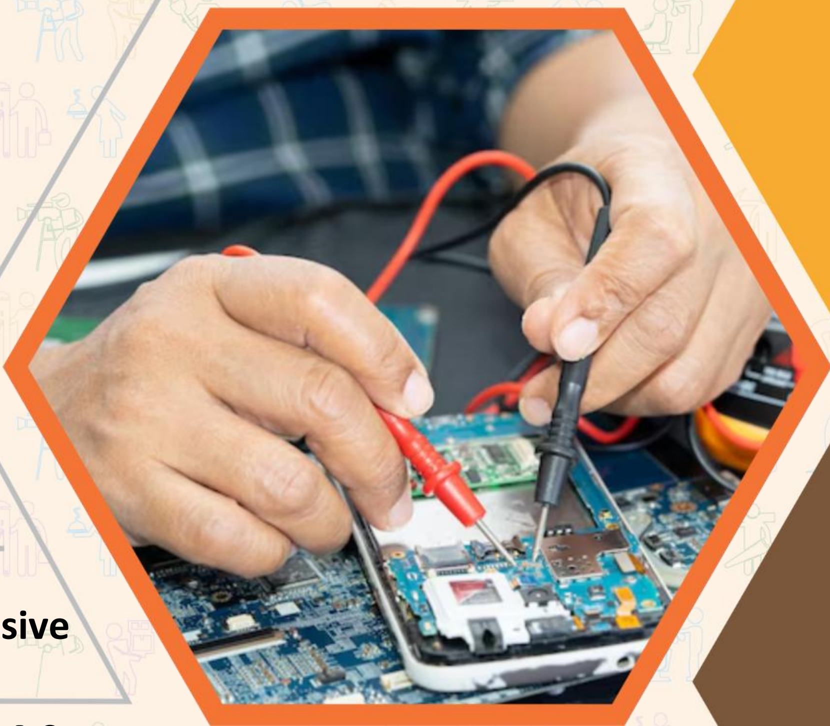
सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

Participant Handbook



Sector
Telecom

Sub-Sector
Passive Infrastructure

Occupation
Operations and Maintenance - Passive Infrastructure

Reference ID: **TEL/Q2500,** Version **4.0**
NSQF Level **3**

Hand Soldering Technician - Telecom Board

This book is sponsored by
Telecom Sector Skill Council
Estel House,3rd Floor, Plot No: - 126, Sector-44
Gurgaon, Haryana 122003
Phone: 0124-2222222
Email: tssc@tsscindia.com
Website: www.tsscindia.com

First Edition, December 2025

Disclaimer

The information contained herein has been obtained from sources reliable to Telecom Sector Skill Council. Telecom Sector Skill Council disclaims all warranties to the accuracy, completeness or adequacy of such information. Telecom Sector Skill Council shall have no liability for errors, omissions, or inadequacies, in the information contained herein, or for interpretations thereof. Every effort has been made to trace the owners of the copyright material included in the book. The publishers would be grateful for any omissions brought to their notice for acknowledgements in future editions of the book. No entity in Telecom Sector Skill Council shall be responsible for any loss whatsoever, sustained by any person who relies on this material. The material in this publication is copyrighted. No parts of this publication may be reproduced, stored or distributed in any form or by any means either on paper or electronic media, unless authorized by the Telecom Sector Skill Council.

> Skilling is building a better India.
> If we have to move India towards development then Skill Development should be our mission.

Shri Narendra Modi
Prime Minister of India

Certificate

COMPLIANCE TO QUALIFICATION PACK– NATIONAL OCCUPATIONAL STANDARDS

is hereby issued by the

TELECOM SECTOR SKILL COUNCIL

for

SKILLING CONTENT : PARTICIPANT HANDBOOK

Complying to National Occupational Standards of

Job Role/ Qualification Pack: "**Hand Soldering Technician - Telecom Board**" QP No. "**TEL/Q2500, NSQF level 3.0**"

Date of Issuance: 8th May 2025

Valid up to*: 30th April 2028

**Valid up to the next review date of the Qualification Pack or the 'Valid up to' date mentioned above (whichever is earlier)*

Authorised Signatory
(Telecom Sector Skill Council)

Acknowledgements

Telecom Sector Skill Council would like to express its gratitude to all the individuals and institutions who contributed in different ways towards the preparation of this “Participant Handbook”. Without their contribution it could not have been completed. Special thanks are extended to those who collaborated in the preparation of its different modules. Sincere appreciation is also extended to all who provided peer review for these modules.

The preparation of this handbook would not have been possible without the Telecom Industry’s support. Industry feedback has been extremely encouraging from inception to conclusion and it is with their input that we have tried to bridge the skill gaps existing today in the industry.

This participant handbook is dedicated to the aspiring youth who desire to achieve special skills which will be a lifelong asset for their future endeavours.

About this book

India is currently the world's second-largest telecommunications market with a subscriber base of 1.20 billion and has registered strong growth in the last decade and a half. The Industry has grown over twenty times in just ten years. Telecommunication has supported the socioeconomic development of India and has played a significant role in narrowing down the rural-urban digital divide to some extent. The exponential growth witnessed by the telecom sector in the past decade has led to the development of telecom equipment manufacturing and other supporting industries.

Over the years, the telecom industry has created millions of jobs in India. The sector contributes around 6.5% to the country's GDP and has given employment to more than four million jobs, of which approximately 2.2 million direct and 1.8 million are indirect employees. The overall employment opportunities in the telecom sector are expected to grow by 20% in the country, implying additional jobs in the upcoming years.

This Participant Handbook is designed to impart theoretical and practical skill training to students for becoming an Hand Soldering Technician - Telecom Board. Hand Soldering Technician - Telecom Board is responsible for maintaining uptime and quality of the network segment (both optical media & equipment) assigned to him by undertaking periodic preventive maintenance activities and ensuring effective fault management in case of fault occurrence. He is also required to coordinate activities for installation and commissioning of as per the route plan.

This Participant Handbook is based on Hand Soldering Technician - Telecom Board Qualification Pack (TEL/Q2500) & includes the following National Occupational Standards (NOSs):

1. TEL/N2500: High-Density Hand Soldering of Components on Telecom Boards
2. TEL/N2501: Rework on Defects and Undertake Selective Soldering
3. TEL/N2502: Cleaning and Inspection of Telecom Boards
4. TEL/N9107: Follow sustainability practices in telecom production and assembly line processes
5. DGT/VSQ/N0101: Employability Skills (30 Hours)

The Key Learning Outcomes and the skills gained by the participant are defined in their respective units. Post this training, the participant will be able maintain uptime and quality of the network segment by undertaking periodic preventive maintenance activities & effective fault management. We hope that this Participant Handbook will provide a sound learning support to our young friends to build an attractive career in the telecom industry.

Symbols Used

Key Learning Outcomes

Steps

Notes

Practical

Unit Objectives

Table of Contents

It is recommended that all trainings include the appropriate Employability skills Module. Content for the same is available here: **https://www.skillindiadigital.gov.in/content/list**

1. Introduction to the Sector and the Job Role of an Hand Soldering Technician - Telecom Board

Unit 1.1 - Introduction to Telecom Sector and Role of an Hand Soldering Technician - Telecom Board

TEL/N2500

Key Learning Outcomes

By the end of this module, the participants will be able to:

1. Explain the importance of Telecom Sector.
2. Discuss the role and responsibilities of an Hand Soldering Technician - Telecom Board.

UNIT 1.1: Introduction to Telecom Sector and Role of an Hand Soldering Technician - Telecom Board

Unit Objectives

By the end of this unit, the participants will be able to:

1. Explain the significance of the telecom sector in the installation and maintenance of optical fiber networks.
2. Elucidate the key skills and technical expertise required for an Hand Soldering Technician - Telecom Board.
3. Describe the challenges faced in splicing, testing, and troubleshooting optical fiber cables in telecom networks.
4. Determine the impact of precision and quality control in optical fiber installation and maintenance for reliable telecom services.
5. Discuss the roles and responsibilities of an Hand Soldering Technician - Telecom Board in ensuring efficient and high-quality network performance.

1.1.1 Telecom Sector in India

The Indian telecom industry has been one of the fastest-growing sectors in the country, striving to tap almost every potential customer with its services. Today, owning a mobile device is a basic necessity, and the demand for seamless connectivity continues to rise.

With the rapid expansion of the Information Technology (IT) sector, the telecom industry in India has experienced a major boom, leading to continuous market growth. Since the Indian population has become highly dependent on telecom services—and with several companies operating both in India and overseas—the sector often faces challenges in maintaining smooth operations amidst growing customer expectations. This study aims to provide insights into the current telecom sector and the measures being taken to enhance customer relationships.

Post-1991 liberalisation, privatisation, and globalisation, the Indian telecom market has become highly competitive, with multiple players operating simultaneously. In such an environment, companies are keen to understand customer perceptions of mobile services to refine their strategies and capture market share.

India remains the world's second-largest telecommunications market. As of March 2025, the total telephone subscriber base stood at around 1,200 million, with an overall tele-density of 85%. The internet subscriber base reached approximately 944 million, while broadband subscriptions grew to over 935 million wireless and about 45 million wired users by mid-2025.

Sector growth and infrastructure expansion:

Telecom infrastructure continues to expand rapidly, with the number of towers and mobile base transceiver stations (BTS) steadily increasing. This expansion has helped improve connectivity and service quality, especially in urban regions, though rural areas still face gaps.

Policy targets and initiatives: The Government has launched the National Broadband Mission 2.0 (2025–30), aiming to provide optical fibre connectivity to all Gram Panchayats and key institutions, with at least 95% uptime, and to raise average fixed broadband speeds to 100 Mbps by 2030. In parallel, the Draft National Telecom Policy 2025 sets ambitious goals such as achieving 100% 4G coverage, 90% 5G coverage, 80% tower fibreisation, broadband access to 100 million households, and the rollout of 1 million public Wi-Fi hotspots by 2030.

Fig. 1.1.1: Telecom Industry

Subscriber trends and market dynamics: By May 2025, India's total telecom subscriber base reached about 1,207 million. Reliance Jio and Bharti Airtel together accounted for nearly all new subscriber additions, while Vodafone Idea and BSNL continued to lose market share. By June 2025, the total wireless subscriber base stood at approximately 1,171 million, driven largely by urban growth, though rural subscriptions showed a slight decline.

1.1.2 Various Sub-Sectors of the Telecom Industry

Telecommunication is a multi-dimensional industry. It is divided into the following subsectors

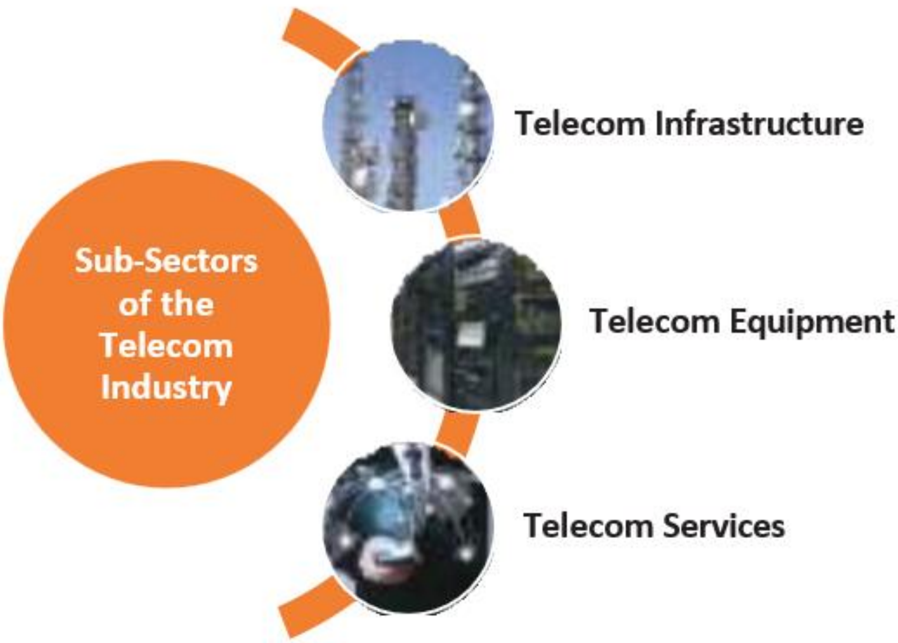


Fig. 1.1.2: Telecom Sub-Sectors

- **Telecom Infrastructure -** It is a physical medium through which all the data flows. This includes telephone wires, cables, microwaves, satellites, and mobile technology such as fifth-generation (5G) mobile networks.
- **Telecom Equipment -** It includes a wide range of communication technologies, from transmission lines and communication satellites to radios and answering machines. Examples of telecommunications equipment include switches, routers, voice-over-internet protocol (VoIP), and smartphones.
- **Telecom Services –** A service provided by a telecommunications provider or a specified set of user- information transfer capabilities provided to a group of users by a telecommunications system. It includes voice, data and other hosts of services.

The major segments within these sub-sectors include the following:

- Wireless communications
- Communications equipment
- Processing systems and products
- Long-distance carriers
- Domestic telecom services
- Foreign telecom services
- Diversified communication services

1.1.3 Impact on Economic Development

A robust telecom infrastructure is a key driver for economic growth and modernization:

- Business Efficiency: High-speed data transfer and communication enable businesses to operate more efficiently, manage global supply chains, and engage in e-commerce.
- Job Creation: The sector is a major employer, creating jobs in infrastructure development, equipment manufacturing, service provision, and maintenance.
- Innovation and GDP: It spurs innovation in related industries (e.g., software, fin-tech) and contributes substantially to the national Gross Domestic Product (GDP).

1.1.4 Fundamentals of Electronics in Telecom Boards

Telecom equipment relies heavily on sophisticated electronic circuits. Understanding the basic components is crucial.

1. Semiconductor Components

These are the fundamental building blocks for controlling current flow.

- **Switch Diode (Small-Signal Diode):**
  - Function: Used primarily in digital and low-power circuits where its ability to quickly switch on and off (rectify) low-current, high-frequency signals is essential.
  - Application: Logic circuits, signal clipping, and high-frequency switching in RF sections.

Fig. 1.1.3 Switch Diode (Small-Signal Diode)

- **Rectifier Diode (Power Diode):**
  - Function: Designed to handle high current and is used to convert an Alternating Current (AC) input into a Pulsating Direct Current (DC) output.
  - Application: In power supply circuits of all telecom equipment.

Fig. 1.1.4 Rectifier Diode (Power Diode)

B. Transistors

A transistor is a semiconductor device used to amplify or switch electronic signals and electrical power.

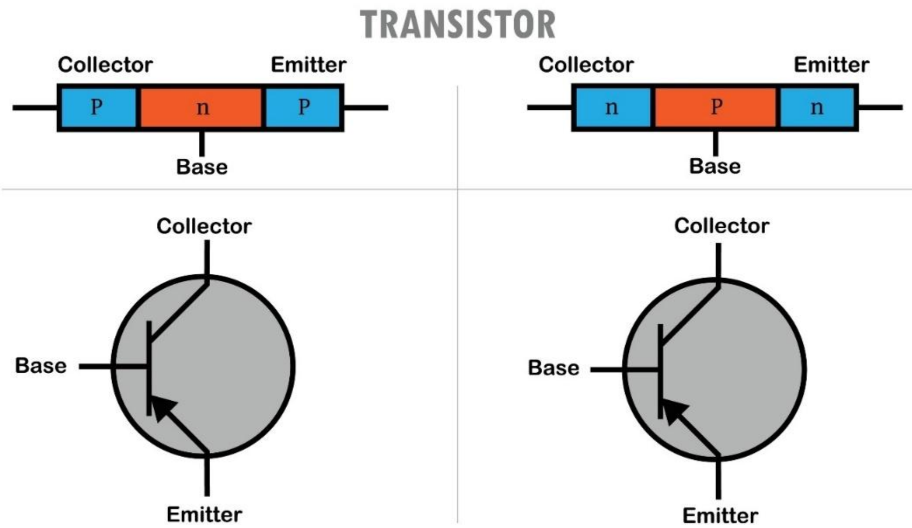


Fig. 1.1.5 Transistor

- **Amplifier Transistor:**
  - Function: Operates in the Active Region to take a small input signal (current or voltage) and produce a larger output signal, increasing the signal's strength.
  - Application: In the front-end Receiver (Rx) and output Transmitter (Tx) stages of telecom devices to boost weak signals.

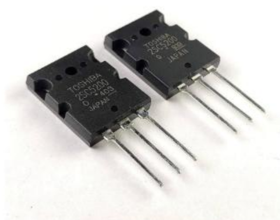


Fig. 1.1.6 Amplifier Transistor

- Switch Transistor:
  - Function: Operates in the Cut-off Region (OFF) or Saturation Region (ON) to act as an electronic switch for digital circuits, controlling the flow of current to other components.
  - Application: Digital logic circuits and microcontrollers for control and data processing.

C. Logic Gates

Logic gates are the elementary building blocks of a digital circuit. They have one or more inputs and produce a single output. The relationship between the input(s) and the output is based on a certain logic.

- Function: They implement the Boolean logic functions (AND, OR, NOT, XOR, etc.) necessary for decision-making and data manipulation within the digital section of telecom boards.
- Application: Used in microprocessors, memory control, switching systems, and data encoding/decoding circuits.

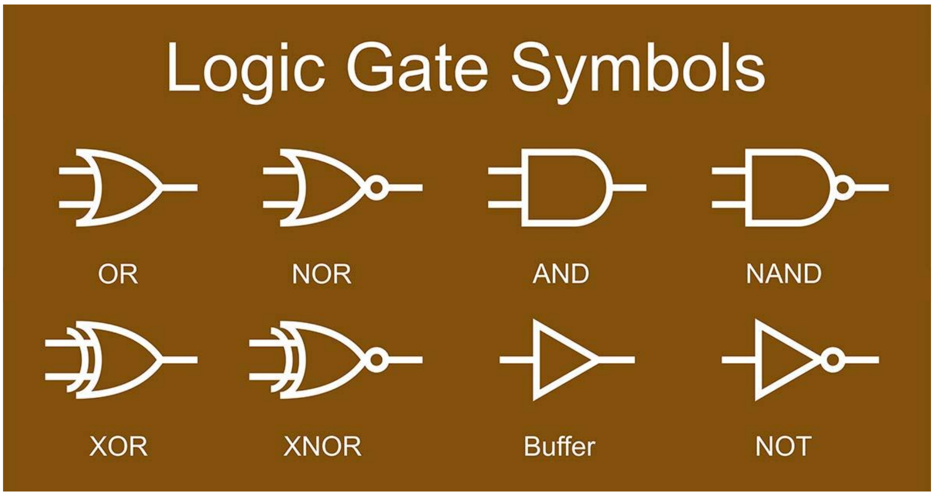


Fig. 1.1.7 Logic Gates

1.1.5 Functions of Electronic Circuits in Telecom Equipment

These circuits work together to facilitate the transmission, reception, and processing of data and voice.

Circuit Type.	Core Function	Example in Telecom Equipment
Transmitter	Converts a low-frequency data/voice signal into an RF signal suitable for transmission over the air or cable.	The circuitry that sends a signal from a mobile phone to a cell tower.
Receiver	Captures the weak incoming RF signal and converts it back into an usable low-frequency data/voice signal.	The circuitry that processes a signal received by a cell phone's antenna.

Switches	Controls the path of data or current flow electronically.	Router/Exchange circuitry that directs a call or data packet to the correct destination.
Power Supplies	Provides the necessary regulated DC voltages and current to all parts of the circuit.	AC-to-DC converters and voltage regulators on a base station board.
Amplifiers	Increases the power or amplitude of a signal.	Low Noise Amplifiers (LNA) in Receivers and Power Amplifiers (PA) in Transmitters.
Multiplexers	Combines multiple low-speed data streams into a single high-speed stream for transmission.	Equipment used in fiber optic networks (DWDM, FDM) to increase channel capacity.
Couplers	Allows two or more RF signals to be combined or separated without introducing significant loss or distortion.	Directional couplers in antenna feed networks.
Registers	Small, high-speed memory areas within a CPU used for temporary storage of data/instructions.	Digital signal processing chips that manage current processing tasks.
Memory (RAM/ROM)	Stores data and programs required for the equipment's operation.	Flash memory storing the operating system of a modem or router.
RF Circuits	General term for circuits that handle Radio Frequency (RF) signals (e.g., filters, mixers, oscillators).	Any circuit operating at high frequencies (above 3kHz) crucial for wireless communication.

1.1.6 Hand Soldering Technician: Roles, Skills, and Challenges

i. Introduction to Hand Soldering

Hand Soldering is the process of joining two or more metal components (like electronic components and printed circuit board pads) by melting a filler metal (solder) that has a relatively low melting point. The solder, once solidified, forms a robust mechanical and electrical connection.

Purpose in Telecom: Hand soldering is critical for prototyping, repairing, and reworking surface mount technology (SMT) and through-hole technology (THT) components on expensive and complex telecom boards.

ii. Key Skills and Technical Expertise Required

A successful Hand Soldering Technician requires a blend of manual dexterity, technical knowledge, and quality focus:

- Soldering and Rework Proficiency: Expert knowledge of the correct temperature, tip selection, flux application, and solder alloy for various components (e.g., fine-pitch SMT, BGA, QFP).
- Blueprint and Schematic Reading: Ability to interpret technical drawings, schematics, and component placement guides to identify and locate components accurately.
- Component Identification: Mastery in recognizing component types (resistors, capacitors, ICs), values, polarity, and orientation (e.g., Pin 1 identification).
- Quality and Inspection Standards: Deep familiarity with industry standards like IPC-A-610 (Acceptability of Electronic Assemblies) to ensure every joint meets high-reliability criteria.
- Microscope Usage: Skill in using a stereo microscope for intricate soldering and inspection tasks on small components.
- Electrostatic Discharge (ESD) Control: Strict adherence to ESD protocols to prevent damage to sensitive components.

iii. Roles and Responsibilities of the Technician

The primary focus is on ensuring the long-term reliability and functionality of electronic assemblies.

- Board Preparation: Cleaning, pre-tinning, and inspecting boards and components before starting work.
- Component Installation: Mounting and soldering new components (both Through-Hole (THT) and Surface Mount (SMT)) onto Printed Circuit Boards (PCBs) according to specifications.
- Rework and Repair: Removing defective components (de-soldering), preparing the site, and installing replacements. This includes repairing damaged PCB traces or pads.
- Quality Inspection: Visually and functionally inspecting finished work to check for soldering defects (e.g., shorts, opens, inadequate wetting, tombstoning).
- Tool and Station Maintenance: Calibrating and maintaining soldering irons, de-soldering tools, and rework stations.
- Documentation: Recording work performed, components used, and defects encountered in a log or work order system.

iv. Challenges in Soldering, Rework, Cleaning, and Inspection

The work involves precision and presents several technical and environmental challenges:

Area of Challenge	Description
Soldering/De-Soldering	Thermal Damage: Risk of overheating and damaging sensitive components (e.g., ICs) or PCB laminate due to excessive heat or contact time. Component Density: Increasingly smaller components and tighter spacing (fine-pitch) make access and precision difficult. Lifted Pads: During de-soldering, the PCB pad can separate from the board due to uneven heat or excessive force.
Reworking Defects	Solder Bridges/Shorts: Accidental connection of adjacent pads or traces, often requiring meticulous cleanup without damaging surrounding areas. Tombstoning: A surface mount component standing up on one end due to uneven wetting/heating during the initial soldering process.

Cleaning	Residue Removal: Effectively removing flux residue (which can be conductive or corrosive) without damaging components or the board finish. Cleaning Agents: Selecting the correct type of cleaner (e.g., Isopropyl Alcohol) that is compatible with the components and board material.
Inspection	Microscopic Defects: Identifying subtle defects like cold joints, fractured solder, or insufficient fillet formation which are invisible to the naked eye. Component Polarity: Verifying the correct orientation of polarized components (diodes, ICs, electrolytic capacitors) as incorrect placement leads to immediate circuit failure.[28]

Exercise

A. Multiple Choice Questions (MCQs):

1. The telecom sector is crucial for modern communication primarily because it:
   a) Generates electricity
   b) Facilitates high-speed data and voice connectivity
   c) Manufactures optical fibers
   d) Regulates government policies
2. Which of the following is a key technical skill required for an Hand Soldering Technician - Telecom Board?
   a) Welding metal cables
   b) Precision fiber cleaving and splicing
   c) Installing electrical transformers
   d) Designing software algorithms
3. One major challenge faced in optical fiber splicing is:
   a) High voltage current in fibers
   b) Aligning fiber cores precisely to minimize signal loss
   c) Excessive fiber flexibility
   d) Overheating of fiber jackets
4. Fiber optic technology primarily improves:
   a) Electrical power transmission
   b) Internet speed and connectivity
   c) Radio signal quality
   d) Cable durability for plumbing
5. The responsibilities of an Hand Soldering Technician - Telecom Board include:
   a) Designing network routers
   b) Installing, splicing, and testing fiber optic cables
   c) Manufacturing telecom hardware
   d) Drafting government policies

B. Short Answer Questions:

1. Explain the significance of the telecom sector in modern communication and economic development.
2. List three key technical skills an Hand Soldering Technician - Telecom Board must possess.
3. Describe one major challenge faced in fiber optic splicing and how it can be addressed.
4. How does fiber optic technology impact internet speed and overall connectivity?
5. Outline the main roles and responsibilities of an Hand Soldering Technician - Telecom Board in network deployment.

C. Fill in the Blanks:

1. An Hand Soldering Technician - Telecom Board is responsible for ___________ and ___________ optical fibers.
2. The telecom sector contributes to economic development by enabling faster ___________ and ___________ transmission.
3. Precise ___________ of fiber cores is critical to reduce signal loss during splicing.
4. Fiber optic cables provide high-speed data transmission due to the principle of ___________.
5. One challenge in splicing optical fibers is ensuring proper ___________ alignment to maintain signal quality.

Notes

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

2. High-Density Hand Soldering of Components on Telecom Boards

Unit 2.1 – Preparing Telecom Boards for Soldering
Unit 2.2 – Performing High-Density Hand Soldering on Telecom Boards

TEL/N2500

Key Learning Outcomes

By the end of this module, the participants will be able to:

1. Explain the key steps involved in inspecting the route plan for optical fiber cable installation.
2. Elucidate the process of coordinating cable laying and pulling to ensure compliance with industry standards.
3. Discuss the importance of adhering to health and safety guidelines in optical fiber installation projects.
4. Explain the significance of reporting and recording installation activities for project tracking and fault management.

UNIT 2.1: Preparing Telecom Boards for Soldering

Unit Objectives

By the end of this unit, the participants will be able to:

1. Explain the importance of interpreting CAD specifications to identify soldering points, pad layouts, and component placements.
2. Describe the setup process for soldering jigs, fixtures, and workstations to ensure stability during soldering.
3. Discuss the selection criteria for soldering tools, including soldering bits, flux types, and solder wire diameters based on application requirements.
4. Elucidate the impact of contamination on soldering quality and the need for proper cleaning of PCB surfaces, soldering tips, and component leads.
5. Explain the significance of temperature control in soldering stations and methods to prevent overheating or cold solder joints.
6. Enlist the safety, health, and environmental (SHE) guidelines related to handling soldering materials, including proper ventilation and personal protective equipment (PPE).
7. Describe the role of electrostatic discharge (ESD) protection in preventing damage to sensitive telecom components.
8. Discuss documentation and record-keeping requirements related to soldering preparation, including tracking materials used and maintaining quality checklists. Demonstrate how to interpret CAD drawings to locate soldering points, pad connections, and component placements.
9. Show how to set up and align soldering jigs and fixtures to ensure component stability and precision during soldering.
10. Demonstrate the process of selecting appropriate soldering materials, including flux, solder wire, and soldering tips for different applications.
11. Show how to clean soldering bits, PCB surfaces, and component leads to prevent contamination and ensure strong solder joints.
12. Demonstrate the proper calibration and temperature setting of a soldering station to match the requirements of different telecom components.
13. Show how to implement ESD protection measures, including the use of anti-static mats, wrist straps, and grounding techniques.
14. Demonstrate safe handling and storage of soldering materials following SHE guidelines.
15. Show how to document and maintain records of soldering material usage, cleaning procedures, and equipment calibration.

2.1.1 Interpreting Technical Specifications and Setup

Effective soldering begins with accurately understanding the design specifications and properly setting up the workspace.

i. Importance of Interpreting CAD Specifications

Computer-Aided Design (CAD) files and their resulting documentation (Gerber files, assembly drawings) are the blueprint for the PCB. Correct interpretation is vital for reliability and function:

- Identifying Soldering Points and Pad Layouts: The CAD data specifies the exact location, size, and material of the solder pads (the metal surfaces where components attach). Misinterpreting this can lead to soldering on the wrong points, causing shorts or open circuits.
- Component Placements and Orientation: Drawings indicate the precise location, footprint, and polarity (the correct way to orient components like diodes, ICs, and electrolytic capacitors) of every part. Incorrect orientation will cause circuit malfunction or damage.
- Thermal Reliefs and Vias: CAD shows specific features like thermal reliefs (patterns that reduce heat sinking to a plane) and vias (holes connecting layers), which influence the required soldering temperature and technique.

ii. Setup Process for Soldering Workstations and Fixtures

A well-organized and stable workstation is fundamental for high-quality, repeatable results.

- Workstation Setup:
  - Ensure the work surface is clean, non-flammable, and well-lit.
  - Position the soldering station, tools, and materials within easy, comfortable reach.
  - Integrate a magnification tool (e.g., a stereo microscope) directly into the workspace for fine-pitch work.
- Jigs and Fixtures:
  - Role: These tools hold the PCB and components rigidly and securely during the soldering process, preventing movement and ensuring consistent alignment.
  - Alignment: Jigs must be carefully aligned to the specific PCB being worked on, often using mounting holes or board edges as references.
  - Stability: Ensure the fixture base is heavy or clamped down to prevent slippage or vibration during the application of the soldering iron.

2.2.2 Selection of Soldering Materials and Tools

Choosing the correct materials and equipment is essential for achieving reliable solder joints on telecom boards.

i. Selection Criteria for Soldering Tools

The choice of soldering iron, tip, flux, and solder must be matched to the specific application, particularly the component type and size.

Tool/Material	Selection Criteria based on Application
Soldering Bits (Tips)	Size: Smaller tips (e.g., chisel, conical) for fine-pitch SMT components; larger tips for THT or high-thermal mass joints. Shape: Conical for precision; chisel for maximum heat transfer/contact area. Material: Iron-plated copper for durability and good heat transfer.
Flux Types	Activity Level: Low-activity No-Clean flux is preferred for telecom and sensitive electronics to minimize corrosion risks. Water-Soluble flux is used where residue removal is mandatory and highly effective. Form: Liquid flux for wave/reflow; flux-core solder wire or flux pens for hand soldering.
Solder Wire Diameters	Component Size: Thin diameters (e.g., 0.5 mm or less) for fine-pitch SMT parts to control the amount of solder deposited. Thicker diameters (e.g., 0.8 mm to 1.0 mm) for standard THT and larger pads. Alloy: Lead-Free alloys (e.g., Sn96.5/Ag3.0/Cu0.5) are standard, requiring higher temperatures than traditional leaded alloys (Sn63/Pb37).

ii. Significance of Temperature Control

Precise temperature management is non-negotiable for quality soldering and component preservation.

- Preventing Overheating: Excessive temperatures can cause thermal stress and permanent damage to delicate component internal structures or can lead to PCB delamination (layers separating).
- Preventing Cold Solder Joints: Insufficient temperature prevents the solder from fully melting and flowing across the pad and lead (poor wetting). This results in a mechanically weak and electrically unreliable cold solder joint.
- Optimal Setting: The correct temperature is typically just high enough to melt the specific solder alloy used and ensure rapid heat transfer to the joint while minimizing the component exposure time (the tip temperature is usually 50°C to 100°C above the solder's melting point).

2.2.3 Contamination Control and Cleaning Procedures

Contamination is a major enemy of a reliable solder joint, leading to poor wetting and long-term corrosion.

i. Impact of Contamination on Soldering Quality

Contaminants on the metal surfaces prevent the solder from bonding properly:

- Poor Wetting: Oxides (tarnish), oils, dirt, or dust on the PCB pads or component leads create a barrier, causing the solder to ball up rather than flow out smoothly (dewetting or non-wetting).
- Weak Joints: Contaminated joints have reduced mechanical strength and higher electrical resistance.

- Corrosion: Residues from certain types of flux, skin oils, or finger grease can become chemically active over time, leading to the corrosion of the copper traces and component leads.

ii. Proper Cleaning Requirements

Regular and effective cleaning is necessary for quality assurance:

- PCB Surface Cleaning: Use appropriate solvents (e.g., Isopropyl Alcohol (IPA)) and lint-free wipes to clean bare boards or rework sites to remove dirt, oils, and previous flux residues before soldering.
- Component Lead Cleaning: Component leads should be cleaned if they appear oxidized. Pre-tinning (applying a thin, fresh layer of solder) to old or oxidized leads is a common practice.
- Soldering Tip Cleaning: The soldering tip must be kept clean and tinned (coated with a thin layer of fresh solder) at all times. Use a damp sponge, brass wool, or tip cleaner to remove burnt flux and oxidation regularly to ensure maximum heat transfer.

2.2.4 Safety, ESD Protection, and Documentation

These essential practices protect personnel, sensitive equipment, and ensure compliance.

i. Safety, Health, and Environmental (SHE) Guidelines

Soldering involves heat and volatile materials, necessitating strict safety protocols:

- Ventilation: Use fume extraction systems (fume hoods or bench-top extractors) to remove hazardous solder fumes (especially lead and flux vapors) from the breathing zone
- Personal Protective Equipment (PPE):
  - Safety Glasses: To protect eyes from spattering solder.
  - Gloves: Optional, but recommended to prevent skin contact with flux and solvents (must be ESD-safe if working with sensitive parts).
  - Heat-Resistant Mats: To protect the workstation from accidental burns.
- Material Handling: Store flux, solvents, and solder in clearly labeled, secure containers, following manufacturer and Material Safety Data Sheet (MSDS) guidelines.

ii. Role of Electrostatic Discharge (ESD) Protection

Telecom components, especially Integrated Circuits (ICs) and RF devices, are highly sensitive to Electrostatic Discharge (ESD), which can destroy them instantly (latent damage).

- ESD Protection Role: ESD measures provide a controlled path to ground for static electricity, preventing uncontrolled discharge through the sensitive component circuitry.
- Implementation Measures:
  - Anti-Static Mats: Grounded work surfaces dissipate static charges safely.
  - Wrist Straps: Worn snugly on the wrist and connected to a common point ground, safely shunting static charge away from the technician's body.
  - Grounded Equipment: All tools, including soldering irons and fixtures, must be properly grounded.
  - ESD-Safe Containers: Components should only be stored and transported in anti-static bags or trays.

iii. Documentation and Record-Keeping Requirements

Accurate documentation ensures traceability, quality control, and process improvement.

- Tracking Materials Used: Record the batch numbers and types of solder wire, flux, and any solvents used for a specific job. This is vital if a material-related defect is found later (e.g., contaminated solder).
- Maintaining Quality Checklists: Use pre-defined checklists to confirm that all preparation steps (e.g., cleaning, jig alignment, temperature calibration) and post-soldering inspection criteria have been met.
- Equipment Calibration Records: Document the calibration status and settings of the soldering station, especially the temperature and tip-to-ground resistance measurements. This validates that the equipment operated within specified tolerances.
- Work Order Logs: Record the date, technician name, board serial number, components worked on, and any defects or unusual observations.

Notes

UNIT 2.2: Performing High-Density Hand Soldering on Telecom Boards

Unit Objectives

By the end of this unit, the participants will be able to:

1. Explain the importance of precise component alignment in high-density telecom boards to ensure functional connections.
2. Describe different soldering techniques, including drag soldering, point-to-point soldering, and controlled heat application, to achieve uniform joints.
3. Discuss the correct use of flux in soldering, its types, and its role in preventing oxidation and improving solder flow.
4. Elucidate the significance of maintaining optimal soldering temperature to avoid overheating and cold joints.
5. Enlist common soldering defects, such as cold joints, solder bridges, and excess solder, along with their causes.
6. Describe corrective actions to fix defects, including reflow techniques, solder wick usage, and desoldering pumps.
7. Discuss industry standards for soldering quality (IPC-A-610) and their role in ensuring telecom board reliability.
8. Explain the role of magnification tools in inspecting solder joints for defects and compliance with industry standards.
9. Describe preventive maintenance practices for soldering stations, including tip cleaning, calibration, and replacement schedules.
10. Discuss safety precautions while soldering, including ventilation requirements, PPE usage, and handling of lead-based and lead-free solder
11. Demonstrate the process of aligning and placing components accurately on high-density telecom boards before soldering.
12. Show how to apply the correct amount of solder and flux to achieve optimal solder joints without bridging.
13. Demonstrate controlled heat application techniques to prevent overheating and thermal stress on components.
14. Show how to use high-density soldering methods, such as drag soldering and point-to-point soldering, to maintain uniformity.
15. Demonstrate the identification of common soldering defects using visual inspection and magnification tools.
16. Show how to correct soldering defects such as cold joints, solder bridges, and excessive solder using desoldering tools.
17. Demonstrate the inspection of solder joints using IPC-A-610 standards and checking for compliance.
18. Show how to perform preventive maintenance on soldering stations, including tip cleaning and equipment calibration.
19. Demonstrate safe handling and disposal of soldering materials following industry safety guidelines.

2.2.1 Component Placement and Soldering Techniques

Achieving a quality solder joint starts with precise placement and the correct heat application method.

i. Importance of Precise Component Alignment

In high-density telecom boards, components (especially fine-pitch Surface Mount Devices - SMT) are packed closely together. Precise alignment is crucial because:

- Functional Connections: It ensures the component leads are perfectly centered over the correct solder pads. Misalignment leads to shorts (solder bridges to adjacent pads) or open circuits (no connection).
- Preventing Bridging: Correct alignment minimizes the gap between the lead and the pad edge, which helps surface tension pull the solder precisely onto the pad, reducing the risk of a solder bridge.
- Rework Facilitation: A correctly aligned component is easier to inspect and less prone to accidental movement or damage during subsequent rework operations.

ii. Specialized Soldering Techniques

Hand soldering high-density boards requires specialized techniques beyond basic point soldering.

- Point-to-Point Soldering (Standard):
  - o Method: Applying the heated tip simultaneously to the component lead and the pad, then feeding a controlled amount of solder to the joint.
  - o Application: Used for Through-Hole Technology (THT) and larger SMT components (e.g., chip resistors/capacitors, two-leaded components).

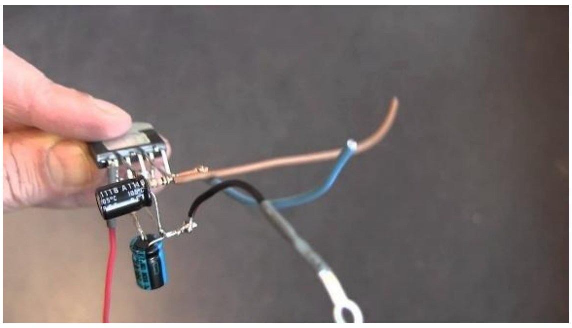


Fig. 2.2.1 Point-to-Point Soldering

- **Drag Soldering (SMT ICs):**
  - o Method: Applying flux to all leads of a multi-pin component (Integrated Circuit - IC), loading a large soldering tip (e.g., mini-wave or hoof tip) with solder, and "dragging" the tip across all pins in one smooth motion.
  - o Goal: To solder all pins quickly and simultaneously, relying on the flux and surface tension to prevent excessive bridging.

- **Controlled Heat Application (Thermal Management):**
  - o Method: Applying heat for the minimum time required (typically 2-4 seconds) to achieve good solder flow while using the lowest effective tip temperature.
  - o Significance: Prevents thermal stress and overheating of sensitive silicon devices and minimizes damage to the PCB laminate.

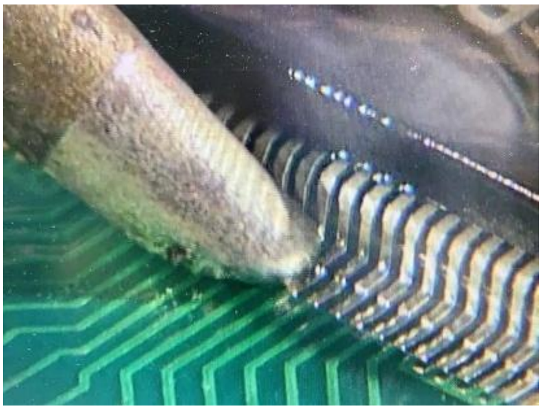


Fig. 2.2.2 Drag Soldering

2.2.2 Flux Application and Temperature Control

Flux and temperature are the two most critical variables controlling solder joint quality.

i. The Correct Use and Role of Flux

Flux is a chemical cleaning agent essential for quality soldering.

- Role in Preventing Oxidation: Flux removes the thin layer of metal oxide (tarnish) that forms instantly on the heated component leads and copper pads. Without this removal, the solder cannot bond to the metal surface (non-wetting).
- Role in Improving Solder Flow (Wetting): By chemically cleaning the surfaces, flux allows the molten solder to flow out smoothly and adhere strongly to the pad and lead, creating a proper fillet (the concave curve of the solder).
- Types of Flux:
    - o Rosin Flux: Derived from pine trees, suitable for general purpose.
    - o Water-Soluble Flux: Highly active and effective, but requires thorough cleaning with water immediately after soldering.
    - o No-Clean Flux: Preferred in telecom; leaves a residue that is non-corrosive and generally acceptable to leave on the board, saving a cleaning step.

ii. Significance of Maintaining Optimal Soldering Temperature

The temperature setting is key to balancing speed and component safety.

- Avoiding Cold Joints: Optimal temperature ensures the solder melts completely and quickly and that enough heat is transferred to both the pad and the component lead. This prevents cold solder joints, which appear dull, grainy, and are electrically unreliable.
- Avoiding Overheating: Excessively high temperatures or prolonged contact cause component damage, solder balling (due to flux being burned off too quickly), and PCB damage (delamination or pad lifting).
- Optimal Range: The tip temperature is typically set \$50^{\circ}\text{C}\$ to \$100^{\circ}\text{C}\$ above the liquidus temperature of the solder alloy to ensure a fast, efficient thermal transfer and minimize the time the component is exposed to heat.

2.2.3 Defect Identification, Correction, and Quality Standards

Quality control ensures every repaired or assembled board meets the rigorous demands of the telecom industry.

i. Common Soldering Defects and Causes

Defect	Description	Primary Cause(s)
Cold Joint	Solder is dull, grainy, rough, and did not flow well.	Insufficient heat (too low temp, short contact time, dirty tip). Component or board movement during solidification.
Solder Bridge	Solder connects two adjacent pads or tracks that should be separate (a short circuit).	Excessive solder applied. Poor component alignment (leads too close). Excessive flux/poor cleanup.
Excess Solder	Too much solder applied, obscuring the joint shape (a convex fillet).	Tip size too large for the pad. Feeding too much solder wire.
Incomplete Wetting	Solder adheres only to the pad or only to the component lead, not both.	Contamination (oxidation, dirt, oil) on the unwetted surface. Insufficient flux.
Lifted Pad	The copper pad separates from the PCB substrate.	Applying excessive force or heat for too long during de-soldering or rework.

ii. Corrective Actions and Rework Techniques

- Reflow Techniques (Fixing Cold Joints/Incomplete Wetting): Reapplying flux and touching the joint with the iron tip for 2-3 seconds allows the existing solder to melt, flow, and wet the surfaces correctly.
- Solder Wick Usage (Removing Excess/Bridges): Place copper braid (solder wick) over the unwanted solder (excess or bridge). Apply the heated iron tip to the wick. Capillary action draws the molten solder into the wick.
- De-soldering Pumps (Suction): Used primarily for THT components. Melt the solder and quickly use the pump's vacuum action to suck the molten solder away from the joint.
- Hot Air Rework Stations: For removing large SMT ICs or Ball Grid Arrays (BGAs), controlled hot air is applied to melt all solder joints simultaneously for removal.

iii. Industry Standards (IPC-A-610) and Inspection

- IPC-A-610 (Acceptability of Electronic Assemblies): This is the globally recognized standard defining the criteria for acceptable, preferred, and defective electronic assembly work.
- Role in Reliability: Adherence to IPC-A-610 (typically Class 3 for high-reliability telecom equipment) ensures consistency, functionality, and long-term reliability of the soldered connections.
- Magnification Tools: Tools like stereo microscopes or digital cameras with magnification are mandatory for inspecting fine-pitch and SMT work. They allow the technician to check for:

- o Proper fillet formation (concave curve).
- o Absence of shorts or bridges.
- o Correct component polarity and alignment.
- o The quality of the metallic luster (indicative of a good joint).

2.2.4 Safety and Preventive Maintenance

Ongoing safety and equipment care are essential for consistent performance.

i. Safety Precautions While Soldering

- Ventilation Requirements: Ensure a local fume extractor is active and positioned near the work to capture and filter solder fumes, protecting the respiratory system.
- PPE Usage: Always wear safety glasses to protect against flux spatter.
- Solder Handling:
  - o Lead-Based Solder: Requires strict hygiene (no eating or drinking at the station, wash hands thoroughly) due to lead toxicity.
  - o Lead-Free Solder: Requires higher temperatures, leading to increased flux fume generation; thus, high-performance ventilation is crucial.

ii. Preventive Maintenance Practices for Soldering Stations

Consistent maintenance extends tool life and maintains soldering quality.

- Tip Cleaning and Tinning: The tip must be wiped frequently (with brass wool or a damp sponge) and immediately re-tinned (coated with fresh solder) to prevent oxidation, which destroys the tip's ability to transfer heat effectively.
- Tip Replacement Schedules: Tips should be replaced when the iron plating wears off, exposing the copper core, or when they can no longer be properly tinned or shaped.
- Calibration: Periodically check the actual tip temperature using a dedicated tip thermometer/calibrator. The station should be recalibrated if the reading deviates significantly from the set point, ensuring the temperature remains optimal and controlled.

2.2.5 Rework and De-soldering Advanced Techniques

- De-soldering Techniques for Multi-pin Components:
  - o Hot Air Removal: Describing the use of hot air rework stations for removing Surface Mount Devices (SMDs), focusing on nozzle selection, airflow, and temperature profiles to ensure safe removal without damaging the board.
  - o Component Skimming: Techniques for removing large, multi-pin ICs (e.g., Quad Flat Packages - QFPs) using specialized tools or precise hot air application.

- Pad and Trace Repair: Methods for repairing damaged or lifted solder pads and severed PCB traces using repair kits, conductive epoxy, or jumper wires, which is critical for expensive telecom boards.
- Solder Joint Profiling: Introduction to using thermal sensors or software to monitor the time-temperature curve during soldering/de-soldering, ensuring the component's maximum temperature limits are not exceeded.

2.2.6 Handling Specialized Telecom Components

- **Handling Ball Grid Array (BGA) Components:**
  - o Explanation of the BGA package structure and why standard hand soldering is inadequate.
  - o Introduction to the principles of BGA Reballing and the use of dedicated BGA rework stations (for removal and placement).
- Radio Frequency (RF) Component Specifics: Discussion on the unique handling and soldering requirements for RF components (e.g., filters, power amplifiers), emphasizing the need for short connections and minimizing parasitic capacitance, which high heat can affect.
- Moisture Sensitivity Level (MSL) Handling: Explaining the concept of MSL and the necessary baking procedures (de-humidification) for components that absorb moisture (especially ICs) before they can be safely exposed to soldering heat.

2.2.7 Troubleshooting and Circuit Verification

- Visual Troubleshooting vs. Functional Testing: Distinguishing between inspecting for visible defects (solder bridges, polarity errors) and verifying circuit performance after rework.
- Basic Measurement Tools: Introducing the use of a Digital Multimeter (DMM) for:
  - o Continuity Checks: Checking for shorts between traces or pads.
  - o Resistance Measurement: Verifying the value of installed passive components.
  - o Voltage Checks: Verifying the presence of necessary power supply voltages after the repair.

Exercise

A. Short Answer Questions:

1. Explain why accurate interpretation of CAD drawings is essential for identifying soldering points, pad layouts, and component placements on telecom PCBs.
2. Describe the importance of temperature control in soldering stations and how improper temperature settings can affect solder joint quality.
3. Discuss the role of ESD protection in safeguarding sensitive telecom components during soldering preparation.
4. Explain how contamination affects soldering quality and why proper cleaning of PCB surfaces and soldering tips is necessary.
5. Describe common soldering defects and how they impact the performance of high-density telecom boards.

B. Multiple Choice Questions (MCQs):

1. Which of the following is used to protect sensitive telecom components from electrostatic discharge?
   a) Heat gun
   b) Anti-static wrist strap
   c) Solder wick
   d) Flux pen
2. Excessive solder on a joint is most likely caused by:
   a) Low flux activity
   b) Using too large a soldering tip
   c) Insufficient heating
   d) Poor ventilation
3. Which document provides global quality standards for soldering workmanship?
   a) ISO-9001
   b) IEC-60870
   c) IPC-A-610
   d) ANSI-Z136
4. The primary purpose of using flux during soldering is to:
   a) Increase solder melting temperature
   b) Prevent oxidation and improve solder flow
   c) Strengthen PCB pads
   d) Cool the solder joint
5. Drag soldering is commonly used for:
   a) Large connectors
   b) High-density SMD components
   c) Desoldering THT pins
   d) Heating large copper planes

C. Fill in the Blanks:

1. Proper ___________ of soldering stations helps prevent overheating, thermal stress, and cold solder joints.
2. Anti-static mats and wrist straps are used as part of ___________ protection during soldering.
3. ___________ is used to remove unwanted solder during defect correction processes.
4. Maintaining clean soldering tips and PCB surfaces helps avoid ___________ that weaken solder joints.
5. The industry standard followed for inspecting solder joint quality is ___________.

Notes

3. Rework on Defects and Undertake Selective Soldering

Unit 3.1 – Verification of Telecom Boards and Identification of Defects

Unit 3.2 – Selective Soldering and Rework of Defective Components

TEL/N2501

Key Learning Outcomes

By the end of this module, the participants will be able to:

1. Explain how advanced tools are used to test the effectiveness of a fiber splice.
2. Describe the process of recording test results for traceability and performance analysis in fiber splicing.

UNIT 3.1: Verification of Telecom Boards and Identification of Defects

Unit Objectives

By the end of this unit, the participants will be able to:

1. Explain the role of CAD layouts and Bill of Materials (BOM) in verifying telecom board assemblies.
2. Describe methods to compare component placement, orientation, and values against given specifications.
3. Discuss common soldering defects, including solder bridges, blowholes, spikes, dry solder joints, and gold finger contamination.
4. Elucidate the industry standards and best practices for telecom board soldering and rework.
5. Enlist various defect identification techniques such as visual inspection, X-ray inspection, and Automated Optical Inspection (AOI).
6. Explain quality control procedures used in PCB assembly to ensure functional and defect-free boards.
7. Describe functional testing methods and tools used to assess the performance of assembled boards.
8. Discuss documentation and reporting procedures for recording defect findings and preparing quality reports.
9. Explain Occupational Health and Safety (OHS) regulations related to telecom board inspection and defect rectification.
10. Demonstrate how to retrieve and interpret CAD layouts and Bill of Materials (BOM) for telecom board verification.
11. Show how to inspect telecom boards for proper component placement, alignment, and orientation.
12. Demonstrate the use of magnification tools to identify soldering defects such as solder bridges, blowholes, and dry solder joints.
13. Show how to perform functional testing of assembled telecom boards using appropriate testing tools.
14. Demonstrate defect identification using different inspection techniques, including visual checks, X-ray, and AOI.
15. Show how to document defect findings and prepare quality reports based on inspection results.
16. Demonstrate compliance with OHS guidelines while handling telecom boards and performing inspections.

3.1.1 Verification Using Technical Documentation

Before and after soldering, technical documents are the definitive source for verifying the board's integrity.

1.1 Role of CAD Layouts and Bill of Materials (BOM)

- CAD Layouts (Assembly Drawings): These visual blueprints show the exact physical location, footprint, and orientation of every component on the Printed Circuit Board (PCB). They are used to verify placement and alignment.
- Bill of Materials (BOM): This is a comprehensive list detailing every part required for the assembly. It specifies the Part Number, Component Value (e.g., resistance, capacitance), and the Reference Designator (e.g., R101, C205) for comparison against the parts physically installed.
- Verification Role: Together, the CAD and BOM serve as the master checklist to confirm that the board contains the correct component in the correct location with the correct orientation.

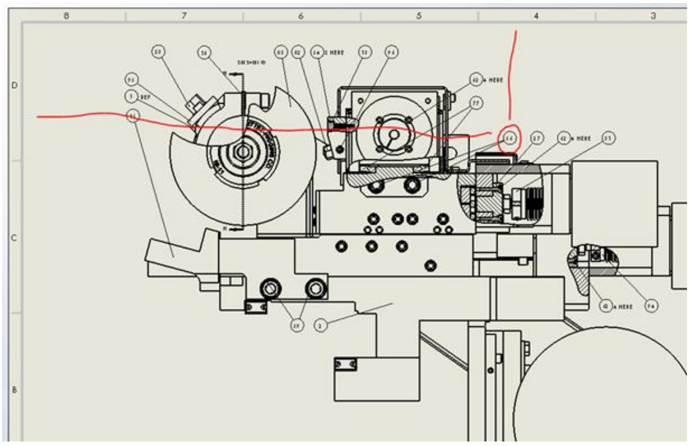


Fig. 3.1.1 Drawing Layout- BOM

3.1.2 Methods to Compare Component Placement and Values

Verification Aspect	Method of Comparison	Tool Used
Placement/Orientation	Visually compare the component's position and polarity markings against the CAD layout on a screen or printout.	Magnification tools (microscope), CAD viewer software.
Component Value	Compare the component's markings (text, color codes) against the BOM's specified value.	Digital Multimeter (DMM) for in-circuit or out-of-circuit resistance/capacitance checks.
Alignment	Use a magnification tool to verify leads are centered on pads and solder fillets are symmetrical according to IPC standards.	Stereo Microscope or High-Resolution Camera.

3.1.3 Soldering Defects and Rework Standards

Identifying and correcting specific soldering flaws is central to quality assurance.
i. Common Soldering Defects and Their Causes

Soldering Defect	Description	Primary Cause(s)
Solder Bridge	Unwanted electrical connection between two adjacent pads or tracks.	Excessive solder applied; poor component alignment; insufficient flux application.
Blowhole/Pin-hole	A hole or void in the solder joint surface.	Moisture contamination in the PCB or component leads; rapid outgassing during soldering.
Spikes (Excessive Solder)	Sharp, pointy protrusion of solder from the joint.	Solder cooling too quickly; tip removal technique too slow or jerky.
Dry Solder Joint (Cold Joint)	Joint is dull, porous, or grainy; characterized by poor wetting.	Insufficient heat (low tip temp, short contact time); contamination; board movement during cooling.
Gold Finger Contamination	Solder or foreign material present on the edge connector gold contacts.	Accidental solder splatter; improper handling; failure to mask gold fingers during processing.

3.1.4 Industry Standards and Best Practices for Rework

- IPC-A-610 (Acceptability of Electronic Assemblies): This is the paramount standard, defining the visual quality and material conditions required for an acceptable electronic assembly. Telecom boards often demand Class 3 (High-Reliability Electronics) criteria.

Best Practices for Rework:

- o Pre-Baking/Dehumidification: Handling Moisture Sensitive Devices (MSDs) requires components to be baked to prevent blowholes/popcorning.
- o Localized Heat: Using localized heat tools (e.g., hot air pencil) to target only the component/joint being reworked, protecting surrounding components from thermal stress.
- o Cleanliness: Thoroughly cleaning the rework site and component leads before replacement.

3.1.5 Defect Identification and Quality Control Procedures

A multi-layered inspection process ensures board quality and functional performance.
i. Defect Identification Techniques

Technique	Method	Purpose in Telecom
Visual Inspection	Manual inspection using the naked eye and magnification tools (microscope).	Identifying polarity, alignment, solder bridges, poor wetting, and component marks.
Automated Optical Inspection (AOI)	A machine-based system that captures images and compares them against a known good board.	High-speed verification of component placement, presence, and solder paste volume in production.
X-ray Inspection (AXI)	Uses X-rays to see through components and solder.	Essential for inspecting hidden solder joints like those under Ball Grid Array (BGA) and QFN packages, checking for voids or shorts.

3.1.6 Quality Control (QC) and Functional Testing

QC Procedures:

Involve defined checkpoints after assembly, soldering, and cleaning. They ensure all specifications and regulatory requirements are met.

- First Article Inspection: Detailed inspection of the very first board assembled to validate the entire process.
- Lot Sampling: Inspecting a statistical sample of boards from a production batch to confirm overall quality.

Functional Testing Methods:

Testing ensures the assembled board actually works as designed.

- In-Circuit Test (ICT): Uses a fixture (Bed of Nails) to contact test points and verify individual components (values, shorts, opens).
- Functional Test (FCT): Simulates the final operating environment by applying power and signals to the board's inputs and monitoring outputs to confirm performance.
- RF Performance Testing: Using specialized tools (Spectrum Analyzers, Network Analyzers) to measure signal quality, power output, and frequency characteristics for RF circuits.

3.1.7 Documentation and Safety (OHS)

Final reporting and adherence to safety rules conclude the quality process.

i. Documentation and Reporting Procedures

Accurate documentation ensures traceability and helps improve future processes.

- Recording Defect Findings: Documenting the defect type (e.g., solder bridge), location (Reference Designator), and the corrective action taken. This often uses standardized forms or a computerized Manufacturing Execution System (MES).
- Quality Reports Preparation: Compiling inspection results, functional test data, and defect logs into a formal report.
    - Yield Rate: Reporting the percentage of boards that passed QC without rework.
    - Pareto Analysis: Reporting the most common defect types to guide process improvement efforts.

ii. Occupational Health and Safety (OHS) Regulations

Safety procedures are mandatory when handling electronics and inspection equipment.

- Electrical Safety: Following Lockout/Tagout procedures when working on power supply units; ensuring all test equipment is properly grounded and calibrated.
- Ergonomics: Proper seating and microscope height setup to prevent strain from prolonged use during visual inspection.
- Handling Hazards:
    - Magnification Tools: Using appropriate eye protection and ensuring the focus of the microscope does not cause eye strain.
    - X-ray Equipment: Strict adherence to radiation safety protocols, including mandatory shielding and dosimetry badge monitoring.
    - Chemical Handling: Correctly storing and disposing of cleaning solvents and flux residues as per environmental regulations.

3.1.8 Advanced Rework and PCB Repair Techniques

Hand Soldering Technicians often perform repairs far beyond simple component swaps, especially on costly telecom boards.

i. De-soldering Techniques for Complex Components

- Hot Air Rework for SMDs (Solder Mask Defined/Non-Solder Mask Defined Pads):
    - Process: Utilizing a hot air station with specific nozzles (e.g., square or circular) that match the component size.
    - Focus: Establishing a controlled temperature profile (a pre-heat, soak, and reflow phase) to ensure the solder melts evenly under the entire component without thermally shocking the PCB or surrounding parts.
    - Airflow Management: Setting low airflow to prevent small components from being blown away while ensuring all leads reach the reflow temperature.
- Component Skimming and Lift-Off: Methods used for quickly removing large, multi-leaded components (like QFPs) by applying heat and gently lifting the component once the solder is molten. Precision is key to avoid lifting pads.

ii. Pad and Trace Repair Methods

Rework can occasionally damage the copper circuitry; repairing this is vital for board salvage.

- Repairing Lifted Solder Pads:
    - Process: Using epoxy or a liquid bonding agent to secure the lifted pad back to the PCB substrate.
    - Connection: Creating a new electrical connection using a thin piece of copper foil or carefully placed wire (jumper wire) from the component lead to the nearest valid trace or via.
- Trace Repair (Severed or Damaged Traces):
    - Method: Carefully scraping the solder mask back from the trace ends, tinning the exposed copper, and bridging the gap with a fine-gauge, insulated jumper wire soldered securely to both trace ends.
    - Protection: Applying a UV-curable solder mask or conformal coating over the repaired area to protect the new connection from corrosion and shorts.

iii. Solder Joint Profiling and Thermal Management

- Solder Joint Profiling: The act of measuring and recording the temperature of a specific solder joint over time during a rework process.
- Significance: Ensures the temperature applied remains within the safe operating parameters of the component and the PCB laminate (typically below 260°C peak for most lead-free processes), preventing thermal decomposition or internal damage to ICs.

3.1.9 Handling Specialized Telecom Components

Certain components require unique attention due to their electrical properties or physical structure.

i. Handling Ball Grid Array (BGA) Components

- BGA Structure: BGAs have solder balls on the component's underside instead of leads, making their joints invisible for visual inspection.
- Rework Requirements: Standard hand soldering is impossible. Removal and replacement require dedicated, highly accurate BGA Rework Stations with bottom-side heating and top-side hot air application, and optical alignment systems.
- BGA Reballing: The process of removing the old solder balls from the BGA package and attaching new, uniform solder balls (using stencils) before re-attaching the component to the board.

ii. Radio Frequency (RF) Component Specifics

- Short Connections: RF circuits are highly sensitive to impedance changes. Soldering connections must be as short and direct as possible to minimize parasitic capacitance and inductance.
- Thermal Sensitivity: High power RF components (like Power Amplifiers) often have large ground pads for heat sinking. Rework requires high heat capacity tools to ensure proper wetting on these large thermal planes.
- Ground Plane Integrity: Maintaining the integrity of the ground planes is critical for RF shielding and performance. Any damage must be repaired immediately.

iii. Moisture Sensitivity Level (MSL) Handling

- MSL Definition: ICs and components absorb atmospheric moisture. When heated rapidly during soldering, this moisture turns into steam, causing the component package to expand, leading to internal cracks (popcorning) or blowholes.
- Handling Procedure: Components with an MSL rating (Level 2 or higher) must be stored in dry environments (e.g., dry cabinets) and, if their exposure time is exceeded, must undergo a Baking Procedure (heating at a low temperature for several hours) before any thermal rework.

3.1.10 Troubleshooting and Post-Repair Validation

The final stage is validating the functional success of the rework.

i. Basic Electrical Measurement Tools

- Digital Multimeter (DMM): Used extensively for quick post-repair checks.
    - Continuity Check: Verifies that a solder bridge (short) has been successfully removed or that a jumper wire has made a connection (open).
    - Resistance Measurement: Confirming that passive components (resistors, inductors) have their correct values after being soldered and that no excessive resistance has been introduced by a poor joint.
- Bench Power Supply: Used to safely inject regulated voltage into the repaired board (often current-limited) to check for unexpected high current draws (indicating a short).

ii. Visual Troubleshooting vs. Functional Testing

- Visual Troubleshooting: The initial check using magnification to look for visible errors (e.g., reversed diode, solder short, component misalignment). A necessary but insufficient step.
- Functional Testing (FCT): The definitive proof that the rework was successful. The board is powered on and subjected to test sequences to verify it performs its intended communication function (e.g., transmitting a signal, processing data, maintaining power regulation).

Notes

UNIT 3.2: Selective Soldering and Rework of Defective Components

Unit Objectives

By the end of this unit, the participants will be able to:

1. Explain the steps involved in marking and categorizing defective components for rework or replacement.
2. Describe criteria for determining whether components can be reused or require replacement.
3. Elucidate proper desoldering techniques for removing faulty joints without damaging the PCB.
4. Discuss selective soldering techniques, including temperature control, solder flow management, and flux application.
5. Enlist different soldering and desoldering tools, such as rework stations, soldering irons, and vacuum desoldering pumps.
6. Explain the importance of maintaining proper soldering station settings to ensure uniform solder joints.
7. Describe verification methods for reworked components using magnification tools and testing procedures.
8. Discuss ESD control measures and best practices for preventing damage to sensitive electronic components.
9. Explain industry protocols for handling lead-free and lead-based soldering materials and their compatibility with components.
10. Describe work process documentation and the escalation matrix for defect reporting.
11. Demonstrate how to identify, mark, and categorize defective components for rework or replacement.
12. Show how to safely remove defective components using proper desoldering techniques.
13. Demonstrate selective soldering techniques while maintaining precise temperature control and solder flow.
14. Show how to inspect reworked components under a microscope for quality assurance.
15. Demonstrate safe handling of soldering stations, desoldering tools, and rework stations.
16. Show how to maintain proper documentation of rework, including defect reports and corrective actions taken.
17. Demonstrate compliance with ESD safety precautions while handling telecom boards and components.

3.2.1 Defect Categorization and Component Management

The process begins with accurately identifying the problem and determining the appropriate action.

Steps in Marking and Categorizing Defective Components

1. Identification: Use visual inspection and magnification tools (microscopes) to pinpoint the exact defect (e.g., solder bridge, dry joint, reversed polarity).

2. Marking: Clearly mark the defective area on the PCB using a non-residue, ESD-safe marking pen or by referencing the component's Reference Designator (e.g., U10, C5) on the work order documentation.
3. Categorization: Classify the defect:
   - Solder Defect: Fault in the joint itself (e.g., cold joint, short). Requires rework/reflow.
   - Component Defect: Component is physically damaged or electrically failed. Requires replacement.
   - PCB Defect: Damage to the board (e.g., lifted pad, severed trace). Requires PCB repair.
4. Isolation: For components requiring replacement, identify nearby sensitive components that must be protected during the de-soldering process (e.g., with thermal tape or shields).

Criteria for Component Reuse or Replacement

The decision to reuse a component is based on risk and cost.

Reuse Criteria:

- The component is undamaged, functioning correctly, and has not exceeded its Maximum Rework Cycles (if specified by the manufacturer).
- The component was removed cleanly and gently without applying excessive heat or force, preserving lead integrity.
- It is a high-cost or long-lead-time component for which replacement is impractical or non-urgent.

Replacement Criteria:

- The component has been subjected to thermal stress (overheated during de-soldering).
- The component is physically damaged (cracked, chipped, bent leads).
- The component is a low-cost, readily available part (e.g., chip resistor/capacitor), where the labor to verify reuse exceeds the cost of a new part.
- It is an ESD-sensitive IC that may have suffered latent damage during removal.

3.2.2 De-soldering and Selective Soldering Techniques

Precise thermal control and targeted application are the hallmarks of quality rework.

Proper De-soldering Techniques

The goal is to remove the solder and component quickly while maintaining the integrity of the PCB pad and trace.

- For Through-Hole Components (THT): Use a vacuum de-soldering pump or a motorized de-soldering station. The tip must heat the joint sufficiently to fully liquefy the solder before the vacuum is applied to extract the molten material.
- For Surface Mount Devices (SMD) - Two Leads: Use a soldering iron and solder wick. Place the wick over the joint and apply the iron to the wick. The copper braid draws the solder away via capillary action.
- For SMD ICs (Multi-pin): Use a hot air rework station. Apply heat evenly across the component and lift gently once the solder flows. Avoid excessive force which can tear pads.
- Cleaning: After component removal, thoroughly clean the vacant pad site using flux and fresh solder (tinning) followed by a final wipe with solvent to prepare for the new component.

Selective Soldering Techniques

Selective soldering refers to targeting heat and solder to a specific joint, often used in contrast to mass reflow processes.

- Temperature Control: Maintaining proper station settings is vital. The temperature must be dynamically adjusted based on the component's thermal mass and the surrounding copper planes. Higher thermal mass requires higher temperature or longer contact time.
- Solder Flow Management: Control the amount of solder applied using the solder wire diameter and the application time. The ideal result is a concave fillet (smooth, uniform curvature) that does not obscure the component lead.
- Flux Application: Apply flux (usually from a flux pen or brush) directly to the specific joint or component leads just before the soldering iron is applied. This prevents re-oxidation during the heat-up phase.

3.2.3 Rework Tools and Process Control

Reliable rework depends on high-quality tools and adherence to strict process parameters.

i. Soldering and De-soldering Tools

Tool	Primary Function	Key Feature
Soldering Iron/Station	Applying controlled heat and solder for component attachment.	Temperature Stability and interchangeable, iron-plated tips.
Hot Air Rework Station	Non-contact heating for component removal and reflow, especially for SMDs.	Adjustable temperature and airflow controls.
Vacuum De-soldering Pump	Suction device for manual removal of molten solder, mainly THT.	Strong, instantaneous vacuum action.
Solder Wick (Desoldering Braid)	Copper braid impregnated with flux for capillary removal of residual solder.	Efficiently cleans residual solder and minimizes pad damage.
Stereo Microscope	High magnification tool used for inspecting fine-pitch components and verifying joint quality.	Provides clear, 3D view of small details.

3.2.4 Maintaining Proper Soldering Station Settings

- Importance of Uniformity: Consistent settings ensure that every solder joint created or reworked is structurally and electrically identical, meeting the high-reliability requirement of telecom equipment.
- Key Parameters:
    - Temperature: Must be calibrated and verified with a tip thermometer to match the chosen solder alloy (lead-free requires higher heat).
    - Tip-to-Ground Resistance: Checked periodically to ensure the tip is properly grounded, preventing electrical leakage that could damage components (should be < 2 Ohms).
    - Tip Selection: Using the correct tip shape and size for the specific pad to maximize heat transfer efficiency and minimize contact time.

3.2.5 Safety, Standards, and Documentation

Final steps involve safety compliance and creating a complete record of the repair.

1. ESD Control Measures and Best Practices

Electrostatic Discharge (ESD) can damage sensitive components during handling.

Best Practices:

- Grounding: Always wear a grounded ESD wrist strap and ensure it's checked daily. The work surface must use an ESD mat connected to a common point ground.
- Handling: Only touch components when necessary and only handle them by the body, not the leads.
- Packaging: Store and transport sensitive components in ESD-safe bags or containers.
- Ionizers: Used in high-risk areas to neutralize static charges that build up on non-conductive materials (insulators).

2. Handling Lead-Free vs. Lead-Based Materials

- Lead-Free Protocols (e.g., SAC305: Sn/Ag/Cu):
    - Requires higher soldering temperatures (approx. $30-40^{\circ}\text{C}$ hotter) than leaded solder.
    - Requires specific fluxes and soldering tips to handle the higher heat and increased oxidation.
- Lead-Based Protocols (e.g., Sn63/Pb37):
    - Requires lower temperatures.
    - Requires strict safety and ventilation protocols due to the toxicity of lead.
- Compatibility: Never mix leaded and lead-free solder on a single joint, as this creates a contaminated joint with an unknown, unreliable melting point. Dedicated tools and tips should be used for each alloy.

3. Documentation and Escalation Matrix

- Work Process Documentation: Detailed recording of the rework action:
  - o Date, Time, Technician ID, Board Serial Number.
  - o Original Defect: Description and reference designator.
  - o Corrective Action: Tools used, component replaced, new material (solder/flux) used.
- Verification: Sign-off by the technician and a separate quality inspector confirming successful repair and functional test pass.
- Escalation Matrix for Defect Reporting: A defined path for reporting repeated, complex, or unresolvable defects:
  - o Level 1: Technician reports to Supervisor/Rework Lead.
  - o Level 2: Supervisor reports recurring issues (e.g., same component failing repeatedly) to the Quality Assurance (QA) and Engineering teams.
  - o Level 3: Engineering investigates the root cause (e.g., component design flaw, process issue) to prevent future failures.

Exercise

A. Short Answer Questions:

1. Explain how CAD layouts and the Bill of Materials (BOM) support accurate verification of telecom board assemblies.
2. Describe the common soldering defects that may appear during PCB assembly and why they pose risks to board reliability.
3. Discuss the importance of industry standards and best practices when performing soldering and rework on telecom boards.
4. Explain the role of different inspection techniques—visual inspection, X-ray, and AOI—in identifying assembly defects.
5. Describe safe handling requirements and OHS regulations relevant to telecom board inspection and defect rectification.

B. Multiple Choice Questions:

1 Which document helps confirm component values, ratings, and quantities during board verification?
   a) Assembly drawing
   b) Routing diagram
   c) Bill of Materials (BOM)
   d) Test report

2 Solder bridges typically occur when:
   a) Pads are oxidized
   b) Excess solder connects two adjacent pins
   c) Components are underheated
   d) PCB surface is improperly cleaned

3 AOI (Automated Optical Inspection) is primarily used for:
   a) Thermal testing
   b) Visual defect detection using programmed image comparison
   c) Electrical continuity checks
   d) Removing defective components

4 Which tool is best suited for removing solder during rework without damaging PCB pads?
   a) Flux pen
   b) Vacuum desoldering pump
   c) Crimping tool
   d) Heat shrink gun

5 Gold finger contamination occurs when:
   a) Too much flux is applied
   b) Solder accidentally touches contact edges meant to remain clean
   c) Component body is misaligned
   d) Solder temperature is too low

C. Fill in the Blanks:

1. ___________ inspection is commonly used to detect internal PCB defects that are not visible to the naked eye.
2. Proper ___________ control is essential during soldering and rework to avoid damaging sensitive telecom components.
3. Blowholes in solder joints are usually caused by trapped ___________ escaping during soldering.
4. After rework, components must be inspected using ___________ tools to verify solder joint quality.
5. All defect findings and corrective actions must be documented in ___________ reports for traceability

Notes

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

4. Cleaning and Inspection of Telecom Boards

Unit 4.1 – Cleaning of PCBs
Unit 4.2 – Inspection of PCBs

TEL/N2502

Key Learning Outcomes

By the end of this module, the participants will be able to:

1. Identify the different types and sources of contamination in PCBs.
2. Describe various methods of PCB cleaning and their applications.
3. Explain the causes and impact of white residue on PCB performance and reliability.
4. Demonstrate correct procedures for storing and handling PCBs after cleaning.
5. List and explain key points of importance in visual inspection of PCBs.
6. Identify the attributes, capabilities, and limitations of Automated Optical Inspection (AOI).
7. List the applications and advantages of Automated X-ray Inspection (AXI).
8. Apply in-circuit testing (ICT) methods to verify assembly integrity.
9. Compare different types of visual inspection systems and their suitability for specific applications.

UNIT 4.1: Cleaning of PCBs

Unit Objectives

By the end of this unit, the participants will be able to:

1. Identify different types and sources of contamination in PCBs.
2. List the common methods used for PCB cleaning.
3. Explain the impact of white residue on PCB quality and reliability.
4. Demonstrate correct methods for storage and handling of PCBs after cleaning.

4.1.1 Waste IPC Standards of Soldering

PCB Cleaning and Flux Residue

PCB cleaning refers to the process of removing solder flux residues and other contaminants from the printed circuit board (PCB) after the surface-mount technology (SMT) process. During reflow soldering, the flux in the solder paste reacts with metal oxides to enable proper wetting of solder and prevent further oxidation of solder joints. However, this reaction produces flux residues, which often remain trapped beneath components, solder joints, or the undersides of solder balls.

To remove these residues, cleaning is performed using aqueous or semi-aqueous solvents, often combined with external agitation (e.g., spray, ultrasonic, or mechanical methods). Effective cleaning is critical because flux residues can cause reliability issues such as electromigration.

Electromigration Mechanism

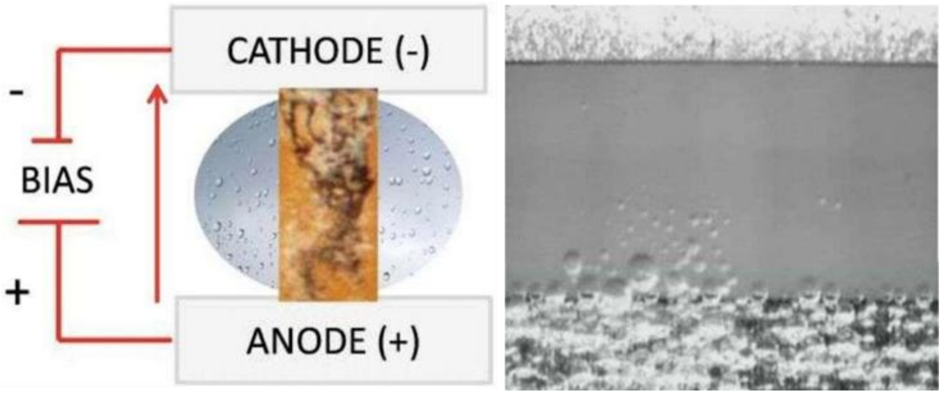


Fig. 4.1.1: Electromigration process

Residual flux, in the presence of humidity and an applied electric field, can initiate an electrochemical process known as electromigration. In this process:

- A thin film of moisture mixed with flux residue forms a conductive path between two adjacent conductors.
- At the positively biased anode, metal ions are generated and begin migrating toward the negatively charged cathode.
- Over time, these ions accumulate as metallic dendrites between conductors.
- The dendritic growth reduces the isolation distance and can eventually create a metal bridge.
- This conductive bridge may lead to short circuits or solder bridging, compromising the functionality and long-term reliability of the PCB assembly.

Importance of Cleaning

Proper PCB cleaning prevents dendritic growth, reduces the risk of electrical shorts, and ensures long-term reliability of electronic assemblies—particularly for high-density, fine-pitch, or safety-critical applications.

Introduction to IPC

IPC (Institute for Printed Circuits), officially known as the Association Connecting Electronics Industries, is a globally recognized trade association that sets standards for printed circuit boards (PCBs) and electronic assemblies. With over 4000 member organizations worldwide, IPC standards are applied across diverse sectors such as advanced microelectronics, aerospace, defense, automotive, computing, medical equipment, industrial systems, and telecommunications.

These standards are essential to ensure that PCB-related products are safe, reliable, consistent, and high-performing. They emphasize maintaining quality, focus, and adherence throughout the entire manufacturing and assembly process.

Importance of IPC Standards

Adopting IPC standards in PCB manufacturing and soldering provides several benefits:

- Ensures high-quality and reliable end products
- Improves communication across employees, vendors, and suppliers
- Helps in cost reduction through consistency and error prevention
- Enhances reputation and opens up new opportunities
- Standardizes terminology and practices, improving global trade and collaboration

Key IPC Terminology

Some important IPC terms relevant to PCB manufacturing and soldering include:

- Acceptance Tests – Verify if the product meets buyer or vendor requirements.
- Assembly – The process of joining and combining parts into a working product.
- Resist – A protective coating material used during plating, etching, or soldering.
- IC (Integrated Circuit) – Multiple electronic circuits integrated into a single unit.
- Flexural Strength – The ability of a material to bend or fold without breaking.
- Critical Operation – A process step or product feature essential for performance.

IPC Standards for Soldering

For soldering processes, the most widely followed IPC standard is:

- IPC J-STD-001 – Requirements for Soldered Electrical and Electronic Assemblies
- Covers materials, methods, and verification criteria for producing reliable soldered connections.
- Used globally for certification and training.
- IPC-A-620 – Requirements and Acceptance for Cable and Wire Harness Assemblies
- Provides guidelines for solder splices, including four approved methods:
    - Mesh
    - Wrap
    - Hook
    - Lap
- Each method is clearly defined with diagrams and acceptance/rejection criteria.

These standards also detail the correct mounting of components such as DIP pins, SIP pins, and sockets.

Critical Requirements in IPC J-STD-001 for Soldering

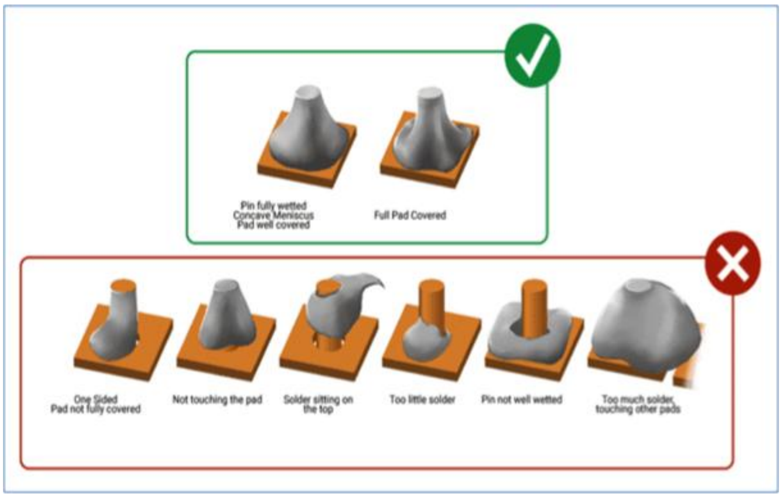


Fig. 4.1.2 Soldering according to J-STD-001 for Soldering

When soldering PCBs and assemblies, IPC emphasizes:

- Cleanliness – Tools, materials, and surfaces must be free of contaminants.
- Thermal Management – Heating and cooling rates should match manufacturer specifications to prevent thermal shock (especially in multilayer chip capacitors).
- Wire Handling – Strands should remain intact; the solder must fully wet the tinned portion of wires.
- Inspection – Cleanliness and solder joints should be inspected prior to applying conformal coatings or stacking.
- Defect Management – Any defect affecting form, fit, or function must be reworked or rejected based on customer requirements.
- Inspection Tools – Use Automated Optical Inspection (AOI) and Automated X-ray Inspection (AXI) for reliable quality checks.
- Exposed Base Metal – May be acceptable depending on conductor design, component leads, land patterns, and solder mask allowances.

Additional Considerations

IPC J-STD-001 also specifies requirements related to:

- Wire preparation and tinning
- Lead forming and shaping
- Material-class-specific flaws
- Plated through-holes and lamination
- Documentation and record-keeping of inspection outcomes

4.1.2 Types of Contamination in PCBs

Contaminants on a PCB can cause various issues, from cosmetic blemishes to severe electrical failures. These substances can interfere with soldering, lead to corrosion, or create unwanted electrical paths. They are broadly categorized as either ionic or non-ionic.

- Ionic Contamination: These are residues that can dissociate into ions in the presence of water, making the surface electrically conductive. Examples include:
- Salts: From fluxes and handling (e.g., salts from fingerprints).
- Flux Activators: Chemicals in flux that are meant to clean surfaces but can become corrosive if not properly removed.
- Non-Ionic Contamination: These residues do not conduct electricity. Examples include:
- Natural and Synthetic Rosins: The solid part of flux that remains after soldering.
- Oils and Greases: From machinery, human contact, or the manufacturing process.
- Solder Balls: Tiny spheres of solder that can create shorts.
- Fingerprints: A mix of both ionic (salts) and non-ionic (oils) contaminants.
- Particles: Dust, dirt, and fragments from the boards themselves.

4.1.3 Types of Cleaning Solvents

Choosing the right solvent is critical for effective cleaning. Solvents are selected based on the type of contamination (ionic or non-ionic) and the manufacturing process.

- Aqueous Solutions: Water-based cleaners. These are effective at removing ionic contaminants like salts and flux activators. They often contain additives like surfactants (to reduce surface tension) and saponifiers (to dissolve rosin-based residues).
- Semi-Aqueous Solutions: These are typically hydrocarbon-based solvents with added surfactants. They are very effective at dissolving non-ionic residues like rosins, oils, and greases. A water rinse is required after using these solvents.
- Hydrocarbon-based Solvents: Including petroleum distillates, alcohols, and ketones. These are flammable but highly effective at dissolving non-ionic contamination.
- Halogenated Solvents: Including brominated or fluorinated solvents (like HCFCs and HFCs). These are known for being non-flammable and very effective at dissolving a wide range of contaminants. However, their use is often regulated due to environmental concerns.

4.1.4 Board Cleaning Methods

Several methods are used to clean PCBs, ranging from simple manual techniques to complex automated systems.

1. Manual Cleaning Method

This method is suitable for low-volume production or for specific rework tasks. It is highly labor-intensive and can be inconsistent.

- Soaking: The board is soaked in a cleaning solvent (e.g., acetone or a specialized cleaning solution) for a few minutes to loosen contaminants.
- Brushing: The solder joints and contaminated areas are manually brushed with a stiff brush while submerged in a cleaning solution (e.g., ethanol) to physically remove residues.
- Rinsing: The board is thoroughly rinsed with deionized (DI) water to remove all remaining cleaning solution and ionic contaminants.
- Dehydration and Drying: The board is dehydrated with a solvent like absolute ethyl alcohol and then dried with a nitrogen gas gun to prevent water spots and corrosion.

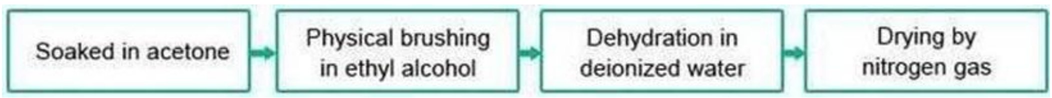


Fig. 4.1.3 Manual cleaning of a PCB

2. Ultrasonic Cleaning Method

This method uses high-frequency sound waves to create microscopic bubbles (cavitation) in a liquid, which effectively scrubs contaminants from the board's surface. It is more efficient than manual cleaning but can be damaging to some sensitive components.

- Soaking and Placement: The board is placed in a special basket and submerged in a solvent (e.g., ethyl alcohol or a dedicated ultrasonic solvent) inside a tank.
- Ultrasonic Action: An ultrasonic generator is activated for a set period (e.g., 5 minutes). The cavitation action removes contaminants from even hard-to-reach areas.
- Rinsing and Drying: The board is then rinsed with DI water, dehydrated with alcohol, and dried with a nitrogen gas gun.

Note: This method is not recommended for components like crystal oscillators, as the high-frequency vibrations can damage their internal structure.

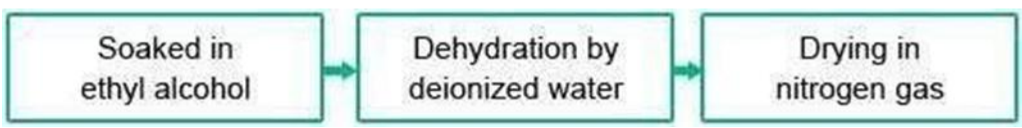


Fig. 4.1.4 Ultrasonic cleaning of a PCB

3. Vapor Degreasing

This is an automated, high-efficiency cleaning method that uses the condensation of a heated solvent vapor to clean parts.

- Vapor Generation: A solvent is heated in a sump at the bottom of the unit, creating a dense, hot vapor.
- Cleaning: The workpiece is lowered into this vapor. As the vapor touches the cooler surface of the part, it condenses, releasing heat and dissolving the contaminants. The contaminated solvent drips back into the sump.
- Purification: Since the contaminants typically have a higher boiling point than the solvent, the vapor remains pure, ensuring that the parts are always cleaned with a fresh, uncontaminated solvent.
- Drying: The parts dry rapidly upon removal from the vapor. A spray stage can be added to the process for parts with blind holes or stubborn contaminants.

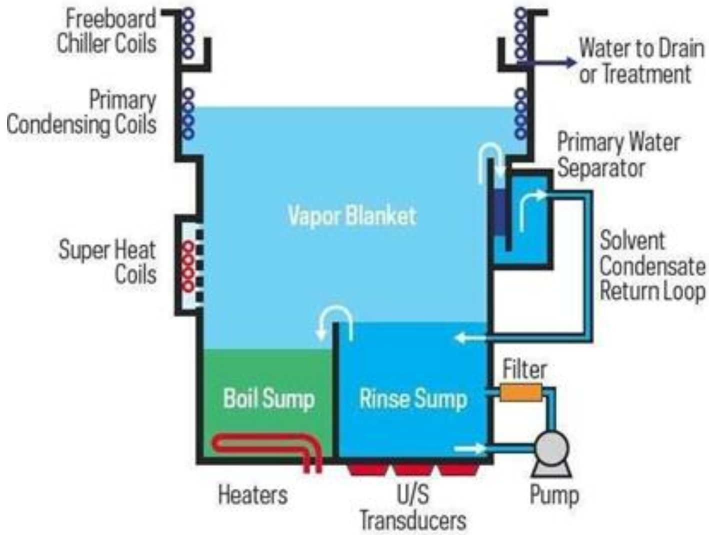


Fig. 4.1.5 A vapour degreasing unit

4.1.5 White Residues on PCBs

White residues are a common post-soldering defect. While often perceived as simple salts, they are complex mixtures of activator salts, flux resins, and other materials. When exposed to heat or certain chemicals, these residues can become corrosive and difficult to remove.

Causes:

- Flux Chemistry: The salts in flux, which act as "activators," can form residues if not properly rinsed. This problem is exacerbated with lead-free solder, which requires higher temperatures and different flux chemistries.
- Improper Process: Insufficient cleaning, incorrect solvent selection, or a reflow profile that doesn't properly activate and consume the flux can all lead to white residues.
- Material Interaction: Poorly cured solder mask or PCB substrates can interact with the flux and contribute to residue formation.
- Environmental Factors: Humidity, fingerprints, and other environmental factors can also be a source of the compounds that form these residues.

4.1.6 Storage and Handling of PCBs After Cleaning

Proper storage is crucial for maintaining the quality of a cleaned PCB. PCBs, especially multi-layer boards, are highly susceptible to moisture absorption due to their porous material structure. Accumulated moisture can cause delamination or "popcorning" during subsequent heating processes.

- Moisture Control: PCBs should be stored in a dry, low-humidity environment, often in moisture barrier bags with a desiccant.
- ESD Protection: The storage area must be ESD-free (Electrostatic Discharge) to protect sensitive components from static damage. This typically involves using ESD-safe racks and shelving.

Fig. 4.1.6 ESD-free racks are used for storage of PCBs

Notes

UNIT 4.2: Inspection of PCBs

Unit Objectives

By the end of this unit, the participants will be able to:

1. Explain the importance and key requirements of visual inspection in PCB assembly.
2. Identify the features and capabilities of Automated Optical Inspection (AOI) systems.
3. Describe the applications and benefits of Automated X-ray Inspection (AXI) methods.
4. Perform in-circuit testing to verify electrical functionality.
5. Compare the working principles, advantages, and limitations of different visual inspection machines.

4.2.1 Visual Inspection

Visual inspection is one of the most basic yet essential steps in the PCB assembly quality control process. It is usually performed after critical stages such as solder paste printing, component placement, and reflow soldering. The type of equipment or method used depends on the inspection requirements and the position of the components on the board.

For example, inspection personnel may use the naked eye or simple magnifiers to detect obvious defects such as missing components, misaligned parts, solder bridges, or excessive/contaminated solder paste. One of the most common tasks is the examination of reflow solder joints, which can be performed by observing how light reflects at different angles from the solder surface (often with the help of prisms or microscopes). On average, an experienced operator can inspect around five joints per second using such methods.

The effectiveness of visual inspection depends on:

- The inspector's skill, knowledge, and consistency.
- The availability and application of well-defined inspection standards.
- Understanding of defect categories for different solder joint types.

Each solder joint type has multiple possible defects (sometimes up to eight defect classifications per joint). Since a PCB assembly may contain six or more different solder joint types, inspection requires thorough training and reference to IPC standards.

However, visual inspection has limitations:

- It cannot provide quantitative measurements required for statistical process control.
- It is unsuitable for hidden or complex joints, such as those found in BGA (Ball Grid Array), QFN (Quad Flat No-lead), J-leaded packages, or flip-chip assemblies.

Despite these limitations, visual inspection remains a cost-effective and easily accessible method for detecting large, visible defects, particularly in early production stages or for low-complexity boards.

4.2.2 Automated Optical Inspection (AOI)

Automated Optical Inspection (AOI) is an advanced inspection technique that uses high-resolution cameras and image-processing algorithms to automatically scan PCBs for defects. Unlike manual inspection, AOI offers speed, consistency, and higher accuracy, making it suitable for modern, high-density, and miniaturized PCB assemblies.

Fig. 4.2.1: AOI equipment

During AOI, the system captures multiple images of the PCB under different lighting conditions (fluorescent, LED, infrared, or UV). These images are compared against the golden board reference or CAD design data stored in the system. Any deviation—such as missing components, incorrect orientation, or defective solder joints—is flagged for review.

Necessity of AOI

- Modern PCBs are more complex, often with multiple layers, fine-pitch components, and extremely small packages such as 0402 or 0201.
- Manual inspection is insufficient for detecting hidden or microscopic defects.
- AOI ensures that defects are identified early in the production process, reducing rework costs and preventing defective products from reaching customers.
- It is critical for industries with high reliability requirements, including medical, military, aerospace, automotive, and telecommunications.

Range	Tolerance
Accuracy	±0.0024mm
Speed	$5in^2$/sec (60FOV/sec)
PCB Max. size	400*330mm
Available Component	0201 chip and fine pitch

Attributes of AOI Equipment

Fig. 4.2.2 Attributes of an AOI equipment

Attributes and Capabilities of AOI

1. Variety of Defects Detected
    - Surface defects: scratches, nodules, stains.
    - Electrical defects: opens, shorts.
    - Solder-related issues: insufficient or excessive solder, bridges, voids.
    - Component defects: incorrect part, missing part, wrong polarity, misalignment.
2. Multiple Inspection Objects
    - Bare PCB inspection: checks for open circuits, shorts, and surface damage.
    - PCBA inspection: verifies component placement, polarity, solder joints, and part values.
3. Flexibility
    - AOI can be integrated at various stages of the SMT line (post-solder paste printing, pre-reflow, post-reflow).
    - Most effective placement is after reflow soldering, as the majority of defects originate during soldering.
    - By identifying defects early, AOI reduces downstream failures and overall production costs.
4. Cost Efficiency

AOI is less expensive compared to Automated X-ray Inspection (AXI) for detecting surface solder defects such as bridges or cold joints.

It is widely used as the primary inspection method before final testing.

Working Principle of AOI

AOI systems rely on image capture and analysis:

1. The PCB is scanned using high-resolution cameras with multiple light sources.
2. Captured images are processed and compared against predefined design data.
3. Software algorithms highlight differences, abnormalities, or potential defects.
4. Results are displayed in real time for operator verification.

Algorithms Used in AOI

1. Template Matching
    - A reference "golden board" image is used.
    - Pixel-by-pixel comparison is performed using normalized cross correlation (NCC).
    - High correlation values indicate correct matches.
2. Object Recognition
    - Compares captured component images against stored ideal images.
    - Effective for verifying polarity, shape, and orientation.
3. Blob Analysis
    - Separates objects (e.g., solder deposits) from the background.
    - Groups pixels into "blobs" for analysis of size, shape, and continuity.
4. Vectoral Imaging Technology (newer approach)
    - Uses geometric feature extraction instead of relying on pixel values.
    - Reduces false calls caused by lighting or color variations.
    - Provides higher accuracy in identifying component placement and orientation.

4.2.3 Automated X-ray Inspection (AXI)

Automated X-ray Inspection (AXI) is a powerful inspection method that uses X-rays instead of visible light to detect hidden defects that cannot be observed using Automated Optical Inspection (AOI). It is especially important for modern high-density PCB assemblies with BGA (Ball Grid Array), CSP (Chip Scale Package), and other hidden-joint components.

Fig. 4.2.3: An AXI equipment

Unlike AOI, which checks surface-level defects, AXI penetrates the PCB and reveals internal features, providing a deeper level of quality assurance.

Goals of AXI

- Process Optimization: Inspection results are used to fine-tune manufacturing steps, such as soldering and reflow parameters.
- Anomaly Detection: Detects and rejects defective parts for scrap or rework, preventing them from advancing further in the production line.

Principle of Operation

- X-rays are generated by an X-ray tube and passed through the target object.
- A detector opposite the emitter captures the varying X-ray intensities caused by different material densities.

Two common detector methods are:

1. Scintillator + Camera: Converts X-rays into visible light, which is then recorded by a camera.
2. Direct Sensor Arrays: Detect X-rays directly and convert them into digital electronic images.

The resulting images highlight internal structures and solder joints. The degree of absorption depends on material density and thickness, allowing hidden features to be revealed.

Unlike AOI, which checks surface-level defects, AXI penetrates the PCB and reveals internal features, providing a deeper level of quality assurance.

Goals of AXI

- Process Optimization: Inspection results are used to fine-tune manufacturing steps, such as soldering and reflow parameters.
- Anomaly Detection: Detects and rejects defective parts for scrap or rework, preventing them from advancing further in the production line.

Principle of Operation

- X-rays are generated by an X-ray tube and passed through the target object.
- A detector opposite the emitter captures the varying X-ray intensities caused by different material densities.

Two common detector methods are:

1. Scintillator + Camera: Converts X-rays into visible light, which is then recorded by a camera.
2. Direct Sensor Arrays: Detect X-rays directly and convert them into digital electronic images.

The resulting images highlight internal structures and solder joints. The degree of absorption depends on material density and thickness, allowing hidden features to be revealed.

Applications of AXI

- Electronics: Inspection of BGAs, CSPs, hidden solder joints, voids, and solder bridges.
- Industrial: Detecting cracks in alloy wheels, welding seam defects in nuclear power stations.
- Food processing: Detection of contaminants like glass, metal, and bone fragments. Used also for process optimization (e.g., detecting hole patterns in cheese to optimize slicing yield).
- Medical & Aerospace: Ensures reliability and safety in life-critical and mission-critical systems.

Benefits of Early Defect Detection via AXI

- Provides feedback at the earliest stage if process parameters or materials are out of control.
- Prevents defective components from moving downstream, saving time and cost.
- Improves overall reliability of final products by catching defects not detectable with functional testing.

Advantages of AXI

- Can “see through” components, making it possible to inspect hidden solder joints (e.g., BGAs).
- Effective for densely packed, multilayer PCBs.
- Provides detailed analysis of solder joint integrity, including voids and bridging.

Disadvantages of AXI

- Equipment is expensive, and ROI is justified mainly in high-density, high-volume production.
- New or uncommon component types may not yet be fully supported by existing AXI algorithms.
- Slower than AOI due to the complexity of image capture and analysis.

4.2.4 In-Circuit Testing (ICT)

In-Circuit Testing (ICT) is an electrical test method that checks whether a populated PCB has been assembled correctly. Unlike AOI or AXI, which rely on visual or X-ray imaging, ICT directly measures electrical parameters to verify component placement, orientation, and connectivity.

ICT detects:

- Shorts and opens.
- Component values such as resistance, capacitance, and sometimes inductance.
- Whether components are present and correctly installed.

Methods of ICT

1. Bed-of-Nails Tester
    - A test fixture with hundreds or thousands of spring-loaded pogo pins aligned to contact specific nodes on the PCB (DUT – Device Under Test).
    - Each pin touches a test point, allowing simultaneous measurement of many nodes.
    - Advantages: Fast, accurate, reliable for high-volume testing.
    - Disadvantages: Expensive to develop, difficult to reconfigure, less effective for dense, fine-pitch boards with limited test points.
2. Flying Probe Tester
    - Uses a small number of movable probes that "fly" across the board, contacting test points sequentially.
    - Advantages: Lower cost, flexible, easily adapted to design changes (software-driven).
    - Disadvantages: Slower than bed-of-nails for large-volume testing.

Fig. 4.2.4: ICT setup

Key Points about ICT

- ICT is structural, not functional—it doesn't test whether the board performs its intended task. Instead, it assumes that if all components are correct and properly soldered, the board will function as designed.
- Best suited for low-to-medium complexity boards or when combined with functional testing.
- Often used together with AOI/AXI to provide a comprehensive inspection and testing strategy.

4.2.5 Comparison between Visual Inspection Machines

The following table lists the comparison between the three visual inspection machines:

Defect Type	AXI	AOI	ICT
Soldering Defect			
Open circuits	YES	YES	YES
Solder Bridge	YES	YES	YES
Solder Short	YES	YES	NO
Insufficient solder	YES	YES (But not Heel)	NO
solder void	YES	NO	NO
Excess solder	YES	YES	NO
Solder Quality	YES	NO	NO
Components Lifted			
Lifted Lead	YES	YES	YES
Missing Component	YES	YES	YES
Misplaced Components	YES	YES	YES
Incorrect components value	NO	NO	YES
Faulty components	NO	NO	YES
BGA and CSP			
BGA short	YES	NO	YES
BCA open circuit Connection	YES	NO	YES

Table 4.2.1: Comparison between the three visual inspection machines

Exercise

Short Questions:

1. Explain the mechanism of electromigration and why cleaning PCBs is critical to prevent it.
2. List any three benefits of adopting IPC standards in PCB manufacturing.
3. Differentiate between aqueous and semi-aqueous PCB cleaning solvents.
4. What are white residues on PCBs, and why are they considered a reliability concern?
5. State one key advantage and one limitation each of AOI, AXI, and ICT.
6. Compare Bed-of-Nails Tester and Flying Probe Tester in In-Circuit Testing (ICT).

Fill in the Blanks:

1. ___________ contamination includes salts and flux activators, while ___________ contamination includes oils, greases, and solder balls.
2. The IPC standard ___________ covers requirements for soldered electrical and electronic assemblies.
3. White residues on PCBs are complex mixtures of ___________, ___________, and other materials.
4. In ultrasonic cleaning, contaminants are removed through a process called ___________.
5. ___________ inspection uses high-resolution cameras and image-processing algorithms to detect surface defects on PCBs.
6. The two common ICT methods are ___________ tester and ___________ tester.

Multiple Choice Questions (MCQs):

1. The main purpose of PCB cleaning is to:
   - a) Remove copper layers
   - b) Prevent electromigration and improve reliability
   - c) Reduce PCB thickness
   - d) Remove solder mask
2. Which IPC standard is most widely used for soldered electrical and electronic assemblies?
   - a) IPC-A-620
   - b) IPC-2581
   - c) IPC J-STD-001
   - d) IPC-6012
3. White residues on PCBs are mainly caused by:
   - a) Overuse of nitrogen in reflow ovens
   - b) Flux chemistry and improper cleaning processes
   - c) High-quality solder paste
   - d) Proper storage of boards

4. Which cleaning method uses microscopic bubbles created by high-frequency sound waves?
    a) Manual cleaning
    b) Ultrasonic cleaning
    c) Vapor degreasing
    d) Brushing
5. Automated X-ray Inspection (AXI) is particularly useful for:
    a) Detecting scratches on PCB surface
    b) Inspecting hidden solder joints like BGAs and CSPs
    c) Measuring resistance and capacitance
    d) Checking solder mask alignment
6. In-circuit testing (ICT) is best described as:
    a) A method for cleaning PCBs after reflow
    b) A structural electrical test for verifying assembly integrity
    c) A visual inspection using microscopes
    d) A flux residue removal method

Notes

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

5. Sustainability Practices in Telecom Production and Assembly Line Processes

Telecom Sector Skill Council

TEL/N9107

Key Learning Outcomes

By the end of this module, the participants will be able to:

1. Explain the organization's sustainability policies and goals.
2. Demonstrate the use of energy-efficient equipment, tools, and automated systems to reduce carbon footprint and optimize material, water, and electricity consumption.
3. Elucidate the key aspects of EPR guidelines, ISO 14001, and e-waste disposal laws.
4. Demonstrate how to inspect, categorize, and store telecom components such as PCBs, cables, batteries, and plastic casings for appropriate processing, ensuring compliance with EPR guidelines.
5. Discuss the methods for identifying recyclable and hazardous components in telecom production.
6. Show how to maintain an inventory of recyclable and hazardous materials while tracking waste management and reporting improper disposal practices.
7. Describe green manufacturing practices, including energy-efficient tools, lead-free soldering, and automation.
8. Show how to follow low-emission soldering and lead-free assembly processes while ensuring compliance with ISO 14001 (Environmental Management System).
9. Explain the proper handling, storage, and disposal methods for e-waste.
10. Demonstrate how to properly dispose of hazardous waste (e.g., lithium batteries, chemical residues) and deposit non-hazardous recyclable materials (e.g., plastics, aluminum, copper) in designated collection areas.

UNIT 5.1: Environmental Compliance and Sustainable Practices

Unit Objectives

By the end of this unit, the participants will be able to:

1. Explain the organization's sustainability policies and goals.
2. Demonstrate the use of energy-efficient equipment, tools, and automated systems to reduce carbon footprint and optimize material, water, and electricity consumption.
3. Elucidate the key aspects of EPR guidelines, ISO 14001, and e-waste disposal laws.
4. Demonstrate how to inspect, categorize, and store telecom components such as PCBs, cables, batteries, and plastic casings for appropriate processing, ensuring compliance with EPR guidelines.
5. Discuss the methods for identifying recyclable and hazardous components in telecom production.
6. Show how to maintain an inventory of recyclable and hazardous materials while tracking waste management and reporting improper disposal practices.
7. Describe green manufacturing practices, including energy-efficient tools, lead-free soldering, and automation.
8. Show how to follow low-emission soldering and lead-free assembly processes while ensuring compliance with ISO 14001 (Environmental Management System).
9. Explain the proper handling, storage, and disposal methods for e-waste.
10. Demonstrate how to properly dispose of hazardous waste (e.g., lithium batteries, chemical residues) and deposit non-hazardous recyclable materials (e.g., plastics, aluminum, copper) in designated collection areas.

5.1.1 Organization's Sustainability Policies And Goals

In today's world, companies are expected not only to make quality products but also to take responsibility for protecting the environment. Telecom manufacturing companies—including those that make chargers, USB cables, batteries, and mobile accessories—follow specific sustainability policies and environmental goals to reduce negative impact on nature, conserve resources, and comply with environmental regulations.

As a Line Assembler, you play a direct role in ensuring that your daily work supports these sustainability efforts.

What Are Sustainability Policies?

Sustainability policies are written commitments made by a company to:

- Use resources wisely
- Reduce waste
- Protect the environment
- Ensure worker and consumer safety
- Comply with environmental laws and certifications

These policies apply to all departments—from design and procurement to manufacturing and packaging. For assembly line workers, this means following standard operating procedures (SOPs) that are eco-friendly and safe.

Organizational Environmental Goals

Every telecom company sets specific environmental goals as part of its sustainability mission. These goals may include:

- Reducing carbon footprint from manufacturing
- Lowering energy and water consumption
- Recycling 100% of production waste
- Safe disposal of lithium batteries and chemical waste
- Using recyclable packaging materials
- Conducting regular environmental audits

Each department, including assembly, contributes to achieving these goals by following procedures and maintaining documentation.

5.1.2 Demonstrate the Use of Energy-efficient Equipment, Tools, and Automated Systems to Reduce Carbon Footprint and Optimize Material, Water, and Electricity Consumption

By using energy-efficient tools, machines, and processes, we not only reduce the carbon footprint but also lower the consumption of valuable resources like electricity, water, and materials.

1. Importance of Using Energy-Efficient Equipment

Energy-efficient equipment is designed to perform the same tasks using less electricity. This helps reduce greenhouse gas emissions and cuts down electricity bills. As a Line Assembler, selecting and properly using such tools supports the company's environmental goals.

Examples of Energy-Efficient Equipment:

- Brushless DC motors in assembly tools – consume less power.
- LED lighting – used at workstations for reduced electricity use.
- Soldering stations with auto power-off – save energy during idle time.

2. Benefits of Automation in Reducing Resource Use

Automated systems in assembly lines improve accuracy, reduce material wastage, and optimize energy use. By programming machines to work precisely, we avoid unnecessary use of components or rework, which in turn saves energy and resources.

Examples:

- Pick-and-place machines – reduce errors and avoid material waste.
- Automated testing systems – lower chances of defective production.
- Energy monitoring sensors – help track and control energy usage in real-time.

3. Optimizing Material Usage

Material optimization helps minimize waste and supports sustainable production.

Best Practices:

- Use components as per the BOM (Bill of Materials) to avoid overuse.
- Handle components carefully to avoid damage or rejection.
- Follow 5S practices to store materials properly, reducing spoilage and loss.

4. Water and Electricity Consumption Control

While telecom assembly uses minimal water, it is still important to conserve wherever used (e.g., for cleaning or cooling). Electricity, however, is used extensively, and thus needs careful monitoring.

Energy and Water Saving Tips:

- Switch off equipment and lights when not in use.
- Use water-based cleaning only when necessary.
- Report leakages or excessive water/electricity usage to supervisors.
- Prefer tools that consume low voltage or have automatic power-off features.

5. Carbon Footprint Reduction in Assembly Work

Carbon footprint refers to the amount of greenhouse gases released into the atmosphere due to human activities. In telecom manufacturing, it can be reduced by:

- Using machines only when needed.
- Replacing manual processes with efficient automated tools.
- Regular maintenance of equipment to ensure energy efficiency.
- Reducing rework and rejects by doing the job right the first time.

5.1.3 EPR Guidelines, ISO 14001, and E-waste Disposal Laws

As the telecom sector grows rapidly, so does the volume of electronic waste (e-waste). To reduce its environmental impact, both national and international frameworks have been introduced. These include EPR (Extended Producer Responsibility), ISO 14001 environmental standards, and e-waste disposal laws. Understanding these is essential for every professional in the telecom manufacturing ecosystem, including Line Assemblers.

Fig 4.1.1 EPR

1. What is EPR?

Extended Producer Responsibility (EPR) is a policy approach that holds manufacturers accountable for the entire lifecycle of their products—especially their end-of-life disposal and recycling. This shifts the burden of waste management from consumers and local authorities to producers, encouraging sustainable product design and responsible recycling.

Extended Producer Responsibility (EPR) is a policy approach that holds manufacturers accountable for the entire lifecycle of their products—especially their end-of-life disposal and recycling. This shifts the burden of waste management from consumers and local authorities to producers, encouraging sustainable product design and responsible recycling.

EPR in India

In India, EPR is enforced under the E-Waste (Management) Rules, 2016, and further refined in the 2022 updates. It mandates that producers, importers, and manufacturers of electrical and electronic equipment:

1. Collect back their sold products once they become waste.
2. Recycle or dispose of them responsibly using authorized handlers.
3. Set up take-back mechanisms or collection centers at accessible locations.

They must also obtain authorization from the State Pollution Control Board or Pollution Control Committee, and provide information to consumers through websites, toll-free numbers, or customer care centers.

Key Aspects of EPR Compliance for E-Waste

1. **Producers' Responsibilities**
   a. Ensure proper collection, storage, and transportation of e-waste.
   b. Maintain detailed records of collection, recycling, and disposal.
   c. Partner with authorized recyclers and dismantlers only.
2. **Consumer Awareness and Participation**
   a. Consumers must be informed about safe disposal methods.
   b. Return old devices to authorized collection points instead of discarding them in general waste.
3. **Authorized Recyclers and Dismantlers**
   a. Only registered recyclers should handle e-waste.
   b. They follow environmentally sound methods to recover valuable materials and prevent pollution.

2. ISO 14001 – Environmental Management System (EMS)

ISO 14001 is an international standard for establishing an effective Environmental Management System (EMS) in organizations. It provides a framework for minimizing environmental impact and complying with applicable laws.

Key Features:

a. **Policy Creation:** Organizations must define clear environmental objectives.
b. **Planning:** Identify significant environmental aspects, legal obligations, and resource use.
c. **Implementation:** Assign roles and train staff to carry out EMS.
d. **Monitoring:** Regular audits and evaluations to improve performance.
e. **Improvement:** Adopt corrective actions and update environmental policies.

Fig. 4.1.2 ISO 14001 - EMS

Why It Matters for Line Assemblers:

a. Ensures proper waste segregation and responsible material handling.

b. Encourages energy and water saving in day-to-day work.

c. Promotes environmental awareness and accountability at all levels.

3. E-Waste Disposal Laws

India's E-Waste (Management) Rules, 2022 outline how e-waste should be collected, stored, transported, dismantled, and recycled.

Key Provisions:

a. E-Waste Classification: Includes mobile phones, chargers, batteries, circuit boards, and accessories.

b. Prohibited Practices: Burning, dumping in landfills, or unregulated handling is banned.

c. Authorized Handling Only: E-waste must be processed only by authorized recyclers and dismantlers.

d. Storage Limit: Temporary storage of e-waste should not exceed 180 days.

e. Tracking and Reporting: Organizations must maintain transparent records of e-waste generation and disposal.

5.1.4 Demonstrate How to Inspect, Categorize, and Store Telecom Components Such as Pcbs, Cables, Batteries, and Plastic Casings For Appropriate Processing, Ensuring Compliance With EPR Guidelines

Telecom manufacturing generates a variety of components, many of which become non-functional or reach end-of-life during production or post-consumer usage. As a Line Assembler, it is important to manage these responsibly.

Component	Description	Material Type
PCBs (Printed Circuit Boards)	Complex electronic boards used in all telecom products	Mixed materials (metals, resins)
Cables	Coaxial, fiber optic, or power cables	Plastic insulation + copper/aluminum
Batteries	Rechargeable (Li-ion, NiMH) or non-rechargeable types	Chemical and metal-based
Plastic Casings	Outer enclosures for telecom devices	ABS, Polycarbonate

1. Inspection Procedure

Step 1: Visual Check

- Look for signs of physical damage, corrosion, leakage, or burnt marks.
- Check for wear and tear in cables and insulation.
- Inspect battery swelling, leakage, or expiry date.

Step 2: Functional Testing (if applicable)

- Use multimeters or basic diagnostic tools to test PCBs and cables.
- Check battery voltage using appropriate testers.

Step 3: Safety Precautions

- Wear ESD gloves and goggles while handling PCBs and batteries.
- Avoid direct contact with leaked chemicals or broken parts.

2. Categorization of Components

Category	Criteria	Examples
Reusable	Undamaged and functionally tested	PCBs with no defects, new cables
Recyclable	Non-functional but recoverable material	Old copper cables, metal casings
Hazardous/Disposal	Leaking, expired, or non-recyclable items	Swollen batteries, burnt PCBs

3. Storing Components as per EPR Guidelines

General Storage Rules:

- Label all bins/boxes clearly (Reusable / Recyclable / Disposal).
- Segregate e-waste from regular scrap.
- Protect components from moisture, dust, and heat.

Component-wise Storage Practices:

Component	Storage Method	EPR Note
PCBs	Anti-static trays, avoid stacking	To be sent to authorized e-waste recycler
Cables	Coiled, tied, and placed in plastic crates	Copper and plastics to be recovered
Batteries	Stored upright in leak-proof containers	Must be collected by EPR collection agency
Plastic Casings	Sorted by plastic type and stacked	To be sent for plastic recycling

4. Documentation and Compliance

- Maintain logs of inspected, categorized, and stored items.
- Use tracking systems or barcodes if available.
- Coordinate with the EPR partner/vendor for pickup and disposal.

5.1.5 Discuss the Methods For Identifying Recyclable and Hazardous Components in Telecom Production

Proper identification of recyclable and hazardous components ensures environmental safety, regulatory compliance (EPR), and cost-efficient material recovery.

How to Identify:

- Visual Check: No cracks, burns, or corrosion (e.g., intact cables, clean PCBs).
- Material Type: Contains valuable materials like copper, aluminum, ABS plastic.

- Function Test: Passes basic tests or has reusable sub-parts.
- Labels/Symbols: Recycling codes or material markings.
- Sorting: Keep metals, plastics, and electronics in separate containers.

Hazardous Components

Parts that pose a risk to health or the environment.

How to Identify:

- Damage Signs: Leaks, swelling, burns, rust (e.g., swollen batteries).
- Warning Labels: Hazard or chemical symbols.
- Expiry Check: Past safe usage date.
- Physical Clues: Unusual smell, heat, or sticky residue.
- Reference Lists: Matches items on hazardous waste guidelines.

Handling After Identification

- Recyclable: Clean, sort, and send to authorized recyclers.
- Hazardous: Isolate in leak-proof containers, label clearly, and hand over to EPR-registered agencies.
- Always wear PPE during handling.

Quick Reference Table

Type	Signs	Action
Recyclable	Undamaged, valuable, reusable material	Sort & send for recycling
Hazardous	Damaged, leaking, toxic, expired	Isolate & dispose safely

5.1.6 Inventory of Recyclable and Hazardous Materials

Maintaining a clear inventory of recyclable and hazardous materials helps track their movement, ensures safe storage, supports EPR (Extended Producer Responsibility) compliance, and prevents unsafe or illegal disposal. Proper documentation also allows quick detection of improper disposal practices so corrective actions can be taken immediately.

Date	Material Type	Component Name / Description	Category (Recyclable / Hazardous)	Quantity	Storage Location	Condition / Remarks	Waste Disposal Method	Disposal Date	Disposal Vendor / EPR Agency	Improper Disposal Noticed? (Y/N)	Corrective Action Taken	Reported To	Signature
05-08-25	Copper Cable	Coaxial Cable – Damaged ends	Recyclable	20 m	Bin A – Metal Scrap	Insulation intact	Sent for copper recovery	06-08-25	ABC Recycling Pvt Ltd	N	N/A	Waste Manager	[Sign]

05-08-25	Battery	Li-ion 3.7V – Swollen	Hazardous	12 units	Hazard Bin – Battery	Leaking	Sent for hazardous waste disposal	07-08-25	XYZ EPR Agency	Y	Noted improper bin mixing – trained staff	Supervisor	[Sign]

5.1.7 Describe Green Manufacturing Practices, Including Energy-efficient Tools, Lead-free Soldering, and Automation

Green manufacturing refers to environmentally responsible production methods that aim to reduce waste, conserve resources, and minimize the ecological footprint of manufacturing activities. In telecom manufacturing, the adoption of sustainable practices not only supports environmental protection but also improves operational efficiency and compliance with regulations. Key practices include:

1. Energy-Efficient Tools and Equipment

- Use of Energy Star–rated machinery and test instruments.
- Low-power soldering stations with automatic standby and shut-off features.
- Variable frequency drives (VFDs) in motors to optimize power usage.
- Reduces electricity consumption, lowers operational costs, and minimizes greenhouse gas emissions.

2. Lead-Free Soldering

- Use of RoHS-compliant solder materials, such as tin-silver-copper (Sn-Ag-Cu) alloys.
- Adjusting soldering temperatures and process parameters to match lead-free material requirements.
- Provides safer working conditions, reduces contamination risks, and complies with environmental regulations.

3. Automation in Production Processes

- Automated assembly lines for printed circuit boards (PCBs).
- Robotic arms for component placement and inspection.
- Computer-controlled soldering and testing systems.
- Improves product quality, reduces defects, minimizes material waste, and optimizes energy use.

5.1.8 Low-Emission Soldering & Lead-Free Assembly (ISO 14001)

In telecom manufacturing, low-emission soldering and lead-free assembly help reduce environmental impact and improve worker safety. To ensure these processes meet ISO 14001 (Environmental Management System) requirements, the following steps should be followed:

1. Preparation and Material Selection

- Use RoHS-compliant, lead-free solder such as tin-silver-copper (Sn-Ag-Cu) alloys.
- Choose fluxes with low volatile organic compound (VOC) content to reduce harmful emissions.
- Store soldering materials in clearly labelled containers to avoid contamination and ensure traceability.

2. Equipment Setup

- Use temperature-controlled soldering stations to prevent overheating, which can increase emissions.
- Install fume extraction systems or soldering stations with built-in smoke absorbers to capture airborne particles.
- Regularly calibrate equipment to maintain process accuracy and energy efficiency.

3. Process Execution

- Preheat components at controlled temperatures to reduce thermal shock and energy waste.
- Apply solder sparingly to prevent material waste.
- Use automated soldering systems where possible to maintain consistency and minimize rework.

4. Waste Management and Recycling

- Collect and segregate solder dross, scrap boards, and used flux for proper recycling or disposal.
- Maintain records of waste quantities and disposal methods as per ISO 14001 documentation requirements.
- Ensure hazardous materials are disposed of only through authorized waste handlers.

5. Compliance and Documentation

- Maintain Standard Operating Procedures (SOPs) for low-emission and lead-free soldering.
- Conduct periodic internal audits to ensure processes meet ISO 14001 standards.
- Keep training records showing workers are aware of environmental responsibilities.

6. Continuous Improvement

- Monitor energy consumption and material usage for each batch to identify areas for efficiency gains.
- Replace outdated equipment with energy-efficient, low-emission models.
- Encourage operator feedback for process improvement in line with ISO 14001's continual improvement principle.

This method not only keeps production environmentally friendly but also ensures regulatory compliance and enhances the company's sustainability reputation.

5.1.9 Handling, Storage, and Disposal Methods for E-waste

E-waste in the telecom industry includes discarded printed circuit boards (PCBs), cables, batteries, antennas, routers, mobile handsets, switches, connectors, plastic casings, and other electronic assemblies. Handling these materials requires safe practices to protect workers, comply with regulations, and prevent environmental harm.

1. Proper Handling

- Use PPE – Gloves, masks, and safety glasses to prevent exposure to hazardous substances such as lead solder, mercury, or cadmium.
- Prevent Damage – Avoid dropping or breaking components like batteries or display units that could release harmful chemicals.
- Segregate by Type – Separate PCBs, batteries, metals, plastics, fibre optics, and cables into dedicated bins.

2. Proper Storage

- Designated Storage Area – Use a separate, secure zone for e-waste, away from production and food areas.
- Closed Containers – Store in sturdy bins, drums, or crates to prevent accidental spillage or damage.
- Temperature Control – Keep away from direct sunlight and high heat, especially for lithium-ion batteries.
- Organize by Hazard Level – Keep hazardous telecom waste (e.g., batteries, lead-based PCBs) apart from non-hazardous recyclable parts (e.g., aluminium housings, plastic covers).
- First In, First Out (FIFO) – Move older stored waste out for processing before newer items.
- Maintain Records – Track each batch with details like type of waste, quantity, date stored, and intended disposal method for compliance with EPR (Extended Producer Responsibility) and ISO 14001.

3. Proper Disposal

- Authorized Recyclers Only – Partner with CPCB/SPCB-approved e-waste recyclers and dismantlers.
- Material Recovery – Recover valuable metals (gold, copper, aluminium) and reusable telecom components before disposal.
- Safe Treatment of Hazardous Waste – Ensure toxic elements like lead, mercury, and cadmium are processed in approved facilities.
- Obtain Disposal Certificates – Keep official recycling or destruction proof for audits and compliance.
- Avoid Informal Sector – Do not hand over to unregistered scrap dealers or dump in open landfills.
- Promote 3R Principle – Reduce e-waste generation, Reuse functional parts, and Recycle eligible components.

5.1.10 Proper Disposal of Hazardous Waste & Deposit of Non-Hazardous Recyclables

Here is a demonstration of how a telecom manufacturer would handle this process.

1. Proper Disposal of Hazardous Waste

Telecom products like routers, base stations, and optical fiber equipment contain a variety of hazardous materials. The manufacturer must handle these with extreme care, as per the rules laid out by the Central Pollution Control Board (CPCB).

- **Identification:** The first step is to accurately identify all hazardous waste streams generated during manufacturing. In a telecom plant, this includes:
  - Lithium Batteries: Found in a variety of devices for power backup or as part of the final product. These are a significant fire risk if damaged.
  - Chemical Residues: Solvents, adhesives, and cleaning agents used in manufacturing, particularly on Printed Circuit Boards (PCBs).
  - Lead-based Solder: While many manufacturers have shifted to lead-free soldering, lead-based materials may still be used in specific applications or older production lines.
  - Capacitors: Some large capacitors can contain hazardous chemicals.
  - Rejected PCBs: PCBs that fail quality control are considered e-waste and contain various hazardous heavy metals like lead and cadmium.

- **Segregation and Containment:** The manufacturer must use separate, dedicated containers for each type of hazardous waste. These containers must be clearly labeled with the waste type, a unique ID, and the date of generation.
    - Battery Storage: Lithium batteries must be stored in a cool, dry area in fire-resistant containers, separated from other waste streams. Any damaged batteries must be individually isolated in non-conductive material and placed in a separate container.
    - Chemical Residues: Chemical waste must be sealed in its original container or a compatible container, labeled, and stored in a designated, well-ventilated area with secondary containment to catch any leaks.
- **Documentation and Manifesting:** As per the E-Waste Rules, the manufacturer is considered a "bulk consumer" and a "producer" and must maintain a detailed manifest. This manifest tracks the unique ID of the waste, its quantity, and the date of its transfer to a certified handler. This is submitted to the State Pollution Control Board (SPCB) as part of quarterly and annual returns.
- **Certified Disposal:** The manufacturer is legally obligated to hand over all e-waste and other hazardous waste only to CPCB-authorized recyclers or dismantlers. They cannot sell this waste to informal "kabadiwalas" or uncertified collectors. The certified recycler provides a certificate of disposal, which serves as the final proof of proper handling and is a crucial document for regulatory audits.

2. Depositing Non-Hazardous Recyclable Materials

Non-hazardous materials are a valuable resource stream in telecom manufacturing. Proper handling of these materials contributes to a circular economy and reduces the need for virgin resources.

- **Identification and Segregation:** The manufacturing facility must set up a clear and organized system for non-hazardous recyclables.
    - **Plastics:** This is a major waste stream from product casings, packaging, and spools. Separate bins should be available for different plastic types, such as ABS and polycarbonate, which are often used in enclosures.
    - **Metals:** Copper wiring, aluminum heat sinks and frames, and steel components are valuable. Separate bins for each metal type will maximize their value.
    - **Cardboard and Paper:** Packaging materials, office paper, and product manuals should be collected in a designated baling area.
- **Collection Areas**: The manufacturing floor and administrative offices must have easily accessible, clearly marked collection points. These collection areas should be managed by a trained team that ensures the materials are clean and not contaminated.
- **Preparation:** Simple preparation steps can significantly increase the value of recyclables. For example, plastic packaging should be free of other materials, and cardboard should be flattened to save space.
- **Partnering with Recyclers:** The manufacturer should partner with certified recyclers for non-hazardous materials as well. While not as strictly regulated as hazardous waste, a certified partner ensures that the materials are actually recycled and not sent to a landfill. The recycler will collect the materials, often in bulk bales, and provide documentation of the quantities received.

By implementing these practices, a telecom products manufacturer can ensure that they are:

- Complying with E-Waste Regulations: The E-Waste (Management) Rules, 2022, mandate the proper disposal of all electronic waste through authorized channels, with a strong emphasis on Extended Producer Responsibility (EPR).
- Enhancing Environmental Safety: Preventing hazardous materials from entering the ecosystem protects soil and water and safeguards public health.
- Promoting a Circular Economy: By effectively recovering and recycling materials like copper, aluminum, and plastics, the company reduces its reliance on new raw materials, contributing to a more sustainable supply chain.

Notes

UNIT 5.2: Waste Management, Disposal, and Environmental

Unit Objectives

By the end of this unit, the participants will be able to:

1. Determine techniques for reducing material wastage without impacting production quality.
2. Demonstrate the process of maintaining and calibrating energy-efficient machinery to ensure optimal performance and minimize environmental impact.
3. Discuss the safe and responsible handling of hazardous and non-hazardous materials in telecom manufacturing.
4. Demonstrate how to coordinate with authorized e-waste recyclers to ensure proper processing and disposal of materials.
5. Describe environmental impact assessment techniques for telecom production.
6. Demonstrate how to follow national and international environmental laws, participate in sustainability audits, check for adherence to guidelines, and implement corrective actions based on assessments.
7. Explain the documentation requirements for sustainability audits and compliance tracking.
8. Demonstrate how to maintain documentation for waste disposal, conduct periodic waste audits, and identify opportunities for further waste reduction.

5.2.1 Techniques for Reducing Material Wastage Without Impacting Production Quality

In telecom product assembly, controlling material wastage is essential for reducing costs, protecting the environment, and maintaining high-quality standards. A Line Assembler must follow best practices to use materials efficiently without affecting the performance or reliability of the final product.

Key Techniques:

- Accurate Measurement & Cutting – Use correct tools and follow specified measurements to avoid extra trimming or rework.
- Right Material Handling – Store cables, connectors, and components properly to prevent damage from dust, moisture, or mishandling.
- Batch Planning – Organize assembly work to use materials in optimal sequence, reducing leftovers.
- Use of Templates & Jigs – Ensure consistent assembly and reduce errors that lead to waste.
- Rework Minimization – Follow standard operating procedures (SOPs) to get it right the first time.
- Recycling & Reuse – Collect leftover lengths of cable, small components, or packaging material for reuse where possible.
- Inventory Management – Issue materials as per job requirements to avoid excess on the shop floor.

Benefits:

- Lowers production cost
- Reduces environmental impact
- Improves workplace efficiency
- Ensures consistent product quality

5.2.1 Techniques for Reducing Material Wastage Without Impacting Production Quality

To ensure smooth production, long equipment life, and reduced environmental impact, a Line Assembler must know how to maintain and calibrate energy-efficient machines used in telecom product assembly.

Steps to Follow:

- Safety First – Switch off the machine and follow lockout/tagout procedures before maintenance.
- Cleaning – Remove dust, grease, and debris from machine parts to avoid wear and overheating.
- Lubrication – Apply the correct lubricant to moving parts to reduce friction and save energy.
- Calibration – Use measuring tools to adjust machine settings (speed, temperature, alignment) as per manufacturer's guidelines.
- Inspection – Check for loose parts, damaged cables, or worn-out components.
- Replace Consumables – Change filters, belts, or nozzles that affect performance.
- Test Run – Restart the machine and run a test to ensure smooth and accurate operation.
- Record Keeping – Log maintenance and calibration details in the equipment register.

Fig. 5.2.1 Energy Efficiency: The Secret to Sustainable Machines

5.2.3 Safe Handling of Hazardous & Non-hazardous Materials In Telecom Manufacturing

In telecom manufacturing, materials can be hazardous (e.g., solder with lead, cleaning chemicals, lithium batteries) or non-hazardous (e.g., plastic parts, aluminium scrap, copper wires). Handling them correctly ensures worker safety, product quality, and environmental protection.

Safe Handling Practices:

- Identify Materials – Read labels and safety data sheets to know hazards.
- Wear PPE – Use gloves, masks, or goggles when dealing with chemicals or sharp components.
- Use Proper Storage – Keep hazardous materials in clearly labelled, sealed containers; store away from heat or moisture.

- Avoid Spillage & Contamination – Handle carefully to prevent leaks or mixing of incompatible materials.
- Follow Disposal Rules –
- Hazardous waste → send to authorised disposal facility.
- Non-hazardous recyclable waste → place in designated bins for plastics, metals, etc.
- Report Incidents – Immediately inform the supervisor of any spills, leaks, or accidents.

5.2.4 Coordinate with Authorized E-Waste Recyclers

Proper disposal of electronic waste (e-waste) is essential to protect the environment and comply with legal requirements. A Line Assembler should know how to work with authorised recyclers for safe processing of discarded materials.

Steps to Follow:

Fig. 5.2.2 E Waste recycling unit

- **Identify E-Waste** – Separate damaged PCBs, cables, connectors, batteries, and other discarded electronic components.
- **Segregate & Store** – Keep e-waste in labelled, secure containers away from regular waste.
- **Contact Authorized Recycler** – Use only government-approved or company-approved e-waste recycling partners.
- **Documentation** – Record type, weight, and quantity of e-waste for tracking.
- **Handover Process** – Ensure safe transfer to recycler with proper receipts or certificates.
- **Follow-Up** – Confirm that the e-waste is processed in an environmentally safe way.

5.2.5 Environmental Impact Assessment (EIA) Techniques for Telecom Production

Environmental Impact Assessment (EIA) helps identify, predict, and reduce negative effects of telecom manufacturing on the environment. Even at the assembly level, understanding EIA principles supports sustainable production.

Area Checked	What to Do	Why It Matters
Material Use	Track raw materials and waste generation	Avoids overuse and reduces scrap
Energy Consumption	Monitor machine electricity usage	Saves energy and reduces costs
Waste Audit	Record hazardous & non-hazardous waste	Ensures safe disposal and recycling
Air Emissions	Measure solder fumes, dust, vapours	Protects worker health & environment
Water Usage	Monitor cleaning/cooling water use	Prevents wastage of resources
Product Life Cycle	Consider impact from production to disposal	Supports sustainable design
Regulatory Compliance	Match practices with ISO 14001 & local laws	Meets legal and industry requirements

EIA is not a one-time activity — it's an ongoing process to make telecom production more efficient and eco-friendly.

5.2.6 Follow Environmental Laws & Participate in Sustainability Audits

A Line Assembler must help the organisation meet national and international environmental regulations while ensuring sustainable production practices. This includes following laws, participating in audits, checking compliance, and taking corrective actions when needed.

Steps to Follow:

1. **Know the Rules**
   - Understand basic environmental laws like the E-Waste Management Rules (India) and ISO 14001 environmental management standards.

2. **During Work**
   - Follow approved waste disposal, recycling, and energy-saving procedures.
   - Use PPE when handling hazardous materials.

3. **Participate in Sustainability Audits**
   - Provide accurate records on material use, waste handling, and energy consumption.
   - Cooperate with internal and external auditors.

4. **Check for Compliance**
    - Compare actual practices with company guidelines and legal requirements.
    - Identify any gaps or violations.

5. **Implement Corrective Actions**
    - Fix issues found in audits (e.g., improper waste storage, excessive scrap).
    - Suggest improvements to reduce environmental impact.

5.2.7 Documentation for Sustainability Audits & Compliance Tracking

1. **Before Audit – What to Keep**
    - Company's Environmental Policy – A copy of the rules we follow for reducing waste and saving energy.
    - Previous Audit Results – Reports from last audits, with notes on what was fixed.
    - Action Plan – A list of things we are doing to meet environmental goals.

2. **Daily/Weekly Records**
    - Waste Records – Write down what waste is made (e.g., scrap plastic, metal pieces, used batteries) and where it is sent. Keep receipts from recyclers.
    - Energy & Material Use – Record monthly use of electricity, water, and materials.
    - Chemical Use & Disposal – Keep logs for soldering chemicals, cleaning agents, and how they are disposed of.
    - Supplier Certificates – Keep proof that suppliers meet environmental standards (e.g., RoHS).

3. **During Audit**
    - Checklists – Mark yes/no against points given by the auditor.
    - Inspection Notes – Write what the auditor finds, with photos if needed.
    - Non-Compliance Records – If any issue is found, write it down and note how it will be fixed.

4. **Tracking Compliance**
    - Follow-up Log – Keep track of what is fixed after an audit, who did it, and when.
    - Reports to Management – Simple summaries for supervisors about waste reduction, recycling, and energy saving.
    - Proof of Submission – Keep copies of reports sent to government or certification agencies.

5. **Good Practice:**
    - Keep all documents in one file/folder (digital or paper), arranged by date. This makes it easy to show proof during audits and helps avoid penalties.

5.2.8 Maintaining Waste Disposal Records, Doing Waste Audits & Finding Ways to Reduce Wast

1. Maintaining Waste Disposal Records

- Record Daily Waste
  - Write down the type of waste (plastic, metal scrap, used solder wire, empty chemical bottles, batteries).
  - Note the weight/quantity.
- **Mark Storage Location**
  - Show where the waste is kept before disposal (e.g., bins, drums, storage racks).
- **Keep Disposal Proof**
  - Attach receipts or certificates from the approved recycler or waste collector.
- **Date & Signature**
  - Sign and date each entry so it is valid for audits.

2. Conducting Periodic Waste Audits

(Once a month or as instructed by the supervisor)

- Collect Records – Gather all daily waste logs.
- Check Waste Types & Amounts – Identify which waste types are most common.
- Look for Trends – Is waste increasing or decreasing compared to last month?
- Report Findings – Share the summary with the supervisor for further action.
- Identifying Opportunities for Waste Reduction

Observe & Suggest:

- Material Use – Avoid cutting extra or using more material than needed.
- Reuse – Check if packaging materials, containers, or leftover wires can be reused safely.
- Process Change – Suggest better methods to reduce scrap (e.g., careful handling of components to avoid breakage).
- Training Needs – Inform the supervisor if workers need refresher training on material handling.

Exercise

Choose The Correct Option From The List Of Responses To Answer The Following Questions:

1. Which technique helps reduce cable wastage during cutting?
   a) Over-cutting
   b) Accurate measurement
   c) Mixing batches
   d) Ignoring SOPs
2. Which step must be done first before maintaining or calibrating a machine?
   a) Lubrication
   b) Lockout/Tagout
   c) Test Run
   d) Cleaning
3. Lead solder and lithium batteries are examples of:
   a) Non-hazardous waste
   b) Recyclable packaging
   c) Hazardous materials
   d) Normal scrap
4. Who should a Line Assembler contact for safe disposal of damaged PCBs and cables?
   a) Local scrap dealer
   b) Authorized e-waste recycler
   c) Supervisor only
   d) Packaging team
5. Which standard is followed for environmental management in telecom manufacturing?
   a) ISO 27001
   b) ISO 14001
   c) ISO 9001
   d) ISO 45001

Short Questions:

1. List any three key techniques for reducing material wastage during telecom assembly.
2. Why is calibration of energy-efficient machinery important in telecom product assembly?
3. Write two safe practices for handling hazardous materials in telecom manufacturing.

True or False:

1. Using PPE such as gloves and goggles is required when handling hazardous chemicals. ☐
2. Non-hazardous recyclable waste can be mixed with regular garbage. ☐
3. E-Waste must always be handed over to authorized recyclers with proper documentation. ☐
4. Sustainability audits are optional and not related to compliance tracking. ☐

Fill in the Blanks:

1. The use of ___________ and jigs ensures consistent assembly and reduces errors.
2. During machine maintenance, ___________ must be followed to ensure safety.
3. ___________ assessment helps identify and reduce negative effects of telecom production on the environment.
4. Waste disposal records must include type, ___________, and disposal proof with date and signature.

Notes

सत्यमेव जयते
GOVERNMENT OF INDIA
MINISTRY OF SKILL DEVELOPMENT
& ENTREPRENEURSHIP

6. Employability Skills (30 Hours)

Telecom Sector Skill Council

It is recommended that all training include the appropriate. Employability Skills Module. Content for the same can be accessed https://www.skillindiadigital.gov.in/content/list

DGT/VSQ/N0101

7. Annexure

Annexure I - QR Codes –Video Links

Annexure-I

QR Codes –Video Links

Module No.	Unit No.	Topic Name	Link for QR Code (s)	QR code (s)
1. Introduction to the sector and the job role of a Hand Soldering Technician - Telecom Board (TEL/N2500)	Unit 1.1 - Introduction to Telecom Sector and Role of an Hand Soldering Technician - Telecom Board	Intro- duc-tion to the Telecom Sec-tor in India	https://youtu.be/Cag-bc-bivtM	Introduction to the Telecom Sector in India
		Fundamentals of Electronics in Telecom Boards	https://www.youtube.com/watch?v=4sBgu_tUpiI	Basic electronics Guide to components
2. High-Density Hand Soldering of Components on Telecom Boards (TEL/N2500)	Unit 2.1 – Preparing Telecom Boards for Soldering	Selection of Soldering Materials and Tools	https://www.youtube.com/watch?v=KElnqQ85ZdQ	Soldering and Soldering Process
		Safety, ESD Protection, and Documentation	https://www.youtube.com/watch?v=xay2p514iS8	Electrostatic Discharge
	Unit 2.2 - Performing High-Density Hand Soldering on Telecom Boards	Component Placement and Soldering Techniques	https://www.youtube.com/watch?v=aWj7N0BF26M	Types of soldering,

Module No.	Unit No.	Topic Name	Link for QR Code (s)	QR code (s)
3. Reflow Soldering on Telecom Boards (TEL/N2505)	Unit 3.1 - Verification of Telecom Boards and Identification of Defects	Soldering Defects and Rework Standards	https://www.youtube.com/watc h?v=e-HsIoQKwEU	Soldering defects and their remedies
	Unit 3.2 - Selective Soldering and Rework of Defective Components	De-soldering and Selective Soldering Techniques	https://www.youtube.com/watc h?v=bG7yW9FigJA	Desoldering
4. Cleaning and Inspection of Telecom Boards (TEL/N2502)	UNIT 4.1 Cleaning of PCBs	PCB Cleaning and Flux Residue	https://www.youtube.com/watc h?v=Ji5aF0RkIlM	Cleaning of PCBs

Telecom Sector Skill Council
Estel House,3rd Floor, Plot No: - 126, Sector-44
Gurgaon, Haryana 122003
Phone: 0124-2222222
Email: tssc@tsscindia.com
Website: www.tsscindia.com