
<tr>
<td>12</td>
<td>Tempo make Model no. 257A, LED Source for transmitter dBm Checking. OR EQUIVALENT</td>
<td>For dBm measurement of Transmitter of LWL, UFB660, SR Gate unit, WRE Gate card &amp; dB Measurement of FOB Cable on loco.</td>
</tr>
<tr>
<td>13</td>
<td>Tempo make model no. 555B, Optical Power meter for transmitter dBm Checking OR EQUIVALENT</td>
<td>For dBm measurement of Transmitter of LWL, UFB660, SR Gate unit, WRE Gate card &amp; dB Measurement of FOB Cable on loco.</td>
</tr>
<tr>
<td>14</td>
<td>GUSET For Checking SR Gate Unit (Make Slazer, Nasik road) Phone – no 08793027385 OR EQUIVALENT</td>
<td>For testing of SR gate unit at LAB</td>
</tr>
<tr>
<td>15</td>
<td>High Voltage Probe (Differential probe) Tektronics make OR EQUIVALENT</td>
<td>for use in ESD lab</td>
</tr>
<tr>
<td>16</td>
<td>De-soldering station, INDEE Make, Model no. DDS01 OR EQUIVALENT</td>
<td>Used to remove Components from PCB.</td>
</tr>
<tr>
<td>Sr.</td>
<td>Description of Item</td>
<td>Application</td>
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<td>-----</td>
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</tr>
<tr>
<td>17.</td>
<td>Soldering station, Weller make Model no. WD-1 OR EQUIVALENT</td>
<td>For soldering purpose</td>
</tr>
<tr>
<td>18.</td>
<td>Antistatic work table, Supplier ENVAIR ELECTRODYNE LIMITED, Pune, phone no- 02030688127 OR EQUIVALENT</td>
<td>for use in ESD lab</td>
</tr>
<tr>
<td>19.</td>
<td>Inspection light Magnifier</td>
<td>Checking PCB Track/Dry solder</td>
</tr>
<tr>
<td>20.</td>
<td>Antistatic card storage Bin, Brushes, Wrist Band, Sleeper (Supplier ECCD, Calcutta) PH no- 03322488356 OR EQUIVALENT</td>
<td>For storage of electronics cards</td>
</tr>
<tr>
<td>21.</td>
<td>Card extender for CEL &amp; Bur With Measurement Print (Slazer NKRD, GG Electronics Nasik) OR EQUIVALENT</td>
<td>To extend card for measurement of various parameter</td>
</tr>
<tr>
<td>22.</td>
<td>EPROM Programmer LAB tool -48 Uxp, Advantech Equipment OR EQUIVALENT</td>
<td>For EPROM Programming.</td>
</tr>
<tr>
<td>Sr.</td>
<td>Description of Item</td>
<td>Application</td>
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<tr>
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<tr>
<td>23.</td>
<td>Locally Developed Test ZIG at ELS, AQ, C. Rly.</td>
<td>For pneumatic card testing.</td>
</tr>
<tr>
<td>A</td>
<td>URB512D15 Card (Input Switch Board/LED Board)</td>
<td>Input/output can be monitor on LDS</td>
</tr>
<tr>
<td>B</td>
<td>URB177D15 Card (Input Switch Board/LED Board)</td>
<td>Input/output can be monitor on LDS</td>
</tr>
<tr>
<td>C</td>
<td>LWL Card /AFB635B08</td>
<td>Closed loop test for dBm Measurement</td>
</tr>
<tr>
<td>D</td>
<td>KUC153A02</td>
<td>Load test</td>
</tr>
<tr>
<td>E</td>
<td>KUA915A01</td>
<td>Load test</td>
</tr>
<tr>
<td>24.</td>
<td>AC Variac 0-230V /5Amp</td>
<td>For calibration of Wandler module &amp; BUR Sync Transformer</td>
</tr>
</tbody>
</table>
REFERENCES

1. RDSO Lucknow Technical circular No. ELRS/TC/0091, rev.0 - Dt. 16.02.2006

2. Field study conducted at various Railway Sheds & Workshops.

3. Field study conducted at Indocen Electronic Systems P Ltd.

4. Presentations given by Ms. INDOCEN during seminar held at CAMTECH on 07.11.2014

5. Suggestion received during seminar held at CAMTECH on 07.11.2014

6. The different books on PCB.

7. Details collected from internet.

OUR OBJECTIVE

To upgrade maintenance technologies and methodologies and achieve improvement in productivity and performance of all Railway assets and manpower which inter-alia would cover reliability, availability, utilisation and efficiency.

If you have any suggestions and specific comments please write to us.

Contact person: Director Electrical
Postal address: Indian Railways
Centre for Advanced Maintenance Technology, Maharajpur, Gwalior,
Pin Code - 474 005
Phone: 0751 – 2470740
0751 – 2470803
Fax: 0751 - 2470841